S.V. NATIONAL INSTITUTE OF TECHNOLOGY SURAT-395007.

Revised Syllabus for B. Tech. IInd to B. Tech. IVth year

(As approved by 48th Senate Meeting held on 26th June, 2020)

Sr. No.	B. Tech. (Branch)	Page Number
1.	Chemical Engineering Department	1 to 127
2.	Civil Engineering Department	128 to 312
3.	Computer Engineering Department	313 to 480
4.	Electrical Engineering Department	481 to 622
5.	Electronics Engineering Department	623 to 752
6.	Mechanical Engineering Department	753 to 895

Revised Syllabus for M.Sc. IInd to M.Sc. Vth year

(As approved by 48th Senate Meeting held on 26th June, 2020)

Sr. No.	M. Sc. (Branch)	Page Number
1.	Applied Chemistry Department	896 to 994
2.	Applied Mathematics & Humanities Department	995 to 1085
3.	Applied Physics Department	1086 to 1187

21/7/20

Dr. Jyotirmay Banerjee
Dean (Academic)

21/7/2020

Dr. S. R. Gandhi
Director

Revised Syllabus for B. Tech. IInd to B. Tech. IVth year
Chemical Engineering Department

SCHEME AND SYLLABUS

B.TECH.-II (CHEMICAL) 3rd SEMESTER SCHEME FOR TEACHING AND EXAMINATION

Sr. No.	Course	Code	Credits	Teaching Scheme Hours per Week			Examination Scheme						Total Marks
							Theory				Practicals		
				L	Tu	Pr	Hr	Sessional	Tu	End Sem	Sessional	End Sem	
1	Mathematics – III	MA213	4	3	1	0	2	50	25	50	---	---	125
2	Mechanical Operations (Core – 1)	CH201	5	3	1	2	2	50	25	50	25	25	175
3	Fluid Flow Operations (Core – 2)	CH203	5	3	1	2	2	50	25	50	25	25	175
4	Heat Transfer Operations (Core – 3)	CH205	5	3	1	2	2	50	25	50	25	25	175
5	Applied Chemistry	CY211	4	3	0	2	2	50	0	50	25	25	150
	TOTAL		23	15	4	8		250	100	250	100	100	800
Total contact hours per week = 27					**Total Credit = 23**							**Total marks = 800**	

B.TECH.-II (CHEMICAL) 4th SEMESTER SCHEME FOR TEACHING AND EXAMINATION

Sr. No.	Course	Code	Credits	Teaching Scheme Hours per Week			Examination Scheme						Total Marks
							Theory				Practicals		
				L	Tu	Pr	Hr	Sessional	Tu	End Sem	Sessional	End Sem	
1	Engineering Mathematics	CH202	4	3	1	0	2	50	25	50	---	---	125
2	Chemical Reaction Engineering – I (Core – 4)	CH204	5	3	1	2	2	50	25	50	25	25	175
3	Mass Transfer Operations – I (Core – 5)	CH206	5	3	1	2	2	50	25	50	25	25	175
4	Chemical Engineering Thermodynamics – I (Core – 6)	CH208	4	3	1	0	2	50	25	50	---	---	125
5	Material Science and Technology (Core – 7)	CH212	4	3	1	0	2	50	25	50	---	---	125
	TOTAL		22	15	5	4		250	125	250	50	50	725

Total contact hours per week = 23 **Total Credit = 22** **Total marks = 725**

B.TECH.-III (CHEMICAL) 5th SEMESTER SCHEME FOR TEACHING AND EXAMINATION

Sr. No.	Course	Code	Credits	Teaching Scheme Hours per Week			Examination Scheme						Total Marks
							Theory				Practicals		
				L	Tu	Pr	Hr	Sessional	Tu	End Sem	Sessional	End Sem	
1	Mass Transfer Operations – II (Core – 8)	CH301	5	3	1	2	2	50	25	50	25	25	175
2	Chemical Engineering Thermodynamics – II (Core – 9)	CH303	4	3	1	0	2	50	25	50	---	---	125
3	Chemical Reaction Engineering – II (Core – 10)	CH305	4	3	1	0	2	50	25	50	---	---	125
4	Institute Elective – I	--	3	3	0	0	2	50	0	50	---	---	100
5	Core Elective – I	CH3AA	3	3	0	0	2	50	0	50	---	---	100
6	Seminar	CH307	1	0	0	2	0	0	0	0	20	30	50
	TOTAL		20	15	3	4		250	75	250	45	55	675
Total contact hours per week = 20						**Total Credit = 20**						**Total marks = 675**	

Institute Elective – I (CH3XX)		
Sr. No	**Code**	**Elective Course**
1.	CH361	Process Plant Safety
2.	CH363	Cleaner Technologies in Chemical Process Industries
3.	CH365	Fuels and Combustion
4.	CH367	Introduction to Engineering Statistics

Core Elective – I (CH3AA)		
Sr. No	**Code**	**Elective Course**
1.	CH321	Bioprocess Engineering
2.	CH323	Computational Heat Transfer and Fluid Flow
3.	CH325	Fundamentals of Biochemical Engineering
4.	CH327	Introduction of Electrochemistry

B.TECH.-III (CHEMICAL) 6th SEMESTER SCHEME FOR TEACHING AND EXAMINATION

Sr. No.	Course	Code	Credits	Teaching Scheme Hours per Week			Examination Scheme						Total Marks
							Theory				Practicals		
				L	Tu	Pr	Hr	Sessional	Tu	End Sem	Sessional	End Sem	
1	Professional Ethics, economics & management	HU302	4	4	0	0	2	50	---	50	---	---	100
2	Instrumentation and Process Control (Core-11)	CH302	5	3	1	2	2	50	25	50	25	25	175
3	Process Equipment Design and Drawing (Core-12)	CH304	5	3	1	2	2	50	25	50	25	25	175
4	Process Modelling and Simulations (Core-13)	CH306	4	3	1	0	2	50	25	50	---	---	100
5	Institute Elective – 2	--	3	3	0	0	2	50	---	50	---	---	100
6	Core Elective -2	**CH3BB**	3	3	0	0	2	50	---	50	---	---	100
	TOTAL		24	19	3	4		300	75	300	50	50	750

Total contact hours per week = 26 **Total Credit = 24** **Total marks = 750**

Institute Elective – 2 (CH3YY)

Sr. No	**Code**	**Elective Course**
1.	CH362	Environmental Health and Safety
2.	CH364	Petrochemical Technology
3.	CH366	Petroleum Refinery Engineering
4.	CH368	Waste to Energy Conversion
5.	CH372	Industrial Waste Management Control

Core Elective – 2 (CH3BB)

Sr. No	**Code**	**Elective Course**
1.	CH322	Polymer Engineering
2.	CH324	Unit Processes
3.	CH326	Chemical Product Design
4.	CH328	Fundamentals of Colloid and Interface Science
5.	CH332	Corrosion and Electrochemical Engineering

B.TECH.-IV (CHEMICAL) 7th SEMESTER SCHEME FOR TEACHING AND EXAMINATION

Sr. No.	Course	Code	Credits	Teaching Scheme Hours per Week			Examination Scheme						Total Marks
							Theory				Practicals		
				L	Tu	Pr	Hr	Sessional	Tu	End Sem	Sessional	End Sem	
1	General Chemical Technology (Core-14)	CH401	5	4	0	2	2	50	---	50	25	25	150
2	Elements of Transport Phenomena (Core-15)	CH403	4	3	1	0	2	50	25	50	---	---	125
3	Core Elective – 3	CH4AA	3	3	0	0	2	50	---	50	---	---	100
4	Core Elective – 4	CH4BB	3	3	0	0	2	50	---	50	---	---	100
5	Summer Training	CH405	2	0	0	0	---	---	---	---	---	---	50
6	Project Preliminaries (Mini Project)	CH407	3	0	0	6	---	---	---	---	40	60	100
	TOTAL		20	13	1	8		200	25	200	65	85	625
Total contact hours per week = 22						**Total Credit = 20**							**Total marks = 625**
$ Refer Table 3													

Core Elective – 3 and Core Elective – 4 (CH4AA, CH4BB)		
Sr. No	**Code**	**Elective Course**
1.	CH421	Sustainability , Green Chemistry and Engineering
2.	CH423	Advances in Chemical Engineering
3.	CH425	Enzyme science and Technology
4.	CH427	Nanomaterials Synthesis by Chemical Methods
5.	CH429	Biomass and Fuel Cell Technology
6.	CH431	Computer Aided Design in Chemical Engineering
7.	CH433	Chemical Process Development and Design
8.	CH435	Green Technology
10.	CH437	Process Intensification
11.	CH439	Rheology of Complex Fluids
12.	CH441	Optimization

B.TECH.-IV (CHEMICAL) 8th SEMESTER SCHEME FOR TEACHING AND EXAMINATION

Sr. No.	Course	Code	Credits	Teaching Scheme Hours per Week			Examination Scheme						Total Marks
							Theory				Practicals		
				L	Tu	Pr	Hr	Sessional	Tu	End Sem	Sessional	End Sem	
1	Core Elective – 5	CH4XX	3	3	0	0	2	50	0	50	---	---	100
2	Core Elective -6	CH4YY	3	3	0	0	2	50	0	50	---	---	100
3	Core Elective - 7	CH4ZZ	3	3	0	0	2	50	0	50	---	---	100
4	Innovation Incubation and Entrepreneurship	HU410	3	3	0	0	2	50	0	50	---	---	100
5	Project	CH402	6	0	0	12	---	---	---	---	80	120	200
	TOTAL		18	12	0	12	---	200	0	200	80	120	600
Total contact hours per week = 24							**Total Credit = 18**						**Total marks = 600**
$ Refer Table 3													

Core Elective – 5, Core Elective – 6 and Core Elective – 7 (CH4XX, CH4YY, CH4ZZ)		
Sr. No	**Code**	**Elective**
1.	CH422	Advanced Particle Technology
2.	CH424	Advanced Process Control
3.	CH426	Computational Fluid Dynamics
4.	CH428	Design of Experiments
5.	CH432	Fluidization Engineering
6.	CH434	Heterogeneous Catalysis
7.	CH436	Interfacial Science and Engineering
8.	CH438	New Separation Techniques
9.	CH442	Chemical Engineering Plant design and Economics
10.	CH444	Safety and Pollution Control in Chemical Process Industries
11.	CH446	Safety , Hazard and risk analysis

Total Credits: 176

B. Tech-II, (Semester-III) Chemical Engineering	L	T	P	C
MA 213: Engineering Mathematics-III	3	1	0	4

Course Outcomes At the end of the course the students will be able to::	
CO1	apply integral transforms to the various mathematical models in Chemical engineering
CO2	develop a Fourier series and Fourier integral for periodic functions for different cases
CO3	utilize the concept of complex analysis to convert and solve the problem in complex domain
CO4	solve the certain type of partial differential equations arising in chemical engineering
CO5	make use of the statistical methods and test for experimental data analysis

LAPLACE TRANSFORMS	**(06 Hours)**
Introduction, Definition, Existence conditions, basic properties, Inverse Laplace transform and properties, Convolution Theorem and properties, Applications of Laplace transforms.	
FOURIER SERIES	**(06 Hours)**
Definition, Fourier series with arbitrary period, in particular periodic function with period 2 π . Fourier series of even and odd function, Half range Fourier series.	
FOURIER INTEGRAL AND FOURIER TRANSFORMS	**(07Hours)**
Fourier Integral theorem, Fourier sine and cosine integral complex form of integral, Inversion formula for Fourier transforms, Fourier transforms of the derivative of a function.	
PARTIAL DIFFERENTIAL EQUATION	**(06 Hours)**
Second order pde of mathematical physics (Heat, wave and Laplace equation, one dimensional with standard boundary conditions, solution by separation of variable method using Fourier series.	
COMPLEX VARIABLES	**(07 Hours)**
Basic mathematical concept, Analytic function, C – R equations, Harmonic functions, its applications, Linear transformation of complex domain, some special transformation, bilinear transformations, conformal mapping and its application, complex integration including contour integration.	
ELEMENTS OF STATISTICS & PROBABILITY	**(10Hours)**
Correlation between two variable, application of correlation, evaluation of coefficients of correlation, Rank correlation, Regression, frequency distribution, Binomial, Poisson's distribution and Normal distribution, application to industrial problem, Test of significance, Chi-square)χ^2 test, student's t Test, application of the t-test, F-distribution.	
Tutorials will be based on the coverage of the above topics separately	**(14 Hours)**
	(Total Contact Time: 42 Hours)

BOOKS RECOMMENDED

1. Kreyszig E., Advanced Engineering Mathematics, John Wiley, Int. Student Ed. 1995.
2. WylieC. R., Advanced Engineering Mathematics, McGraw Hill, Int. Student Ed. 1993.
3. O'Niel Peter, Advanced Engineering Mathematics, Thompson, Singapore, Ind. Ed. 2002.
4. Greenberg Michael D., Advanced Engineering Mathematics, Pearson, Singapore, Ind. Ed. 2007.
5. RamanaB. V., Higher Engg. Mathematics, The McGraw-Hill Inc., New Delhi, 2007.

Mechanical Operations

L	T	P	Credit
3	1	2	05

Core – 1: CH201 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Recognize and identify problems associated with characterization, handling, processing, and transportation of bulk solids encountered in process industries.
CO2	Analyze and estimate the effects of different types of forces on fluid particle interactions in unit operations
CO3	Predict behavior of fluid solid system based on the process variables.
CO4	Calculate efficiency and the size of the unit operations based on the desirable performance
CO5	Design different fluid solid separation equipment
CO6	Devise effective strategies to use computing tools to enhance problem solving skills.

2. Syllabus:

- **INTRODUCTION** **(1 Hour)**
  Overview of different operations practiced in industry, some real Industrial examples.

- **PARTICLE CHARACTERIZATION** **(4 Hours)**
  Particle size measurements, Describing the Size & shape of a Single Particle, Description of Populations of Particles, Conversion between Distributions, Bulk properties measurement, characterization of powder flowability & powder compaction, Sieving and other methods of size measurements: Sieve analysis.

- **SIZE REDUCTION** **(3 Hours)**
  Size reduction of solids, Mechanism of size reduction, Energy for size reduction, Laws of Crushers, Model Predicting Energy Requirement and Product Size Distribution, Types & Classification of size reduction equipment, Types of Milling Circuit: Open and closed-circuit grinding.

- **BEHAVIOUR OF SINGLE PARTICLE AND MULTIPLE PARTICLES IN A FLUID** **(5 Hours)**
  Settling of a suspension of particles, Multiple particles in suspension.

- **FLUID FLOW THROUGH A PACKED BED OF PARTICLES & THEORY OF FILTRATION** **(4 Hours)**
  Estimation of packed bed parameters, Prediction of pressure drop using Kozeny-Carman Equation, Ergun's equation.

- **FLUIDIZATION OF SOLIDS** **(5 Hours)**
  Estimation of fluidized bed parameters, Prediction of pressure drop and minimum fluidization velocity using Ergun's equation, Geldart's powder classification. Types of fluidization.

- **PHYSICAL SEPARATORS** **(9 Hours)**
  Filters, Cyclones, Electrostatic Precipitator, Fabric filters, Centrifugal Separators, Flotation, Jigging, Magnetic separation processes.

- **SIZE ENLARGEMENT (AGGLOMERATION)** **(3 Hours)**
  Types of Forces affecting Agglomeration, Effects of particle size, Wetting, Nucleation and Growth mechanisms, granulation, Types of granulators.

- **MIXING OF PARTICULATE MATERIALS AND STORAGE OF POWDERS** **(6 Hours)**
  Random mixing and perfect mixing, segregation of particles, mechanisms of segregation, Equipments for mixing of particles and powders. Solids, Storage, Transportation and Handling of Solids

- **HEALTH EFFECTS OF PARTICULATE MATERIALS** **(2 Hours)**

(Total Lecture Hours: 42 + Tutorial Hours: 14)

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3. Practicals:

1. Measurements of bulk and flow properties of powders
2. Particle size measurements and analysis of particles
3. To study powder compaction behaviour
4. Measurement of angle of repose
5. Particle size characterization by sieve analysis
6. Study of particle size reduction by ball milling
7. Demonstration experiment on size reduction by crusher and roller crusher
8. Particle size and shape analysis by image processing
9. Measurement of Blaine Number of cement using air permeability device.
10. Study of sedimentation of $CaCO_3$ Suspension
11. Measurement of fluid properties and particle size using Stokes' Law
12. Study of flow through packed bed and fluidized bed with/without virtual lab (http://vlab.co.in)
13. The prediction of pressure drop through packed bed using artificial neural network and virtual lab (http://vlab.co.in)
14. Study of powders through hopper.

4. Books Recommended:

1. Martin Rhodes, "Introduction to Particle Technology", 2nd Edition, John Wiley & Sons, 2008
2. McCabe W.L., Smith J.C., Harriott P., "Unit Operations of Chemical Engineering", 6th & 7th Eds., McGraw-Hill, New York, 2001 & 2005.
3. Foust A.S., Wenzel L.A., Clump C.W., Maus L., Anderson L.B. "Principles of Unit Operations",2nd Edition, John Wiley & Sons, New York, 1980.
4. Badger W.L., Banchero J.T., "Introduction to Chemical Engineering", McGraw Hill, New York,1997.
5. Coulson J.M., Richardson J.F., "Chemical Engineering", Vol. 2, 5th Ed., Elsevier, New Delhi, 2002.

Fluid Flow Operations

L	T	P	Credit
3	1	2	05

Core -2: CH203 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Predict the velocity profile and flow behaviour in various types of systems
CO2	Calculate pressure loss in different types of flow systems
CO3	Calculate power requirement for fluid transport
CO4	Compare and select appropriate types of fluid moving machineries for fluid transport
CO5	Justify the use of specific fluid moving machineries
CO6	Evaluate discharge coefficient of various flow meters, select appropriate flow meters, and justify the selection of flow meters for a variety of flow conditions

2. Syllabus:

- **INTRODUCTION** **(3 Hours)**
  Definition of Unit Operations, Definition and basic concepts of fluid, Properties of fluids, Stress, Deformation, Dimensional analysis.

- **FLUID STATICS AND ITS APPLICATIONS** **(4 Hours)**
  Nature of fluids: Incompressible and compressible fluids, Pressure concepts, Hydrostatic equilibrium in gravitational and centrifugal field, Manometers, Inclined manometer, Continuous gravity decanter and centrifugal decanter.

- **FLUID FLOW PHENOMENA** **(5 Hours)**
  Types of flow, Potential flow, One dimensional flow, Laminar flow, Reynolds number, Newtonian and non-Newtonian fluids, Velocity gradient and Rate of shear, Viscosity of gases and liquids, Turbulent flow, Nature of turbulence, Eddy viscosity, Eddy diffusivity of momentum, Flow in boundary layers, Laminar and turbulent flow in boundary layers, Boundary layer formation in straight tube and flat plates, Boundary layer thickness, Boundary layer separation and wake formation.

- **BASIC EQUATIONS OF FLUID FLOW AND THEIR APPLICATIONS** **(6 Hours)**
  Stream line and stream tubes, Average velocity, Mass velocity, Continuity equation, Momentum balance, Navier-Stokes equations, Bernoulli's equation.

- **FLOW OF INCOMPRESSIBLE FLUIDS** **(7 Hours)**
  Flow of incompressible fluids in pipes, Friction factor, Laminar flow of Newtonian and non-Newtonian fluids, Turbulent flow in pipes and closed channels, Effect of roughness, Friction factor chart, Drag reduction in turbulent flow Friction factor in flow through channels of noncircular cross section, Friction from changes in velocity or direction, Effect of fittings and valves, Practical use of velocity heads in design, Minimization expansion and contraction losses.

- **FLOW OF COMPRESSIBLE FLUIDS AND ITS APPLICATIONS** **(4 Hours)**
  Continuity equations, Velocity of sound, Stagnation temperature, Processes of compressible flow.

- **FLUID FLOW MEASUREMENTS** **(3 Hours)**
  Fluid flow measurement: Venturi meter, Orifice meter, Rotameter, Pitot tubes, etc.

- **FLUID MOVING MACHINERIES** **(5 Hours)**
  Transportation and metering of fluids, Pipe, fitting and valves, Construction, working and characteristic features of various types of pumps, compressors, blowers and fans

- **APPLICATIONS OF FLUID MECHANICS** **(5 Hours)**
  Flow past immersed bodies: Drag, Drag coefficients, Flow through beds of solids, Particle motion, Terminal velocity, Hindered settling, Settling and rise of bubbles and drops, Fluidization, Introduction to computational fluid dynamics.

(Total Lecture Hours: 42 + Tutorial Hours: 14)

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3. Practicals:

1. Experiment on equivalent length of pipe fittings
2. Experiment on viscosity by Stokes' law
3. Experiment on Reynolds number
4. Experiment on friction in annulus
5. Experiment on venturimeter
6. Experiment on orifice meter
7. Experiment on characteristics of the centrifugal pump
8. Experiment on flow through 'V' notch
9. Experiment on flow through rectangular notch
10. Virtual Lab experiments

4. Books Recommended:

1. White F. M., "Fluid Mechanics",7th Ed., McGraw Hill, 2011.
2. Bird R.B., Stewart W.E., Lightfoot E.N., "Transport Phenomena", 2nd ed., Wiley, 2006.
3. Batchelor G. K., An Introduction to Fluid Dynamics, Cambridge Univ Press, 1967.
4. Gupta V., Gupta S. K., "Fluid Mechanics and Its Applications", Wiley, 1984.
5. McCabe W.L., Smith J.C., Harriott P., "Unit Operations of Chemical Engineering", 7th Ed., McGraw-Hill, New York, 2005.

Heat Transfer Operations

L	T	P	Credit
3	1	2	05

Core – 3: CH205 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain conduction, convection and radiation principles and applications
CO2	Solve mathematically model heat transfer problems
CO3	Estimate heat transfer coefficient for convection
CO4	Identify the type of heat transfer model that needs to be applied
CO5	Analyze the performance of heat exchangers
CO6	Select evaporator for industrial applications

2. Syllabus:

- **INTRODUCTION** **(2 Hours)**
  Modes of Heat Transfer: Conduction, Convection and Radiation

- **CONDUCTION** **(5 Hours)**
  General conduction equation in Cartesian co-ordinate, Steady state conduction through Plane, Cylindrical and Spherical co-ordinates, Steady state conduction with heat generation, Transient heat conduction.

- **FORCED CONVECTION** **(8 Hours)**
  Concept of thermal boundary layer, thermal and hydrodynamic boundary layer, Dimensional analysis, Internal and external forced convection in laminar and turbulent flow. Empirical correlations.

- **NATURAL CONVECTION** **(4 Hours)**
  Qualitative description of free convection flows, Hear transfer correlations for free convection.

- **BOILING AND CONDENSATION** **(4 Hours)**
  Boiling phenomena, Regimes in pool boiling, Heat transfer in pool boiling, forced convection boiling, Film and drop condensation and corresponding correlations.

- **EVAPORATION AND CRYSTALIZATION** **(5 Hours)**
  Different type of evaporators, Single effect and Multi-effect evaporator, Material and Heat balance in single and multi-effect evaporators. Equilibrium in crystallization, operation and equipment.

- **HEAT EXCHANGERS** **(6 Hours)**
  Types of heat exchanger, Overall heat transfer coefficient, LMTD correction factor, Fouling factor, Effectiveness-NTU method, Application and design of Double pipe heat exchanger and Shell-and-tube heat exchanger, Spiral and Plate heat exchanger, Extended surface heat exchanger, Compact heat exchanger.

- **RADIATION HEAT TRANSFER** **(4 Hours)**
  Basic concepts of radiation heat transfer, Radiative heat exchange between surfaces, Radiation shield. View factor

- **EXTENDED SURFACES** **(4 Hours)**
  Different type of fin, Temperature profile in a fin and heat transfer through fin, effectiveness and fin efficiency

(Total Lecture Hours: 42 + Tutorial Hours: 14)

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3. Practicals:

1. Experiment on "Heat transfer through composite wall at different temperature"
2. Experiment on "Thermal conductivity of insulating powder (Asbestos powder)
3. Experiment on "Heat transfer in double pipe heat exchanger in laminar flow"
4. Experiment on "Heat transfer in turbulent flow"
5. Experiment on "Heat transfer by forced convection"
6. Experiment on "Heat transfer coefficient in natural convection"
7. Experiment on "Heat transfer in Plate Heat Exchanger"
8. Experiment on "Shell and tube heat exchanger"
9. Experiment on "Heat transfer by radiation: Stefan-Boltzmann Law"
10. Experiment on "Heat Transfer in Agitated Vessel"

4. Books Recommended:

1. Hollman, J. P., "Heat Transfer – Basic Approach", McGraw-Hill Pub., 10th Ed. 2010.
2. Incropera, F.P., DeWitt, D.P., Bergman T.L., Lavine A.S. "Incropera's Principles of Heat and Mass Transfer", Global Edition, Wiley India Edition, 2019.
3. Kern, D. Q., "Process Heat Transfer", McGraw-Hill Int. Edition, New York, 1997.
4. Bergman, T.L.,Lavine A.S., Incropera, F.P., DeWitt, D.P., "Fundamentals of Heat and Mass Transfer", 7th Ed, Wiley, 2010.
5. Suryanarayana, N. V., "Engineering Heat Transfer", 2nd Ed, Penram International Publishing(I) Private Ltd., Mumbai, 2015.

Engineering Chemistry

L	T	P	Credit
3	0	2	04

CY211 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Extend the application of organic chemistry for drug synthesis
CO2	Distinguish the rate of chemical reactions and surface chemistry
CO3	Adapt green chemistry principles in industrial applications
CO4	Identify and quantify compounds using spectroscopic and thermal techniques
CO5	Apply chemistry knowledge in the synthesis of nanomaterials
CO6	Interpret analytical data for qualitative and quantitative analysis of chemical compounds

2. Syllabus:

- **ORGANIC CHEMISTRY** **[8 Hours]**
  Carbohydrates: Structures and reactions of monosaccharides (glucose and fructose), disaccharides (sucrose and maltose) and polysaccharides (starch and cellulose). Enzymes: Importance, classification, types of reactions and chemical composition. Heterocyclic compounds: Aromaticity, synthesis and reactions of pyrrole, furan and thiophene.

- **SURFACE CHEMISTRY** **[5 Hours]**
  Colloids: Types, lyophilic and lyophobic sols; characteristics, preparations, purification and properties (optical, kinetic and electrical) and applications. Associated colloids (surfactants), emulsions (role, types and preparation) and gels (types and properties).

- **NEW APPROACHES IN CHEMISTRY** **[8 Hours]**
  Green chemistry applications in fine chemicals and pharmaceutical industries. Photochemical reactions: basic concepts and relevant examples. Some aspects of supramolecular chemistry. Fuel cells, biofuels, H_2 as fuel, batteries and super capacitors.

- **ANALYTICAL TECHNIQUES FOR CHEMICAL ANALYSIS** **[12 Hours]**
  Principles and instrumentations: UV-Visible, Fluorescence, and Infra-red Spectroscopy, Mass spectrometry, TGA, DTA, SEM, TEM and DC polarography. Chromatography – Basic concepts; paper and thin layer chromatographic techniques with suitable examples. Introductory discussion of mass spectroscopy, GC, TLC and HPLC.

- **ELECTROCHEMISTRY** **[4 Hours]**
  Electrolytes, Electrolysis: Faraday's laws, applications (electro-plating, electro-refining of metals, electro-manufacturing and electro-typing). Electrochemical series, Nernst equation, Kohlrausch's law and its applications.

- **CHEMISTRY OF NANOMATERIALS** **[5 Hours]**
  Synthetic Methods: Chemical Routes: Chemical reduction, microemulsions, microwave heating, solvothermal and sonochemical synthesis. Physical methods: Inert gas condensation, plasma arc technique, ion sputtering, Laser ablation, laser pyrolysis, and chemical vapour deposition method.

[Total Lecture Hours: 42]

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3. Practicals:

1-5. Systematic qualitative analysis of organic compounds (Five different molecules).
6. Separation of aminoacids by Paper Chromatography.
7. Separation of compounds by Thin-layer chromatography.
8. Estimation of metal ions concentration by spectrophotometric method.
9. Preparation of ZnS nanoparticles.

4. Books Recommended:

1. R. T. Morrison, R. N. Boyd, "Organic Chemistry", seventh edtion, Prentice Hall, 2011.
2. P. Atkins, Paula J. D., "Atkin's Physical Chemistry", Oxford (Indian Edition), Oxford University Press, 2012.
3. J. W. Steed, J. L. Atwood, "Supramolecular Chemistry", John Wiley, 2nd Edn, 2009.
4. D. A. Skoog, F. J. Holler, T. A. Nieman, "Principles of Instrumental Analysis", sixth edition, 2006.
5. B. K. Sharma, "Engineering Chemistry", Krishna Prakashan Media (P) Ltd., Meerut, 2001.

Engineering Mathematics

L	T	P	Credit
3	1	0	04

Course Code: CH202 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Analyze the application of numerical techniquesin chemical engineering problem.
CO2	Formulate and analyze the chemical engineering problems as mathematical models.
CO3	Adapt appropriate solution strategies for accurate solutions.
CO5	Adapt appropriate numerical techniques for the successful solution of the given problem.
CO4	Analyze the engineering data and find an alternate strategy.
CO6	Solve chemical processes and design problems: Learning by doing.

2. Syllabus:

- **TREATMENT AND INTERPRETATION OF ENGINEERING DATA** **(5Hours)**
  Curve fitting, Non-linear least square regression. Interpolation: Newton's Forward/Backward interpolation formula, Lagrange's interpolation formula and experiments their application. Tests of significance, Analysis of variance.

- **INTERPRETATION OF ENGINEERING DATA** **(5Hours)**
  Significant figure, classification of measurements, propagation of errors, variation and distribution of random errors, properties of variance, confidence limits for small samples.

- **NUMERICAL SOLUTION OF ALGEBRAIC EQUATIONS** **(10Hours)**
  Linear systems of equations, solutions by Creamer's Rule, Matrix methods, Gaussian, Gauss-Jordan, Jacobean, Gauss-Seidel and Relation methods. Non-linear equations: Bisection, Regula-falsi, Secant and Newton- Raphson methods.

- **NUMERICAL SOLUTION OF DIFFERENTIAL EQUATIONS** **(12Hours)**
  Ordinary differential equations: Runge- Kutta, Euler's and Milne's predictor-corrector methods. A solution of boundary value problems. Finite differences: Finite differences, Partial differential equations, Solutions of elliptic, parabolic, and hyperbolic types of equations.

- **FORMULATION OF PHYSICAL PROBLEMS** **(10Hours)**
  Mathematical statement of the problem, Representation of problems, Formulation on reactant conversion in to the product, Radial heat transfer through a cylindrical conductor, salt accumulation in a stirred tank.

(Total Lecture Hours: 42 + Tutorial Hours: 14)

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3. Books Recommended:

1. Mickley HS, Sherwood and Reed, Applied Mathematics in Chemical Engineering, 2nd edition. McGraw.Hill Book Co.. New York, 1957.
2. V. G. Jenson & G. V. Jeffrey's, Mathematical Methods in Chemical Engineering, 2nd edition, Academic Press, 1977.
3. Luyben WL, Process Modeling, Simulation and Control for Chemical Engineering, 2nd edition, Mc Graw Hill India, 2013
4. M. K. Jain, S.R.K. Iyengar and R. K. Jain, Numerical Methods for Scientific and Engineering Computations, 4rth edition, New Age International publications, 2004.
5. Mark E. Devis, Numerical Methods and Modelling for Chemical Engineers, 1st edition, John Wiley and Sons, Inc, Reprint 2013.

Mass Transfer Operations – I

L	T	P	Credit
3	1	2	05

Core – 5: CH206 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain a scope of mass transfer operations in chemical industries.
CO2	Determine diffusivity and flux for compounds present in gas, liquid and solid system.
CO3	Analyze the mechanism of mass transfer in various systems related to chemical engineering and estimate mass transfer coefficient.
CO4	Estimate number of stages using graphical and analytical methods and stage efficiency for separation operations excluding distillation.
CO5	Estimate number of trays for distillation using graphical and analytical methods.
CO6	Appraise importance of gas-liquid contacting equipments used in humidification.

2. Syllabus:

- **INTRODUCTION** **(2 hours)**
  Introduction to Mass Transfer Operation, Classification, and method
- **DIFFUSION AND MASS TRANSFER** **(8 hours)**
  Molecular diffusion in fluids, Steady state diffusion (both gases and liquids), Diffusion through variable cross-sectional area, Diffusivity of liquids and gases, Diffusion in solids
- **MASS TRANSFER COEFFICIENTS** **(7 hours)**
  Mass transfer co-efficient in laminar and turbulent flow, Mass, heat, and momentum transfer analogies
- **INTER PHASE MASS TRANSFER** **(5 hours)**
  Equilibrium, Diffusion between phases, Material balance, Stages, and efficiency
- **DISTILLATION** **(14 hours)**
  VLE data, Single stage, differential and continuous distillation, McCabe-Thiele and Ponchon-Savarit method, Distillation in a packed column, Azeotropic, extractive, molecular, and multicomponent distillation, Reactive distillation
- **HUMIDIFICATION** **(6 hours)**
  Basic concepts, Psychometric properties, Gas-liquid contact operations - Adiabatic and non-adiabatic operations, Cooling towers, Design of cooling towers

(Total Lecture Hours: 42 + Tutorial Hours: 14)

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3. Practicals (At least 9 experiments to be performed):

1. To determine the diffusion co-efficient of given constituents at different conditions and compare the results of experimental value.
2. To determine the mass transfer co-efficient for air and water system at atmospheric condition
3. To determine the latent heat of vaporization of water.
4. To determine the yield of crystals of a given chemical with and without seeding and to explain the mechanism of crystallization.
5. To study the principle of differential distillation and to verify Rayleigh's equation
6. To evaluate the performance of azeotropic distillation for binary system.
7. To verify Henry's law for steam distillation
8. To extract essential oil from given plant material
9. To determine the various psychometric parameters of Air-Water vapour system
10. Experiments through virtual lab

4. Books Recommended:

1. Treybal R.E., "Mass Transfer Operations", 3rd Ed., McGraw-Hill, Singapore, 1981.
2. McCabe W.L, Smith J.C., Harriott P., "Unit Operations in Chemical Engineering", 6th & 7th Eds., McGraw-Hill, New York, 2001 & 2005.
3. Coulson J.M., Richardson J.F., Backhurst J. R., Harker J.H. "Chemical Engineering" Vol. 1. 6th Ed. Elsevier, New Delhi, 2004.
4. Dutta, B. K., "Principles of Mass Transfer and Separation Process" PHI Learning Pvt Ltd., New Delhi, 2007.
5. Foust, A. S., Wenzel, A. L., Clump, C. W., Maus, L., Andersen, L. B. "Principles of Unit Operations", 2nd Ed., John Wiley & Sons, Singapore, 2004.

Chemical Reaction Engineering - I

L	T	P	Credit
3	1	2	05

Core – 4: CH204 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Discuss kinetics of homogeneous reactions and applications
CO2	Solve kinetics, constant volume and variable volume batch reactor problems
CO3	Design for single and multiple reactions
CO4	Analyze the performance of CSTR and PFR.
CO5	Estimate heats of reaction from thermodynamics and product distribution
CO6	Discuss kinetics of biochemical reactions and design of bio-reactors

2. Syllabus:

- **INTRODUCTION** **(1 Hour)**
  Chemical kinetics, Classification of reactions, Variables affecting the rate of reaction, Reaction rate

- **KINETICS OF HOMOGENEOUS REACTIONS** **(5 Hours)**
  Concentration dependent term and temperature dependent terms of rate equation, Single and multiple reactions, Elementary and non-elementary reactions, Molecularity and order of reaction, Rate constant, Representation of reaction rate, Kinetic models, Temperature dependency from Arrhenius' law, thermodynamics, various theories, Activation energy, Searching for the reaction mechanism

- **INTERPRETATION OF BATCH REACTOR DATA** **(7 Hours)**
  Constant volume batch reactor, Variable volume batch reactor, Integral method and differential method of analysis of kinetic data, Temperature and reaction rate

- **INTRODUCTION TO REACTOR DESIGN** **(3 Hours)**
  Types of reactors, PFR, CSTR etc., Material & energy balances single ideal reactor, Space-time and space-velocity, Holding time, Introduction of non-ideal flow

- **DESIGN FOR SINGLE REACTIONS** **(7 Hours)**
  Size comparison of single reactors, General graphical comparison, Multiple reactor system, Recycle reactor, Autocatalytic reactions

- **DESIGN FOR MULTIPLE REACTIONS SYSTEMS** **(8 Hours)**
  Reaction in parallel, Reaction in series, Series-parallel reaction and applications

- **TEMPERATURE & PRESSURE EFFECTS** **(4 Hours)**
  Single & multiple reactions, Heats of reaction from thermodynamics, Product distribution

- **INDUSTRIAL APPLICATIONS** **(4 Hours)**
  Types of reactors used in industries, Advanced chemical reactors.

- **INTRODUCTION TO BIOCHEMICAL REACTION ENGINEERING** **(3 Hours)**
  Types of bio-reactors, Design, scale-up, operation and control of bio-reactors, Kinetics of biochemical reactions

(Total Lecture Hours: 42 + Tutorial Hours: 14)

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3. Practicals:

1. Integral method of analysis of kinetic data
2. Differential method of analysis of kinetic data
3. Activation energy and frequency factor
4. Half-life method
5. Pseudo first order reaction
6. Study of reaction kinetics in Batch Reactor
7. Study of reaction kinetics in Mixed Flow Reactor
8. Study of reaction kinetics in Plug Flow Reactor
9. Testing of kinetic data using Artificial Neural Network

4. Books Recommended:

1. Levenspiel O., "Chemical Reaction Engineering", 3rd Ed., John Wiley & Sons, Singapore, 1998.
2. Fogler H.S., "Elements of Chemical Reaction Engineering", 4th Ed., Prentice-Hall, NJ, 2006
3. Smith J. M., "Chemical Engineering Kinetics", 3rd Ed., McGraw-Hill, New York, 1981.
4. Froment G.F., Bischoff K.B., "Chemical Reactor Analysis and Design", 2nd Ed., John Wiley & Sons, Singapore, 1990.
5. Inamdar S.T.A., "Biochemical Engineering – Principles and Concepts", 3rd Edition, Prentice-Hall of India, New Delhi, 2012.

Chemical Engineering Thermodynamics - I

L	T	P	Credit
3	1	0	04

Core – 6: CH208

Scheme

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Develop a fundamental understanding of the basic principles of chemical engineering thermodynamics and calculations.
CO2	Explain the PVT behavoir of fluids and different equation of states
CO3	Estimate the volumetric properties of real fluids
CO4	Estimate the key thermodynamic properties of real fluids
CO5	Apply thermodynamic principles to the analysis of chemical processes and equipment such as turbines, compressors, heat pumps, and refrigeration cycles among others.
CO6	Evaluate changes in different thermodynamic properties for pure fluids using different techniques such as equations of state (EOS), tables, and charts.

2. Syllabus:

- **INTRODUCTION** **(6 Hours)**
  Introduction and Fundamentals of Thermodynamics Systems and variables,Work, Heat, Reversible and Irreversible Processes, internal energy, First Law: Closed and Open Systems, enthalpy, equilibrium state, phase rule, heat capacity specific heat, Steady and Transient Processes. Significance of Chemical Engineering Thermodynamics

- **PROPERTIES OF PURE SUBSTANCES** **(9 Hours)**
  Thermodynamics diagrams; Equation of states; Generalized correlations and acentric factor; Estimation ofthermodynamic properties.

- **HEAT EFFECTS** **(5 Hours)**
  Heat capacities of gases as a function of temperature of liquids and solids, sensible heat, heat ofvaporization, heat of reaction etc.

- **SECOND AND THIRD LAW OF THERMODYNAMICS** **(5 Hours)**
  Concept of entropy, reversible heat engine, entropy change and irreversibility, third law of thermodynamics.

- **THERMODYNAMIC PROPERTIES OF FLUID** **(7Hours)**
  Mathematical relation among thermodynamic functions, Maxwell's relations, Interrelation between H, S, U, G, C_p, C_v, properties of single- and two-phase system. Residual properties

- **THERMODYNAMICS OF FLOW PROCESS** **(6 Hours)**
  Throttling process, flow through nozzles, turbine, compressor, and pump

- **REFRIGERATION AND LIQUEFACTION** **(4 Hours)**
  Carnot refrigeration cycle, air refrigeration cycle, liquefaction processes.

(Total LectureHours:42 + Tutorial hours: 14)

3. Books Recommended:

1. Smith J. M., Van Ness H. C., M.M. Abbott, “Introduction to Chemical Engineering Thermodynamics”, 7th Ed., McGraw-Hill, New York, 2005
2. Rao Y. V. C., “Chemical Engineering Thermodynamics”, Universities Press Limited, Hyderabad, 1997.
3. Kyle B.G. "Chemical&Process Thermodynamics”, 2nd Ed., Prentice-Hall of India, New Delhi,1990.
4. Sandler, S.I., "Chemical and Engineering Thermodynamics", 2nd Ed., Wiley, New York, 1989.
5. J.W. Tester and M. Modell, “Thermodynamics and its Applications”, 3rd ed.,Prentice Hall, 1999

Materials Science and Technology

L	T	P	Credit
3	1	0	04

Core – 7: CH212 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Define the relationships between structure and properties of different classes of materials
CO2	Apply basic elements of alloy thermodynamics and reaction kinetics and develop quantitative analysis of phase transformations in material processing
CO3	Evaluate the role of modes of failures in design of engineering materials
CO4	Interpret the influence of composition of a material on its corrosion behavior and propose commercially viable preventive measures
CO5	Recognise the significance of novel materials like biomaterials and nanomaterials in engineering applications.
CO6	Identify and select proper materials for relevant engineering applications

2. Syllabus:

- **INTRODUCTION AND CONCEPTS FROM PHYSICAL METALLURGY** **(5 Hours)**
  Basic concepts and significance of materials science and engineering, Classes of engineering materials and their salient properties, Atomic structure and interatomic bonding in solids, Crystal structures, Crystallographic directions and planes, Determination of crystal structures

- **CRYSTALLINE IMPERFECTIONS AND DIFFUSION IN SOLIDS** **(5 Hours)**
  Point, line, surface and volume defects; Diffusion mechanisms, Fick's first and second law of diffusion, Solid phases and phase diagrams, solid solutions.

- **PHASE DIAGRAMS** **(5 Hours)**
  Solid solutions, Gibbs phase rule, phase diagrams for binary isomorphous and eutectic alloy systems, Iron-Iron carbide phase diagram, Phase transformations and kinetics

- **FERROUS METALS AND ALLOYS** **(4 Hours)**
  Cast iron, wrought iron, Effects of alloying elements, Steel, Low and High Alloy steels

- **NON-FERROUS METALS AND ALLOYS** **(4 Hours)**
  Aluminum, Copper, Tin, Nickel and Titanium

- **POLYMERIC, CERAMIC AND COMPOSITE MATERIALS** **(5 Hours)**
  Types, properties and applications of polymeric, ceramic and composite materials, Methods of fabrication of polymeric and composite materials.

- **ENGINEERING PROPERTIES AND FAILURE OF MATERIALS (5 Hours)**
  Important mechanical, thermal and electrical properties, plastic and elastic deformation, Failure modes viz. creep, fracture, fatigue.

- **BIOMATERIALS (4 Hours)**
  Introduction to biomaterials, concept of biocompatibility, properties of biomaterials, bimetallic alloys, ceramic biomaterials, polymeric biomaterials.

- **CORROSION AND ITS PREVENTION (5 Hours)**
  Electrochemical principles involved, Types of corrosion, Corrosive environments and prevention of corrosion, Factors determining the choice of materials of construction in chemical process industries

(Total Lecture Hours: 42 + Tutorial Hours: 14)

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3. Books Recommended:

1. Callister, W.D. and Rethwisch, D.G., "Fundamentals of Materials Science and Engineering: An Integrated Approach", John Wiley & Sons, 4th Edition, 2011.
2. Smith, W.F., Hashemi, J. and Prakash, R., "Materials Science and Engineering", McGraw Hill, 4th Ed., 2010.
3. Shackelford, J.F. and Muralidhara, M.K., "Introduction to Materials Science for Engineers", 6th Ed., Pearson Education, 2009.
4. Raghavan, V., "Materials Science and Engineering – A First Course", 5th Ed., PHI Learning, 2009.
5. Jastrzebski, Z. D., "Nature and Properties of Engineering Materials", John Wiley & Sons, 2nd Edition, 1976.

Mass Transfer Operations – II

L	T	P	Credit
3	1	2	05

Core – 8: CH301 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the mass transfer principles with reference to solid-liquid, gas-liquid, liquid-liquid contact.
CO2	Evaluate the scope of absorption, adsorption, liquid-liquid extraction, crystallization, leaching and drying.
CO3	Design (process design) the equipments for absorption, adsorption and liquid-liquid extraction.
CO4	Recommend suitable mode of operation and equipment for absorption, adsorption, liquid-liquid extraction, crystallization, leaching and drying.
CO5	Determine the time of drying and rate of drying for removal of moisture.
CO6	Appraise the concept of novel separation like membrane separation, supercritical fluid extraction, microwave assisted extraction, ultrasound assisted extraction, etc.

2. Syllabus:

- **ABSORPTION** **(8 Hours)**
  Equilibrium, Material balance for single component transfer, Multi-stage and packed tower operation (Equilibrium approach and rate approach), Graphical and analytical method for tray/ stage determination, Multi-component system, Non-isothermal operation, Absorption with chemical reaction

- **EQUIPMENT FOR GAS-LIQUID OPERATIONS** **(3 Hours)**
  Sparged and agitated vessels, Venture scrubber, Wetted wall towers, Tray and packed towers, Mass transfer coefficients for packed towers, Hydrodynamic considerations

- **LIQUID-LIQUID EXTRACTION** **(8 Hours)**
  Liquid equilibria, Stage-wise extraction, Graphical and analytical method for tray/ stage determination, Stage type extractor, Differential extractor

- **ADSORPTION AND ION-EXCHANGE** **(6 Hours)**
  Adsorption equilibria, Stage-wise and continuous operations, Graphical and analytical method for tray/ stage determination, Principle of ion exchange, Equipments for adsorption and ion exchange

- **DRYING** **(6 Hours)**
  Equilibrium, Batch and continuous drying, Mechanism and rate of drying, Equipments

- **LEACHING** **(4 Hours)**
  Steady state and unsteady state operations, Methods of calculation, Equipments

- **CRYSTALLIZATION** **(3 Hours)**
  Equilibrium, Operations and equipment

- **INTRODUCTION TO RECENT SEPARATION TECHNIQUE** **(4 Hours)**
  Membrane separation, Supercritical fluid extraction, Microwave assisted extraction, Ultrasound assisted extraction, etc.

(Total Lecture Hours: 42 + Tutorial Hours: 14)

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3. Practicals (At least 9 experiments to be performed):

1. To obtain ternary diagram for a given at a room temperature and select a suitable solvent.
2. To evaluate the performance of solvent extraction for a single stage and multiple stage cross-current operation for a given system.
3. To study and verify the Freundlich isotherm by adsorbing a given solute from a solution on activated carbon.
4. To determine the efficiency for repetitive cycles of adsorption in a packed bed column.
5. To compare efficiency of the leaching operation for different solvents and select a suitable solvent.
6. To evaluate the performance of microwave assisted extraction (MAE) and ultrasound assisted extraction (UAE) in leaching.
7. To assess the performance of fluidized bed drying.
8. To assess the performance of cooling tower.
9. To analyze the sample of unknown concentration using Gas Chromatography.
10. To analyze the sample of unknown concentration using UV visible spectroscopy.
11. To explain the mechanism of Pervaporation and demonstrate its working.
12. To demonstrate the working of Adsorption.
13. Experiments through virtual lab

4. Books Recommended:

1. Treybal R.E., "Mass-Transfer Operations", 3rd Ed., McGraw-Hill, Singapore, 1981.
2. McCabe W.L, Smith J.C., Harriott P., "Unit Operations in Chemical Engineering", 6th &7th Eds., McGraw-Hill, New York, 2001 & 2005.
3. Coulson J.M., Richardson J.F., Backhurst J. R., Harker J.H. "Coulson & Richardson's Chemical Engineering", Vol. 1, 6th Ed., Elservier, New Delhi, 2004.

4. Foust, A. S., Wenzel, A. L., Clump, C. W., Maus, L., Andersen, L. B. "Principles of Unit Operations", 2nd Ed., John Wiley & Sons, Singapore, 2004.
5. Dutta, B. K., "Principles of Mass Transfer and Separation Process" PHI Learning Pvt Ltd., New Delhi, 2007.

Chemical Engineering Thermodynamics - II

L	T	P	Credit
3	1	0	04

Core – 9: CH303 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Develop a fundamental understanding of the basic principles of chemical engineering thermodynamics for phase equilibrium
CO2	Compare ideal gas/solution models to reflect behavior of real mixtures based on the concepts of chemical potential, fugacity, and excess free energy
CO3	Explain the Vapour-Liquid Equilibrium relations to solve the process separation
CO4	Evaluate the different methods/assumptions for performing phase equilibrium calculations
CO5	Apply the appropriate models to calculate phase equilibrium problems
CO6	Determine the equilibrium products and their concentration in equilibrium when dealing with systems involving chemical reactions.

2. Syllabus:

- **THERMODYNAMIC PROPERTIES OF FLUIDS** **(16 Hours)**

  Single Phase Mixtures and Solutions; Partial molar properties, Gibbs-Duhem equation, chemical potential, Ideal and non-ideal mixtures/Solutions, fugacity and fugacity coefficient for pure components and for mixture of gases and liquids. Lewis Randall rule, Henry's law, Excess properties of mixtures, activity co-efficient.

- **PHASE EQUILIBRIUM** **(17 Hours)**

  Phase rule, Phase Equilibrium Criteria, vapor-liquid equilibrium of ideal and non-ideal solution at low to moderate pressures, Raoult's Law and Modified Raoult's Law; testing of vapor-liquid equilibrium data, activity co-efficient models, LLE, Triangular diagrams.

- **CHEMICAL EQUILIBRIUM** **(9 Hours)**

  Criteria, equilibrium conversion (X), constant (K), effect of Temp. & Pressure on K, evaluation of K, evaluation of equilibrium conversion for gas phase reaction.

(Total theory hours 42 + Tutorial hours 14)

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3. Books Recommended:

1. Smith J. M. Van Ness H. C., Abbott M.M., "Introduction to Chemical Engineering Thermodynamics", 6th& 7th Eds., McGraw-Hill, New York, 2001 & 2005.
2. Sandler, S.I., "Chemical and Engineering Thermodynamics", 2nd Ed., Wiley, New York, 1989.
3. Rao Y. V. C., "Chemical Engineering Thermodynamics", Universities Press

Limited, Heydrabad, 1997.

4. Kyle, B.G., "Chemical and Process Thermodynamics", 2nd Ed., Prentice-Hall of India, New Delhi,1990.
5. Koretsky, Milo D., Engineering and chemical Thermodynamics, John Wiley & Sons(Asia) Pte ltd., Singapore

Chemical Reaction Engineering - II

L	T	P	Credit
3	1	0	04

Core – 10: CH305 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Demonstrate concepts of chemical reaction & reactor engineering, and kinetics of heterogeneously catalysed reactions.
CO2	Interpret catalyst characterisation results and suggest improvement in catalysts
CO3	Analyse flow behaviour and Evaluate performance of a chemical process equipment in light of RTD
CO4	Analyse and compare catalysis in different industries (e.g., Petrochemicals, Refining Processes)
CO5	Illustrate advance concepts in heterogeneous catalysis
CO6	Correlate safe operations with process catalyst systems

2. Syllabus:

- **RESIDENCE TIME DISTRIBUTION** **(7 Hours)**
  Non ideal flow in reactors, RTD of fluid in reactors, Age distribution, F curve, C curve and E curve, Intensity Function, Effects of RTD on performance of Chemical Process Equipment

- **FLUID- FLUID REACTIONS** **(6 Hours)**
  The rate equation, Kinetic regimes for mass transfer and reaction, fast reaction, intermediate reaction, slow reaction, Slurry reaction kinetics, Application to design

- **FLUID SOLID NON-CATALYTIC REACTIONS** **(8 Hours)**
  Particles of single size, plug flow of solids, Mixture of particles of different and unchanging sizes, mixed flow of particles of a single unchanging size, Selection of a model, Determination of rate controlling step, Application to design, Application to fluidized bed

- **CATALYTIC REACTORS** **(8 Hours)**
  Kinetics, External and Internal Diffusional Resistances, Effects of Heat Generation/Absorption, Effectiveness Factors, Fixed Bed, Fluid Bed, Trickle bed, Slurry Reactors, LHHW Models, Method of Initial Rates

- **CATALYSIS** **(6 Hours)**
  Typical Catalysts used in chemical processes, Catalyst Characterizations, Catalyst Deactivation and Regeneration, Temperature Progression, Moving Bed Reactors, Metal recovery from the Spent Catalysts, nanocatalysis

- **ZEOLITE CATALYSIS** **(3 Hours)**
  Synthesis, Applications in Refining and Petrochemical Processes, Rise of Acidity, Modifications, Shape Selectivity

- **ENVIRONMENTAL CATALYSIS** **(2 Hours)**
  Importance, Applications, Reactions involved

- **STRUCTURED REACTORS** **(2 Hours)**
  Configurations, Preparation, Hydrodynamics and Applications, Accelerated Deactivation of catalysts, Laboratory reactors, Oscillatory motion of reactants in catalyst pores, Microreactors.

(Total Lecture Hours: 42 + Tutorial Hours: 14)

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3. Books Recommended:

1. Fogler H.S., "Elements of Chemical Reaction Engineering", 4th Ed., Prentice Hall, NJ, 2006.
2. Levenspiel O., "Chemical Reaction Engineering", 3rd Ed., John Wiley & Sons, Singapore, 1998.
3. Smith J. M., "Chemical Engineering Kinetics", 3rd Edition, McGraw Hill, N Y, 1981.
4. Davis M.E., Davis R.J., "Fundamentals of Chemical Reaction Engineering", McGraw-Hill, New York,2003.
5. Froment G.F., Bischoff K.B., "Chemical Reactor Analysis and Design", 2nd Ed., John Wiley & Sons, Singapore, 1990.

Elective: PROCESS PLANT SAFETY

L	T	P	Credit
3	0	0	03

CH361 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Recognize the importance of safety in any chemical process industries.
CO2	Adapt the basic fundamentals of chemical process safety, laws of safety.
CO3	Apply various the methods of hazard identification for any chemical process.
CO4	Perform the risk analysis and risk assessment for any system to minimize the hazards.
CO5	Recognize different relief systems which are used in plant.
CO6	Evaluate the characteristics of various causes of incidents like toxic release, fire and explosion etc.

2. Syllabus:

- **INTRODUCTION** **(04 Hours)**
  Safety Programs, Accident Loss Statistics- FAR, OSHA, Fatality rate, Acceptable risk, Inherent safety, Nature of the accident process and their steps.

- **TOXICOLOGY** **(04 Hours)**
  Entry of toxicants in Biological organism (BO), Elimination of Toxicant from BO, Effect of Toxicants in BO, Dose Versus Response, TLVs.

- **INTRODUCTION TO RELIEFS** **(05 Hours)**
  Relief Concepts, Definitions, Location of Reliefs, Relief Types, Relief Systems.

- **FIRE AND EXPLOSION** **(07 Hours)**
  The fire triangle, Distinction between Fire and explosion, estimation of flammability characteristics of vapor and liquids, Limiting oxygen characteristics and inerting, Detonation and deflagration, BLEVE, Vapor-cloud explosion, Fire extinguisher.

- **HAZARD IDENTIFICATION** **(07 Hours)**
  Process hazard checklists, HAZOP study, Safety Reviews, Other methods, Problem solving.

- **RISK ASSESSMENT** **(10 Hours)**
  Review of Probability theory, Probability of Coincidence, Revealed & Unrevealed failures, Fault tree analysis, Cut Sets, Path sets, Reliability diagram, Event tree analysis, Quantitative risk analysis, Layer of Protection analysis, Consequence, Frequency, Problems solving.

- **CASE HISTORIES** **(05 Hours)**

  Flixborough, England, Bhopal Gas Tragedy, A massive explosion in Pasadena, Leakage of 2,3,7,8-tetrachlorodibenzoparadioxin in Seveso, Related to Static Electricity, Chemical Reactivity, System Designs, Procedures.

(Total Lecture Hours: 42 Hours)

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3. Books Recommended:

1. Crowl D. A., Louvar J. F., "Chemical Process Safety", Prentice-Hall, 2nd Ed., New York, 2002.
2. Sanders R E., "Chemical Process Safety", Butterworth-Heinemann, 3rd Ed., New Delhi, 2005.
3. Green D.W., Perry R.H., " Perry's Chemical Engineers' Handbook", McGraw-Hill, 8th Ed., 2007.
4. "Lees' Loss Prevention in the Process Industries: Hazard Identification, Assessment and Control", Butterworth-Heinemann, 4th Ed., 2012.
5. Raju, K.S.N., "Chemical Process Industry Safety", McGraw Hill Education Pvt Ltd., India, 2014.

Elective: Cleaner Technologies in Chemical Process Industries

L	T	P	Credit
3	0	0	03

CH363 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Recognize the role of cleaner/greener technologies in the survival and sustainable development of chemical processing industries.
CO2	Interpret the concept and principles of cleaner production in industries.
CO3	Apply the basic principles of green chemistry/green engineering to develop environmentally sound technologies.
CO4	Identify reagents, reactions and technologies that should be and realistically could be targeted for replacement by green alternatives.
CO5	Explain the role of life cycle assessment in sustainable production.
CO6	Appraise the social and environmental responsibility of engineers in the global community.

2. Syllabus:

- **INTRODUCTION TO CLEANER TECHNOLOGY** **(3 Hours)**
  Industrial impacts on the environment, Concept of sustainable development, Cleaner technology and cleaner production, Basis, necessity and scope of cleaner production/cleaner technologies in survival of chemical process industries.

- **CLEANER PRODUCTION TOOLS** **(5 Hours)**
  C.P. tools, techniques, methodology, Assessment of cleaner production.

- **GREEN CHEMISTRY AND GREEN ENGINEERING** **(8 Hours)**
  Principles and concepts of green chemistry and green engineering, green chemistry metrics, Environmentally benign solvents, design of cleaner production/green processes.

- **INHERENTLY SAFER DESIGN** **(6 Hours)**
  Industrial process safety strategies, Hazard Prevention by CT Alternatives, HAZOP, HAZAN, Inherent safety concepts and strategies.

- **LIFE CYCLE ASSESSMENT** **(6 Hours)**
  ISO 14000, Life cycle analysis of products and processes, LCA methodologies

- **ENERGY AND ENVIRONMENTAL AUDIT** **(5 Hours)**
  Energy conservation, Energy audit and its methodology, Environmental auditing

- **WASTE MINIMIZATION CIRCLES** **(4 Hours)**
  Concept, Need and benefits, Methodology, Techniques and barriers

- **INDUSTRIAL CASE STUDIES** **(5 Hours)**
  Typical case studies from industrial sectors viz. Petrochemicals, Polymers, Chloralkali, Dyes, Pharmaceuticals, Pesticides, Food processing, Textile and Specialty Chemicals.

(Total Lecture Hours: 42)

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3. Books Recommended:

1. Gujarat Cleaner Production Centre, “Cleaner Production and its Application to Industries”, GCPC, Gandhinagar, Gujarat, 2010.
2. Lennart Nilsson, Per Olof Persson, Lars Ryden, Siarhei Darozhka, Audrone Zaliauskiene “Cleaner Production: Technologies and Tools for Resource Efficient Production”, Baltic University Press, 2007.
3. United Nations Environment Programme “Cleaner Production - A Training Resource Package”, 1st Edition, UNEP/Earthprint, 1996.
4. David T. Allen, David R. Shonnard, “Green Engineering: Environmentally Conscious Design of Chemical Processes ”, Prentice Hall, 2001.
5. Concepción Jiménez-González, David J.C. Constable, “Green Chemistry and Engineering: A Practical Design Approach”, John Wiley & Sons, 2011.

4. Additional Reading:

1. Kenneth L. Mulholland “Identification of Cleaner Production Improvement Opportunities”, John Wiley & Sons, 2006.
2. Center for Chemical Process Safety (CCPS) “Inherently Safer Chemical Processes: A Life Cycle Approach”, John Wiley & Sons, 2010.
3. Asian Productivity Organization, “Working Manual on Energy Auditing in Industries”, APO, Japan, 2008.

Elective: Fuels and Combustion

L	T	P	Credit
3	0	0	03

CH365 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Discuss energy resources, global energy consumption, fundamentals of combustion
CO2	Describe origin, classification, analysis, properties of solid, liquid, gaseous fuels and their applications
CO3	Solve combustion stoichiometry and thermodynamics problems
CO4	Analyze the performance of combustion appliances
CO5	Discuss production processes and technologies of Agro and Bio fuels and their applications
CO6	Explain the social and environmental responsibility of engineers in the global community

2. Syllabus:

- **INTRODUCTION** **(3 Hours)**
  Global energy consumption, properties of fuels, coal, liquid fuels, gaseous fuels and agro-residues.

- **SOLID FUELS** **(12 Hours)**
  Solid Fuels, Coal, origin, coal mining, classification of coal, analysis and properties, action of heat on coal, gasification, oxidation, hydrogenation and liquefaction of coal, efficient use of solid fuels.

- **LIQUID FUELS** **(10 Hours)**
  Origin and classification of petroleum, crude exploration, petroleum refining processes, transportation, storage and handling of liquid fuels, properties & testing of petroleum products, internal combustion engine.

- **GASEOUS FUELS** **(5 Hours)**
  Types of gaseous fuels: natural gases, methane from coal mines, manufactured gases, producer gas, water gas, biogas, refinery gas, LPG, cleaning and purification of gaseous fuels.

- **MANUFACTURED FUELS** **(2 Hours)**
  Agro fuels, Bio-Fuels: types of bio-fuels, production processes and technologies, bio fuel applications

- **COMBUSTION** **(10 Hours)**
  Combustion stoichiometry and thermodynamics, calculation of heat of combustion, theoretical & actual combustion processes - air fuel ratio, estimation of dry and wet flue gases for known fuel composition, calculation of the composition of fuel & excess air supplied, flue gas analysis.

(Total Lecture Hours: 42)

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3. **Books Recommended:**

1. Sarkar, S., "Fuels and Combustion", 3rd. ed., Universities Press,2009
2. Dave, R.A. (Ed.), "Modern Petroleum Technology", Vol. 1, Upstream, 6th ed., John Wiley & Sons Ltd,2001.
3. Lucas, A.G. (Ed.) "Modern Petroleum Technology", Vol. 2, Downstream, 6th ed., John Wiley & Sons Ltd,2002.
4. Glassman, I. "Combustion", 2nd ed., Academic Press,2014.
5. Rao, B.K.B., "Modern Petroleum Refining Processes", 4th ed., Oxford & IBH Publishing Co. Pvt. Ltd,2018

Elective: Introduction to Engineering Statistics

L	T	P	Credit
3	0	0	03

CH367 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Understanding of descriptive statistics by quantitative reasoning and data visualization
CO2	Knowledge of the basics of inferential statistics from sample data analysis
CO3	Understanding the consept of the probability and regression analysis
CO4	Apply statistical reasoning and procedures in the analysis of real data
CO5	Employ the concept of parametric and non-parametric test for statistical analysis
CO6	Solve statistical problem using software package

2. Syllabus:

- INTRODUCTION **(4 Hours)**
  Definition and scope of statistics, concepts of statistical population and sample. Data: quantitative and qualitative, attributes, scales of measurement nominal, ordinal, interval and ratio.

- MEASURES OF CENTRAL TENDENCY **(5 Hours)**
  Mean, Median, Mode. Measures of Dispersion: Range, Mean deviation, Standard deviation, Coefficient of variation.

- DATA ANALYSIS **(5 Hours)**
  Types of variables, data collection principles, types of studies, examining numerical data Graphical methods: histograms and other graphs, Examining categorical data, Tabular methods: contingency tables, Graphical methods: bar plots and other graphs, Frequency distributions, cumulative frequency distributions and their graphical representations. Stem and leaf displays

- PROBABILITY **(6 Hours)**
  Elementary probability rules, conditional probability, normal distribution, binomial distribution, probability distribution function

- HYPOTHESIS TESTING **(4 Hours)**
  Null hypothesis, alternative hypothesis, p-value, Type-I and Type-II error, confidence interval, central limit theorem

- REGRESSION **(5 Hours)**
  Lines of regression, properties of regression coefficients, Multiple and Partial correlation coefficients in three variables and their properties.

- **PARAMETRIC AND NON-PARAMETRIC TESTS** **(5 Hours)**
  One Sample t-test, paired t-test, ANOVA, two-way ANOVA, sign test, Wilcoxon's signed rank test.

- **APPLICATION OF STATISTICAL ANALYSIS IN ENGINEERING** **(8 Hours)**
  Case Studies, Elementary statistics using software package like MINITAB, Excel.

(Total Lecture Hours: 42)

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3. Books Recommended:

1. Goon,A.M., Gupta,M.K. and Dasgupta,B. (2002): Fundamentals of Statistics, Vol. I& II, 8th Edn. The World Press, Kolkata.
2. Mood, A.M., Graybill, F.A. andBoes, D.C. (2007): Introduction to the Theory of Statistics, 3rd Edn. (Reprint), Tata McGraw-Hill Pub. Co. Ltd.
3. Bhat B.R, Srivenkataramana T and Rao Madhava K.S.(1996): Statistics: A Beginners Text, Vol. I, New Age International (P) Ltd.
4. Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia
5. Tamhane, A. C. and Dunlop, D. D. (2000) Statistics and Data Analysis: From Elementary to Intermediate. Prentice Hall: Upper Saddle River, NJ.

Elective: Bioprocess Engineering

L	T	P	Credit
3	0	0	03

CH321 **Scheme**

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1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Recognize the basic of microbiology and bioprocess engineering.
CO2	Apply the fundamentals of metabolic reaction occurred in micro-organism and their role in various industrial applications.
CO3	Analyze the microbial growth kinetics and its importance in various industrial applications.
CO4	Compare chemical engineering with bioprocess engineering.
CO5	Design different types of bioreactors and understand their working.
CO6	Summarize various techniques involved in downstream processes for the recovery of bio-compounds.

2. Syllabus:

- **AN OVERVIEW OF BIOLOGICAL BASICS** **(4 Hours)**
  Classification of cells; Cell Conctruction; Cell Nutrients.
- **MAJOR METABOLIC PATHWAYS** **(8 Hours)**
  Bioenergetics; Glycolysis; TCA Cycle; Respiration; Control Sites in Aerobic Glucose Metabolism; Overview of Biosynthesis; Overview of Anaerobic Metabolism; Overview of Autotrophic Metabolism; Metabolic Regulations.
- **MICROBIAL GROWTH** **(8 Hours)**
  Batch Growth; Quantifying growth kinetics; Continuous growth.
- **BIOREACTORS** **(8 Hours)**
  Introduction to bioreactors; Batch and fed-batch bioreactors; Continuous bioreactors; Bioreactor operation; Immobilized Cell Systems; Sterilization; Aeration.
- **BIOSEPARATIONS** **(8 Hours)**
  Biomass removal; Biomass disruption; Membrane based techniques; Extraction; Adsorption and Chromatography.
- **INDUSTRIAL PROCESSES** **(6 Hours)**
  Description of industrial processes; Process flow-sheeting; Process economics.

(Total Lecture Hours: 42)

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3. Books Recommended:

1. Shuler, M.L., and Kargi, F., "Bioprocess Engineering: Basic Concepts", Prentice Hall, 2001.
2. Aiba, S., Humphrey, A.E., and Mills, N.F., "Biochemical Engineering", 2nd edition, Academic Press, New York, 1973.
3. Bailey, J.E., Ollis, D.F., "Biochemical Engineering Fundamentals", 2nd ed., McGraw Hill, 1986.
4. Atkinson, B., "Biochemical Reactors", Pion Ltd., London, 1974.
5. Pyle, D.L., "Separation for Biotechnology", Royal Society of Chemistry, Cambridge, 1994.

Elective: Computational Heat Transfer and Fluid Flow

L	T	P	Credit
3	0	0	03

CH323 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Formulate and analyze the heat transfer and fluid flow problems.
CO2	Adapt appropriate solution methodology for accurate solutions.
CO3	Analyze and adopt the appropriate numerical discretization technique to solve the heat transfer problems.
CO4	Adapt the appropriate computational requirements for accurate solution of the given problem.
CO5	Adapt the appropriate algorithm to solve the given problem.
CO6	Select the appropriate software tool/package to solve heat transfer and fluid flow problems and analyzing the results.

2. Syllabus:

- **INTRODUCTION** **(5 Hours)**
  Mathematical description of fluid flow and heat transfer, conservation equations for mass, momentum, energy and chemical species, classification of partial differential equations, coordinate systems, CFD software packages and tools.

- **DISCRETIZATION TECHNIQUES** **(7 Hours)**
  One dimensional steady state diffusion problem's: Solution methodology for linear and non-linear problems (Point-by-point iteration, TDMA). Two- and three-dimensional discretization: Discretization of unsteady diffusion problems (Explicit/Implicit and Crank-Nicolson's algorithm; stability of solutions).

- **MODELLING OF DIFFUSION PROBLEMS** **(8 Hours)**
  Finite difference method (FDM), Convergence, Consistency, Error and Stability, Accuracy, Boundary conditions, CFD model formulation. Taylor Series and control volume formulations; modelling of heat conduction, convection-diffusion, and flow field using finite volume method (FVM); introduction to FVM with unstructured grids; modelling of phase change problems; introduction to turbulence modelling; application to practical problems.

- **MESH GENERATION AND SOLUTION ALGORITHMS** **(7 Hours)**
  Structured and Unstructured mesh, Guideline on mesh quality and design, Mesh refinement and adaptation. Discretization schemes for pressure, momentum, and energy equations-Explicit and implicit Schemes, First order upwind scheme, second order upwind scheme, QUICK scheme, SIMPLE, SIMPLER and MAC algorithm, pressure-velocity coupling algorithms, velocity-stream function approach, solution of Navier-Stokes equations.

- **TURBULENCE AND MULTIPHASE PROBLEMS** **(5 Hours)**
  Large Eddy Simulation (LES). Direct Numerical Simulation (DNS). Modelling of multiphase problems: volume of fluid (VOF) and Level Set Methods.

- **CASE STUDIES-PROJECTS/EXERCISES** **(10 Hours)**
  Solving simplified problems: formulation, discretization with coarse/fine grids, applying appropriate boundary and initial conditions and solving by hand calculations. Solving practical problems using software: writing user sub-routines; post-processing and interpretation of results.

(Total Lecture Hours: 42)

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3. Books Recommended:

1. S. V. Patankar, "Numerical Heat Transfer and Fluid Flow," Special Indian Edition, Hemisphere Publishing Corporation, CRC Press, reprinted in 2017.
2. D. A. Anderson, J. C. Tannehill, and R. H. Pletcher, "Computational Fluid Mechanics and Heat Transfer," Second Edition, Hemisphere Publishing Corporation, 1997.
3. J. H. Ferziger and M. Peric, "Computational Methods for Fluid Dynamics", Second Edition,Springer, Berlin, 1999.
4. H. K. Versteeg and W. Malalasekera "An Introduction to Computational Fluid Dynamics: The Finite Volume Method" Second Edition, Pearson, Prentice Hall, 2007.
5. Atul Sharma"Introduction to Computational Fluid Dynamics: Development, Application and Analysis" First Edition, John Wiley & Sons Ltd. 2017.

Elective: Fundamentals of Biochemical Engineering

L	T	P	Credit
3	0	0	03

CH325 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Determine the scope of biochemical engineering chemical and biochemical industries.
CO2	Relate the Basics of microbial growth.
CO3	Describe the significance of genetically modified organism in industrial applications.
CO4	Summarize the overview of bioseparation methods.
CO5	Explain various separation methods used in biochemical industries for downstream processes.
CO6	Give examples on various industrial applications.

2. Syllabus:

- **INTRODUCTION** **(6 Hours)**
  Scope and possibilities; Characteristics and classification of biological matter; Basics of microbial growth.

- **OVERVIEW OF BIOSEPARATIONS** **(4 Hours)**
  An Overview of bioseparations; Cell disruptions; Genetically modified organism.

- **SEPARATION METHODS** **(20 Hours)**
  Filtration; Centrifugation; Adsorption; Extraction; Membrane separation processes; Concepts of precipitation, Chromatography – Basic concepts; Gel filtration; Ion exchange chromatography; Hydrophobic chromatography; Affinity chromatography; Suitable examples; Electrokinetic methods of separations; Finishing operations and formulations

- **INDUSTRIAL APPLICATIONS** **(12 Hours)**
  Biomass to Biofuels; Bioremediation; Biocatalysts; Biofouling; Microbial Polymer and plastics; Natural resources recovery.

(Total Lecture Hours: 42)

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3. Books Recommended:

1. Bailey, J.E., Ollis, D.F., "Biochemical Engineering Fundamentals", 2nd ed., McGraw Hill, 2010.
2. Weatherley, L. "Engineering Processes for Bioseparations", Butterworth-Heinemann Ltd., Oxford, 1995. (reprint)
3. Pyle, D.L. "Separation for biotechnology", Royal Society of Chemistry, Cambridge, 1994. (reprint)
4. Scragg, A. "Environmental Biotechnology", 2nd Ed., Oxford University Press, 2011.
5. Sivasankar, B "Bioseparations Principles and Techniques", PHI Learning private limited, New Delhi, 2010.

Elective: Introduction to Electrochemistry

L	T	P	Credit
3	0	0	03

CH327 Scheme

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Describe the fundamentals of electrochemical reactions
CO2	Apply knowledge of the principles of electrochemical reactions and electrochemical techniques
CO3	Evaluate the information that can be obtained from the electrochemical techniques studied during analysis
CO4	Review the application in various fuel cell technologies and in storage devices
CO5	Discuss the utilization of various advanced techniques

2. Syllabus:

- **INTRODUCTION TO ELECTROCHEMISTRY** **(5 Hours)**
  Basic electrochemical concepts, Electrochemical concepts of oxidation and reduction; Electrode Reaction; Simple Electron Transfer Reactions; Equilibrium Potentials; Potential differences at interfaces.

- **ELECTROCHEMICAL CELLS** **(5 Hours)**
  Electrolytic and Galvanic cells; different types of electrodes;Electrodes and electrode reactions; Reference electrodes; electrode potentials including standard electrode potential, half - cell and cell reactions; emf of a Galvanic cell and its measurement.

- **EXPERIMENTAL ELECTROCHEMISTRY** **(5 Hours)**
  Two-Electrode vs. Three-Electrode Cells, Working, Counter and Reference Electrodes; Electrolytes; Separators and Membranes; Nernst equation and its applications; Relationship between cell potential and Gibbs' energy change.

- **FUEL CELL ELECTROCHEMISTRY** **(15Hours)**
  Introduction, structure, principles, workings, potentials, limitations, scale up of various fuel cells like Hydrogen fuel cell, Microbial fuel cell, Microbial desalination cell, Microbial electrolysis cell, Benthic microbial fuel cell, Osmotic microbial fuel cell, etc. Principle of battery, advanced rechargeable battery, Li-ion batteries, nano-structured materials for Li-ion batteries, Power management system, capacitors, and supercapicators.

- **VARIOUS ADVANCED TECHNIQUES FOR PERFORMANCE** **(12Hours)**
  Electrochemical techniques, Electrochemical impedance spectroscopy (EIS) and its application, cycling voltammetry and linear polarization, types of voltage losses, polarization curve, fuel cell efficiency, Tafel equation, exchange currents, columbic efficiency, Role and significance of bioelectrochemistry, Glycolysis; TCA (TriCarboxylicacid) Cycle, Respiration, Electron transport mechanism.

(Total Lecture Hours: 42)

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3. **Books Recommended:**

1. Bockris, J.O.M. and Reddy, A.K.N., "Modern Electrochemistry –Vol. I & II", Second Edition, Plenum Press, New York, 2000.
2. Logan, B.E., "Microbial Fuel Cells", First Edition, Wiley, New Jersey, 2007.
3. Hoogers, G, "Fuel Cell Technology Hand Book", CRC Press, New York, 2003.
4. Bard, A.J. and Faulkner, L.R. "Electrochemical Methods – Fundamentals and applications" 2nd Edition John Wiley & Sons, New York, 2001.
5. Bailey, J.E., Ollis, D.F., "Biochemical Engineering Fundamentals", 2nd Edition, McGraw Hill, New York 1986.

B. Tech. III (Chemical Engineering), Semester - VI

Professional Ethics, Economics and Business Management

L	T	P	Credit
4	0	0	05

HU 302 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Identify application of ethics in society and development of understanding regarding Professional ethical issues related to Chemical engineering
CO2	Develop managerial skills to become future engineering managers
CO3	Develop skills related to various functional areas of management (Marketing Management, Financial Management, Operations Management, Personnel Management etc.)
CO4	Build knowledge about modern management concepts (ERP, SCM, e-CRM, etc.)
CO5	Develop experiential learning through Management games, Case study discussion, Group discussion etc.
CO6	Apply knowledge of Economics and Business management aspects in Chemical engineering

2. Syllabus:

- **PROFESSIONAL ETHICS** **(14 Hours)**

  Introduction, Approaches to Ethics, Meaning of Ethics, Major attributes of Ethics, Business Ethics, Factors influencing Ethics, Importance of Ethics, Ethics in Management, Organizational Ethics, Ethical aspects in Marketing, Mass communication and Ethics - Television, Whistle blowing, Education – Ethics and New Professional, Intellectual Properties and Ethics, Introduction to Professional Ethics, Engineering Ethics, Ethical issues related to Chemical Engineering

- **ECONOMICS** **(8 Hours)**

  Introduction To Economics, Micro & Macro Economics, Applications & Scopes Of Economics, Demand Analysis, Demand Forecasting, Factors Of Production, Types Of Cost, Market Structures, Break Even Analysis

- **MANAGEMENT** **(12 Hours)**

  Introduction to Management, Features Of Management, Nature Of Management, Development of Management Thoughts – Scientific Management By Taylor & Contribution of Henry Fayol, Coordination & Functions Of Management, Centralization & Decentralization, Decision Making; Fundamentals of Planning; Objectives & MBO; Types of Business Organizations: Private Sector, Public Sector & Joint Sector; Organizational Behavior: Theories of Motivation, Individual & Group Behavior, Perception, Value, Attitude, Leadership

- **FUNCTIONAL MANAGEMENT** **(18 Hours)**

Marketing Management: Core Concepts Of Marketing, Marketing Mix (4p), Segmentation – Targeting – Positioning, Marketing Research, Marketing Information System, Concept of International Marketing, Difference Between Domestic Marketing & International Marketing; Operations Management: Introduction to Operations Management, Types of Operation Systems, Types of Layouts, Material Handling, Purchasing & Store System, Inventory Management; Personnel Management: Roles & Functions of Personnel Manager, Recruitment, Selection, Training, Industrial Dispute, Collective Bargaining; Financial Management: Goal of Financial Management, Key Activities In Financial Management, Organization of Financial Management, Financial Institutions, Financial Instruments, Sources of Finance

- **MODERN MANAGEMENT ASPECTS** **(4 Hours)**

Introduction To ERP, e – CRM, SCM, RE – Engineering, WTO, IPR Etc.

Tutorial: Case Study Discussion, Group Discussion, Management games and Assignments / Mini projects & presentation on related Topics

(Total Lecture Hours: 56 + Tutorial Hours:14)

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3. Books Recommended:

1. Balachandran V.and Chandrasekaran, Corporate Governance, Ethics and Social Responsibility, PHI, 2nd Edition, 2011
2. Prasad L.M., Principles & Practice Of Management, Sultan Chand & Sons, 8th Edition,2015
3. Banga T. R. & Shrama S.C., Industrial Organisation & Engineering Economics, Khanna Publishers, 25th Edition, 2015
4. Everett E. Adam, Ronald J. Ebert, Production and Operations Management , Prentice Hall of India, 5th edition, 2012
5. Kotler P., Keller K. L, Koshi A.& Jha M., Marketing Management – A South Asian Perspective, Pearson, 14th Edition, 2014
6. Tripathi P.C.,Personnel Management & Industrial Relations, Sultan Chand & sons, 21st Edition, 2013
7. Chandra P., Financial Management, Tata McGraw Hill, 9th Edition, 2015

Instrumentation and Process Control

L	T	P	Credit
3	1	2	05

Core – 11: CH302 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Developand analysethe differential equation models of first order system and Analyse dynamic behaviour of first order system to various disturbances like step, impulse, sinusoidal, ramp etc, as well as linearization problems
CO2	Analysesecond order system and higher order system for dynamicbehaviour to various disturbances
CO3	Develop closed loop transfer functions and Evaluate stability of control system with various tools like Routh test criterion etc
CO4	Evaluate frequency response and Create bode diagrams and evaluate stability by bode stability criteria
CO5	Design control system by controller tuning methods to industrial control systems, Analyse Control valves,
CO6	Recognize advanced controllers and their requirement, Apply measurement concepts of process parameters in process industries for control, create root locus, recognize control valve characrtistics

2. Syllabus:

- **INTRODUCTION** **(1 Hour)**
  Steady and unsteady state design equation for an agitated heated tank. Introduction to P, PI, and PID controls.

- **DYNAMICS OF FIRST ORDER SYSTEMS** **(4 Hours)**
  Dynamics of first order systems subjected to various disturbances like step, ramp, impulse & sinusoidal e.g. liquid level tanks, mixing process, thermometer etc. response of first order system in series.

- **DYNAMICS OF SECOND ORDER SYSTEMS** **(5 Hours)**
  Dynamics of second order systems subjected to various disturbances like step, impulse, sinusoidal.

- **LINEAR CLOSE LOOP SYSTEM** **(3 Hours)**
  Linear close loop system, Servo and Regulator problem.

- **CLOSED LOOP TRANSFER FUNCTION** **(4 Hours)**
  Closed loop transfer function, block diagrams for various simple systems, Transient response of the control system.

- **STABILITY OF CONTROL SYSTEM** **(4 Hours)**
  Stability of control system, Routh test criterion, Concept of Root Locus, frequency analysis, Bode diagrams for simple order system (first order system, second order system, P, PI, PD controllers)

- **USE OF MATLAB IN PROCESS CONTROL** **(2 Hours)**

- **ADVANCED CONTROL** **(5 Hours)**
  Cascade Control, Feed forward Control, Ratio control, Split Range Control, Auctioneering Control and Multivariable Control.

- **CONTROLLER TUNING AND PROCESS IDENTIFICATION** **(4 Hours)**

- **CONTROLLERS AND CONTROL ELEMENTS** **(2 Hours)**
  Controller, control elements, control valves.

- **DISTRIBUTED CONTROL SYSTEM (DCS)** **(2 Hours)**
  Distributed control system (DCS), Programmable Logical Control System (PLC).

- **FLOW, LEVEL, PRESSURE AND TEMPERATURE MESUREMENT** **(4 Hours)**
  Construction, working principle, selection criteria and application of the measurement devices

- **SENSOR AND TRANSDUCER, INSTRUCTION PANELS, INTERFACE** **(2Hours)**

(Total Lecture Hours: 42 + Tutorial Hours: 14)

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3. Practicals:

1. Dynamics of First Order Liquid Level System.
2. Study of Linearization
3. Dynamics of Non Interacting Tanks.
4. Dynamics of Interacting Tanks.
5. Response of Manometer system
6. On-Off Controller.
7. P-PI Controller.
8. Cascade and Split Range Controller.
9. Ratio and Feed Back - Feed Forward Controller.
10. Dynamic Simulation of Distillation Operation.
11. Control of CSTR in Series.
12. Control of PFR.
13. Control of Evaporator.
14. Study of Temperature Control Trainer, Pressure Control Trainer, Flow Control Trainer, Level Control Trainer.

15. Dissolved Oxygen Meter.

16. Thermocouple Calibration

4. **Books Recommended:**

1. Coughnowr D.R., LeBlanc S. E. "Process Systems Analysis and Control", 3rd Edition, McGraw Hill Inc., New York, 2009.
2. Stephanopoulos G.," Chemical Process Control", Prentice Hall of India Pvt. Ltd., New Delhi, 2001.
3. Luben W.L,Luben M.L., "Essentials of Process Control", McGraw Hill Inc., New York, 1997.
4. Coughnower D. R. , Koppel L. B. ,"Process system Analysis and control " McGraw Hill Inc., New York, 1stEdition, 1986.
5. Eckman D.P., "Industrial Instrumentation", Wiley Eastern Limited, 2004.

Process Equipment Design and Drawing

L	T	P	Credit
3	1	2	05

Core – 12: CH304 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Select appropriate material of construction for various types of process equipments
CO2	Choose appropriate design methodology for designing various parts of process equipments as well as entire vessels
CO3	Classify various process equipments according to various design codes and standards
CO4	Design and evaluate process equipments including pressure vessels, heat exchangers, distillation columns, extraction columns, absorbers, strippers, storage tanks, etc.
CO5	Design process equipments subjected to internal pressure and external pressure
CO6	Analyze the environmental, plant, and personnel safety criteria and implement them in designing process vessels.

2. Syllabus:

- **INTRODUCTION** **(2 Hours)**
  Introduction to Chemical Engineering Design, Process design, Mechanical aspects of process equipment design, General design procedure, Equipment classifications, Design codes and standards (IS, ASTM and BS)

- **CRITERIA IN VESSEL DESIGN** **(3 Hours)**
  Properties of materials, Material of construction for various equipments and services, Material specifications, Fabrication techniques

- **DESIGN OF PRESSURE VESSELS** **(11 Hours)**
  Design of pressure vessels under internal pressure, Construction features, Pressure vessel code, Design of shell, various types of heads, nozzles, flanges for pressure vessel, Design and construction features of thick-walled pressure vessels, Various types of jackets and coils for reactors, Auxiliary process vessels

- **SUPPORTS FOR VESSELS** **(4 Hours)**
  Design consideration for supports for process equipments, Design of brackets support, leg support skirt, support, saddle support.

- **DESIGN OF STORAGE VESSEL** **(3 Hours)**
  Storage of nonvolatile and volatile liquids and gases, Codes for storage vessel design, Bottom, Roof and Shell designs.

- **DESIGN OF VESSELS UNDER EXTERNAL PRESSURE** **(3 Hours)**
  Design criteria for external design pressure, vessels operated under vacuum, Use of stiffeners, Design of covers, pipes and tubes

- **DESIGN OF HEAT EXCHANGERS** **(8 Hours)**

Types of heat exchangers, Selection criteria, Design of heat exchangers- shell, tube, baffles, closures, channels, tube sheets etc.

- **DESIGN OF DISTILLATION AND ABSORPTION COLUMNS (6 Hours)**
  Basic features of tall vertical equipments/ towers, Towers/Column Internal, Design of tower shell and internals, supports etc.

- **PROCESS HAZARDS & SAFETY, MEASURES IN EQUIPMENT DESIGN (2 Hours)**
  Equipment testing, Analysis of hazards, Pressure relief devices, Safety measures in process equipment design

(Total Lecture Hours: 42 + Tutorial Hours: 14)

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3. Practicals:

Selected Design and Drawing

1. Design & drawing of Pressure Vessels
2. Design & drawing of Heat Exchangers
3. Design & drawing of Distillation Columns
4. Design & drawing of Reactors
5. Design & drawing of Storage Vessels
6. Design & drawing of Evaporators
7. Design & drawing of Crystallizers
8. Design & drawing of Dryers, etc.
9. Sketches of equipment accessories such as covers for pressure vessels, flanges, flange facing, supports, roofs for storage vessel, jackets, coils, tube sheet for heat exchangers, baffles in head exchangers, trays for distillation columns, packing for distillation towers, liquid distributors etc.
10. AutoCAD drawing: Flange, Hub, 3-D Pressure vessel, 3-D Flange

4. Books Recommended:

1. Joshi M.V., Mahajani V.V., Umarji S.B., "Joshi's Process Equipment Design", 5rd Ed., MacMillan, Delhi, 2014.
2. Indian Standard 2825 (1969).
3. Bhattacharyya B.C., "Introduction to Chemical Equipment Design: Mechanical Aspects", 5th Ed., CBS Publishers, New Delhi, 2008.
4. Soares C., "Process Engineering Equipment Handbook", McGraw-Hill, New York, 2002.
5. Cheremisinoff N.P., "Handbook of Chemical Processing Equipment", Butterworth Heinemann, Oxford, 2000.

Process Modeling and Simulation

L	T	P	Credit
3	1	0	04

Core-13: CH306 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Formulate and develop mathematical models of chemical engineering systems
CO2	Solve and validate the developed model
CO3	Analyze various phenomena in chemical processes
CO4	Find errors while analyzing experimental data
CO5	Develop simulation skills to solve mathematical problems with the help of various simulation software.
CO6	Develop prediction and decision-making skills based on mathematical models.

2. Syllabus:

- **INTRODUCTION** **(4 Hours)**
  Physical and mathematical modelling, Principles of similarity, Independent variables, Dependent variables, Parameters and boundary conditions

- **MODELS** **(10 Hours)**
  Principle of formulations, Mathematical consistency of model, Continuity equations, Component continuity equations, Energy equations, Equations of motion, Transport equations, Equilibrium, Chemical Kinetics with examples.

- **APPLICATIONS IN CHEMICAL ENGINEERING SYSTEMS** **(16 Hours)**
  Heater, Boiler, Heat Exchanger, Condenser; Evaporation, Distillation Column, Adsorption column, Absorption Column, Stripping Column, Extraction, Leaching, Drying, Crystallization, CSTR, Plug flow reactor, Ammonia reactor.

- **SIMULATION** **(8 Hours)**
  Simulation and Information Flow diagram; Parameter estimation; Tools of Simulation

- **INDUSTRIAL SIMULATORS** **(4 Hours)**
  Introduction and applications

(Total Lecture Hours: 42 + Tutorial Hours: 14)

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3. Books Recommended:

1. Mickley H. S., Sherwood T. S., Reed C. E., "Applied Mathematics in Chemical Engineering", Tata-McGraw-Hill, New Delhi, 2nd Edition, 2002.
2. Jensen V.G., Jeffreys G.V., "Mathematical Methods in Chemical Engineering", 2nd Ed., Academic Press, London, 1978.
3. Salariya R. S., "Computer Oriented Numerical Methods", Khanna Publisher, India, 2015.

4. Lubyen W. L., “Process Modeling, Simulation and Control for Chemical Engineers”, 2nd Ed., McGraw-Hill,New York, 1989.
5. Pushpavanam S., “Mathematical Methods in Chemical Engineering”, Prentice-Hall of India, New Delhi, 1st Edition, 2001.

Elective: Environment Health and Safety

L	T	P	Credit
3	0	0	03

CH362 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able:

CO1	To describe the environmental ecosystem and its significance.
CO2	To analyze the effects of pollutants on the environment and health.
CO3	To decide the treatment technologies for waste effluents.
CO4	To justify the significance of safety for industries and available laws.
CO5	To estimate the hygiene and occupational health in industrial environment.
CO6	To propose the treatment methodologies for resource generation.

2. Syllabus:

- **INTRODUCTION** **(5 Hours)**
  Importance of Environment, its components, ecology, biosphere, interaction, impact of development, pollution and its effects, reversibility of environment. Safety, Health and safe practices in industries and its importance, sources of pollution from Chemical Industries, public awareness, and sustainability.

- **IMPACT ON BIOLOGICAL ENVIRONMENT** **(8 Hours)**
  Discharge of various effluents (water, air, and solid) and their impacts on environmental and human health, characterization, identification, different treatment processes (chemical, biological, and advanced), Mix first and separate later (MFSL) approach and its disadvantages, decentralization, tertiary treatment, and disinfection.

- **SOLID WASTE TREATMENT AND DISPOSAL** **(9 Hours)**
  Definition, Types of solid waste, generation, onsite handling, storage & processing, Different types of disposal techniques, recovery of resources, reuse of solid waste, electronic waste, policies, and current practices.

- **SAFETY PRACTICES IN INDUSTRIES** **(5 Hours)**
  Safety, loss prevention, safe practice, codes of safety, and integrity for various types of processes, safety and morals, accidents, accident reporting and investigation, personal protective equipments', releases mitigation procedures, financial aspects of safety, case histories, release of toxic effluents

- **INDUSTRIAL HYGIENE AND OCCUPATIONAL HEALTH** **(5 Hours)**
  Industrial hygiene, health and environmental effects, safety and health training, stress safety, radiations and industrial hazards, industrial noise, vibration, electric hazards, Disposal of scrap and other trade wastes, spillage prevention, housekeeping and its advantages, First aid, causalities and injuries.

- **LEGISLATIVE MEASURES** **(5 Hours)**
  Different laws related to liquid, solid, and gases effluents, Different standards and legislations, Factories Act, Workman's Compensation Act, Air Water Pollution Act, Bureau of Indian Standards on safety and health, OSHA, etc.

- **RESOURCE GENERATION** **(5 Hours)**
  Minimizing waste generation, reduce, reuse and recycling of by-products, Waste utilization, waste to energy concept, Sustainability, various advanced techniques like UASB, MFC, OMFC etc.

(Total Lecture Hours: 42)

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3. Books Recommended:

1. Masters G.M., "Introduction to Environmental Engineering and Science", Prentice-Hall, New Delhi, 3rd Edition, 2008.
2. MaCarty S., "Chemistry for Environmental Engineering", Tata-McGraw-Hill, New Delhi, 5th Edition
3. Metcalf & Eddy, "Waste Water Engineering: Treatment, Disposal and Reuse", Tata-McGraw-Hill, New Delhi, 4th Edition, 2002.
4. Crowl D. A., Louvar J. F., "Chemical Process Safety", Prantice-Hall, 2nd Ed., New York, 2002.
5. Grady, C.P.L, Daigger, G, and Lim, H, C, "Biological Waste Water Treatment", 2nd Edition, Marcel Dekker, 1999.

4. Further Reading:

1. Lees, F.P., "Loss Prevention in Process Industries", Butterworths, NewDelhi, 4thEdn., Aug 2012
2. Rao, C. S., "Environmental Engineering", Wiley Eastern Limited, New Delhi, 1995.
3. Droste R. L., "Theory and Practice of Water and Wastewater Treatment", Wiley India, 1996.

Elective: Petrochemical Technology

L	T	P	Credit
3	0	0	03

CH364

Scheme

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Identify the origin, accumulation and types of petroleum.
CO2	Explain the process of fractionation of crude oil and identify the specifications required for good quality petroleum product.
CO3	Discuss the production process of various types of petrochemical products.
CO4	Describe the operation of various petrochemical industries and process parameters for petrochemical production.
CO5	Describe safety and environmental aspects in petrochemical industries.
CO6	Apply subject knowledgeto solve problems arising in various petrochemical industries.

2. Syllabus:

- **ORIGIN OF PETROLEUM AND INTRODUCTION TO PETROCHEMICALS** **(4 Hours)**
  Originof petroleum, Classification of crude, Composition of crude, Types of refineries and refinery products, Raw material for organic chemical industries, Profile of petrochemical industry and its structure.

- **UNIT PROCESSES AND PETROCHEMICAL PROCESSING** **(6 Hours)**
  Unit processes in petrochemical industries and applications, Nitration and derived chemicals like nitrobenzene, nitrotoluenes, Halogenation and derived chemicals like DCM, MCA, VCM, chlorobenzene, Esterification and production of C1 to C4 alcohols.

- **PRODUCTION OF OLEFINS AND DERIVATIVES** **(10 Hours)**
  Naphtha and gas cracking for production of olefins, Recovery of chemicals from FCC and steam cracking, Ethylene derivatives: Ethylene Oxide, Ethylene glycol, Vinyl chloride, Propylene and Propylene oxide.

- **PRODUCTION OF AROMATICS AND SPECIALTY PRODUCTS** **(10 Hours)**
  Aromatics separation train, Aromatics product profile - Benzene, Toluene, Xylene, Ethyl benzene & Styrene, Cumene and phenol, Bisphenol, Aniline, Specialty products likeindustrial grease- Manufactureof calcium grease, Liquid paraffin and petroleum jelly. Polymer gasoline: Feed stock and reactions of polymer gasoline.

- **PRODUCTION OF POLYMERS, ELASTOMERS AND FIBERS** **(12 Hours)**
  Polymers: Polyethylene, Polypropylene, Polystyrene, Polyvinylchloride, polycarbonate, Thermoset resin: phenol formaldehyde, ureaformaldehyde and melamine formaldehyde Elastomers: Styrene Butadiene Rubber(SBR), Poly butadiene, Nitrile rubber, Polymides or Nylons (PA), DMT and Terephthalic acid, Polyester, Acrylic fibre, Modified acrylic fibre, Acrylonitrile, Acrolein, Viscose rayon and Acetate rayon.

(Total Lecture Hours: 42)

3. Books Recommended:

1. Groggins P.H., 'Unit Processes in Organic Synthesis', Tata McGraw Hill, 5th Edition, 1995.
2. Chauvel A. and Lefebvre G., 'Petrochemical Processes - I' Gulf Publication; 1st Edition, 1989.
3. Mall I.D., 'Petrochemical Process Technology', Macmillan India Ltd., 2007.
4. Rao M. Gopala, Marshall Sittig, 'Dryden's Outlines of Chemical Technology', East West Press, 3rd Edition, 1997.
5. Wiseman P., 'Petrochemicals,' Ellis Horwood Ltd., 1986.

Elective: Petroleum Refinery Engineering

L	T	P	Credit
3	0	0	03

CH366

Scheme

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Demonstrate characteristics of crude oil
CO2	Categorize crude before refining
CO3	Explain characteristics of refinery products
CO4	Demonstrate primary and secondary processing required for crude
CO5	Identify different products from primary and secondary processes
CO6	Summarize all the refining processes and effect of the process variables on conversion

2. Syllabus:

- **INTRODUCTION** **(2 Hours)**
  Overall Refinery Flow
- **PRODUCTS** **(3 Hours)**
  Low-Boiling Products, Distillate Fuels, Heating Oils, Residual Fuel Oils and their specification and applications.
- **REFINERY FEEDSTOCKS** **(3 Hours)**
  Crude Oil Properties, Composition of Petroleum, Crudes Suitable for Asphalt Manufacture, Crude Distillation Curves like ASTM, TBP, EFV
- **CRUDE DISTILLATION** **(4 Hours)**
  Desalting Crude Oils, Atmospheric Topping Unit, Vacuum Distillation, Auxiliary Equipment
- **COKING AND THERMAL PROCESSES** **(4 Hours)**
  Types, Properties, and Uses of Petroleum Coke, Process Description—Delayed Coking, Flexicoking, Fluid Coking, Yields from Flexicoking and Fluid Coking, Visbreaking.
- **CATALYTIC CRACKING** **(4 Hours)**
  Fluidized-Bed Catalytic Cracking, Cracking Reactions, Cracking Catalysts, FCC Feed Pretreatment, Process Variables, Heat Recovery
- **CATALYTIC HYDROCRACKING** **(4 Hours)**
  Hydrocracking Reactions, Feed Preparation, Hydrocracking Process, Hydrocracking Catalyst, Process Variables, Hydrocracking Yields.
- **HYDROPROCESSING AND RESIN PROCESSING** **(4 Hours)**
  Composition of Vacuum Tower Bottoms, Processing Options, Hydroprocessing, Expanded-Bed Hydrocracking Processes, Moving-Bed Hydroprocessors, Solvent Extraction.

- **HYDROTREATING** **(3 Hours)**
  Hydrotreating Catalysts, Aromatics Reduction, Reactions, Process Variables, Construction and Operating Costs

- **CATALYTIC REFORMING AND ISOMERIZATION** **(4 Hours)**
  Reactions, Feed Preparation, Catalytic Reforming Processes, Reforming Catalyst, Reactor Design, Yields and Costs, Isomerization

- **ALKYLATION AND POLYMERIZATION** **(4 Hours)**
  Alkylation Reactions, Process Variables, Alkylation Feedstocks, Alkylation Products, Catalysts, Hydrofluoric Acid Processes, Sulfuric Acid Alkylation Processes, Comparison of Processes, Alkylation Yields and Costs, Polymerization.

- **PRODUCT BLENDING** **(3 Hours)**
  Reid Vapor Pressure, Octane Blending, Blending for Other Properties.

(Total Lecture Hours: 42)

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3. Books Recommended:

1. James H. Gary, Glenn E. Handwerk, Mark J. Kaiser, "Petroleum Refining Technology and Economics", 5th Edi., CRC Press 2007
2. W. L. Nelson, *Petroleum Refinery Engineering*, 4th Ed, McGraw-Hill Book Company, New York, 1958.
3. David S.J. Jones, Peter R. Pujado, "Handbook of Petroleum Processing", 1st Ed., Springer Publication, 2008.
4. Rao B.K.B., "Modern Petroleum Refining Processes", 4th Ed., Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, 2002, (4th Ed).
5. Mohamed A. Fah Im, Taher A. Alsahhaf, and Amal Elkilani, Fundamentals of Petroleum Refining, 1st Ed., Elsevier, 2009.

Elective: Waste to Energy Conversion

L	T	P	Credit
3	0	0	03

CH368

Scheme

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	To explain the potential of energy from waste.
CO2	To classify the biological routes for energy production from waste.
CO3	To explain the basic principles of electrochemistry for the conversion of waste in to electricity.
CO4	To decide the various types of fuel cells/ reactors for the conversion of waste to Energy.
CO5	To estimate the performance of fuel cell by various advanced techniques.
CO6	To propose the advanced techniques/systems for full scale operations.

2. Syllabus:

- **INTRODUCTION** **(3 Hours)**
  Characterization and classification of waste as fuel, potential, conventional practices for waste management, need of nonconventional techniques, segregation of waste, thermodynamic aspects, types of various techniques, environmental aspects, future, and limitations.

- **POTENTIAL OF ENERGY FROM WASTE** **(5 Hours)**
  Quantum of various types of waste (solid and liquid: E-waste, agro based, forest residue, industrial waste, municipal solid and liquid waste), basic calculations for energy potentials, demand and supply of energy, **case** study from incineration, gasification, anaerobic digestion, pyrolysis, syngas utilization etc.

- **BIOLOGICAL ASPECTS** **(8 Hours)**
  Fermentation, anaerobic digestion, algal biomass cultivation, examples like slow rate and high rate reactors, UASB reactors, biochemical aspects for efficient conversion, methane to electricity conversion.

- **ELECTROCHEMICAL ASPECTS** **(6 Hours)**
  Basics of electrochemistry involved in fuel cell, bio-electrochemistry fundamentals, types of cells (galvanic and electrolytic) and lithium ion batteries etc.

- **VARIOUS TYPES OF FUEL CELLS** **(8 Hours)**
  Introduction, structure, principles, workings, potentials, limitations, scale up of various fuel cells like Hydrogen fuel cell, Microbial fuel cell, Microbial desalination cell, Microbial electrolysis cell, Benthic microbial fuel cell, Osmotic microbial fuel cell, etc.

- **VARIOUS ADVANCED TECHNIQUES FOR PERFORMANCE** **(7 Hours)**
  Polarization, Electrochemical Impedances spectroscopy, Cyclic voltammetry, columbic efficiency, Tafel plots, etc.

- **HYBRID SYSTEMS AND CASE STUDY** **(5 Hours)**
  Potential of single units and stacking of multiple units, integration potentials of various hybrid technologies, integration of solar energy, pilot scale demonstration of units, limitations, Power management system for DC/DC or DC/AC conversion

(Total Lecture Hours: 42)

3. Books Recommended:

1. Rogoff, M.J. and Screve, F., "Waste-to-Energy: Technologies and Project Implementation", Elsevier Store, 2nd Edition, Kindle Edition, 2011
2. Bard A. J., Faulkner L. R., "Electrochemical Methods: Fundamentals and Applications", 2nd Edition, Wiley, 2010.
3. Bagotsky V.S., Skundin A. M., "Electrochemical Power Sources: Batteries, Fuel Cells, and Supercapacitors" 1st Edition, 2014.
4. Young G.C., "Municipal Solid Waste to Energy Conversion processes", John Wiley and Sons, 1st Edition, 2010
5. Logan B. E., "Microbial Fuel Cells", First Edition, Wiley (2007).

4. Further Reading:

1. Davis M. L. and Cornwell, D. A., "Introduction to environmental engineering", Mc Graw Hill International Edition, Singapore, 2008.
2. Sofer, Samir S. (ed.), Zaborsky, R. (ed.), "Biomass Conversion Processes for Energy and Fuels", New York, Plenum Press, 1981.

Elective: Industrial Waste Management Control

L	T	P	Credit
3	0	0	03

CH372 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Recognize different types of industrial waste and their characteristics.
CO2	Analyze the role of microorganisms and its importance in Biological treatment of wastewater.
CO3	Compare different secondary wastewater treatment methods.
CO4	Design different types of wastewater treatment reactors.
CO5	Adapt various waste treatment methods.
CO6	Solve the problems related to wastewater treatment methods.

2. Syllabus:

- **INTRODUCTION** **(3 Hours)**
  Industrial waste, types of industrial waste, sources of industrial waste, characteristics of industrial waste, effects of waste on sewage treatment plants, waste reduction alternatives.

- **WASTEWATER CHARACTERISTICS** **(2 Hours)**
  Types of wastewater, Significance of wastewater contaminants, Discharge limit of wastewater, handling and storage of wastewater.

- **TREATMENT OF WASTEWATER** **(20 Hours)**
  Preliminary or primary treatment of wastewater: Different physical and chemical treatments, Secondary treatment: Aerobic and anaerobic treatment, BOD, COD, MLSS, MLVSS, Attached growth, Suspended growth, Activated sludge growth process, Upflow anaerobic sludge blanket reactor, trickling filter, Rotating biological contactor etc. Various post treatment methods such as lagoon, stabilizing pond, facultative pond etc. Tertiary treatment or advanced treatment: Membrane separation process, membrane bioreactor, nitrogen removal process, phosphorus removal process, Disinfection.
- **SLUDGE TREATMENT AND DISPOSAL** **(5 Hours)**
  Sequence of operations for sludge treatment: Concentration, Digestion, Conditioning, Dewatering, Oxidation.

- **SOLID WASTE TREATMENT** **(12 Hours)**
  Definition, Types of solid waste, storage and handling of solid waste, Different treatment of solid waste, E-waste treatment, Hazardous waste management.

(Total Lecture Hours: 42)

3. **Books Recommended:**

1. Board, NIIR "Modern Technology of Waste Management: Pollution Control, Recycling, Treatment and Utilization", Asia Pacific Business Press Inc., 2003.
2. Hammer, M.J. and Hammer M.J. Jr." Water and Wastewater Technology", 6th Ed. Prentice Hall Inc., 2008.
3. Bhatia, S.C., "Managing Industrial Pollution", Macmillan India Ltd., 2003.
4. Rao, C.S. "Environmental pollution control engineering", New Age International, 2nd Ed., 2011.
5. Nag, A. and Vizayakumar, A. "Environmental education and solid waste management", New Age International, 2005.

Elective: Polymer Engineering

L	T	P	Credit
3	0	0	03

CH322 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Estimate the basic concept of monomer, polymer and repeating units with properties.
CO2	Classify different polymerization reactions and their mechanisms/kinetics
CO3	Analyse and improve skills in thermal and mechanical properties of polymers
CO4	Describe the viscoelastic behaviour of polymers with respect to their chemical structures and molecular weights
CO5	Demonstrate an ability to predict how the molecular weight will affect properties.
CO6	Analyze polymerization data and predict the conversion and molecular weight,

2. Syllabus:

- **INTRODUCTION** **(2 Hours)**
  Monomers, polymers, classification of polymers

- **POLYMER CHEMISTRY** **(9 Hours)**
  Polymerization methods: addition and condensation; their kinetics, copolymerization, monomer reactivity ratios and its significance, kinetics, different copolymers, random, alternating, azeotropic copolymerization, block and graft copolymers, techniques for copolymerization-bulk, solution, suspension, emulsion

- **POLYMER CHARACTERIZATION** **(10 Hours)**
  Concept of average molecular weight, determination of number average, weight average, viscosity average and Z-average molecular weights, Fractional precipitation, Fractional Elution, Gel Permeation Chromatography (GPC), membrane osmometry, dilute solution viscosity method, ultracentrifugation, analysis of polymers using IR, XRD, thermal (DSC, DMTA, TGA), microscopic (optical and electronic) techniques.

- **POLYMER BLANDS AND COMPOSITES** **(4 Hours)**
  Difference between blends and composites, their significance, choice of polymers for blending, FRP, particulate, long and short fibre reinforced composites, Nanocomposites.

- **POLYMER TECHNOLOGY** **(3 Hours)**
  Polymer compounding, need and significance of polymer compounding, different compounding ingredients for polymer, crosslinking and vulcanization.

- **POLYMER PROCESSING** **(6 Hours)**
  Compression molding, transfer molding, injection molding, blow molding, reaction injection molding, extrusion, pultrusion, calendaring, rotational molding, thermoforming, rubber processing in two-roll mill, internal mixer.

- **POLYMER DEGRADATION** **(3 Hours)**
  Definition, Types of degradation, some new research on polymer degradation.

- **POLYMER SYNTHESIS AND PROPERTIES** **(5 Hours)**
  Commodity and general-purpose thermoplastics and thermosetting polymers: PE, PP, PS, PVC, PF, MF, UF, Epoxy, Unsaturated polyester etc.

(Total Lecture Hours: 42)

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3. Books Recommended:

1. Gowariker, V.R., Viswanathan, N.V., and Sreedhar, J.,"Polymer Science" 1st Edition, Halsted Press (John Wiley & Sons), New York, 1986.
2. Billmeyer, F.W., "Text Book of Polymer Science, 3rd edition, John Wiley & Sons, New York, 1984.
3. Ghosh, P. "Polymer Science & Technology of Plastic, Rubber, Blends and Composites" 2nd Edition, Tata McGraw-Hill, New delhi, 2008.
4. Morton-jones, D.H., Chapman and Hall, "Polymer Processing", Springer, London, 1989,1st Edition.
5. McCrum, N.G., Buckley, C.P. and Bucknall, C.B., "Principles of Polymer Engineering", 2nd Edition, Oxford Science Publication, 1997.

Elective: UNIT PROCESSES

L	T	P	Credit
3	0	0	03

CH324

Scheme

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Recognize the significance of unit processes in the field of chemical engineering.
CO2	Apply the basic chemical process kinetics, types of reactor for different types of reaction.
CO3	Determine the selection of appropriate equipment for different process.
CO4	Summarize all the unit processes.
CO5	Analyze the chemistry behind the manufacturing of different chemical products.
CO6	Evaluate the effect of various physical and chemical factors on unit processes.

2. Syllabus:

- **INTRODUCTION** **(4 Hours)**
  Definition and importance of Unit processes in Chemical Engg., Outlines of unit processes, and operations, Chemical process kinetics and Factors affecting it, types of reactors, Symbols used in Chem. Engg. Process flow diagram.

- **NITRATION** **(4 Hours)**
  Definition & scope of nitration reactions, Nitrating agents, Aromatic Nitration (schimid and Biazzi; nitrators) mixed acid for nitration, D.V.S. value and nitric reaction, Comparison of batch Vs. Continuous nitration, manufacture of Nitrobenzene, Dinitrobenzene.

- **AMINATION BY REDUCTION** **(6 Hours)**
  Definition & scope of Amination reactions, various methods of reductions and factors affecting it, Batch and Continuous process for manufacture of Aniline from Nitrobenzene, Continuous process for manufacture of Aniline from nitrobenzene using catalytic fluidized bed reactor, material of construction in such processes.

- **HALOGENATION** **(5 Hours)**
  Definition and scope of various halogenation reactions, Halogenating agents, thermodynamics and kinetics of halogenations reactions. Benzene hexa-chloride and vinyl chloride from Ethylene and Acetylene.

- **SULFONATION AND SULFATION** **(3 Hours)**
  Definition and scope of such reactions, sulfonating and sulfating agents and their applications, Chemical and physical factors affecting it. manufacture of Benzene sulfonates, Sulfation of Dimethyl Ether and Lauryl Alcohol.

- **AMINATION BY AMMONOLYSIS** **(3 Hours)**
  Definition & types of reactions, Aminating agents, Physical and Chemical factors affecting it. Catalyst used in Ammonolysis, manufacture of Aniline from chlorobenzene and Nitroaniline from Dichloro Nitro Aniline.

- **OXIDATION** **(5 Hours)**
  Definition and Types, Oxidizing agents, Liquid phase oxidation. Thermochemistry and kinetics. manufacture of Acetaldehyde from Acetic acid and manufacture of Acetic acid from Ethanol. Vapor phase oxidation of Benzene and Naphthalene, Apparatus and its material of construction for oxidation reactions.

- **HYDROGENATION** **(5 Hours)**
  Definition and its scope, properties of hydrogen and sources of hydrogen, gas catalytic hydrogenation and hydrogenolysis, Kinetics and thermodynamics of hydrogenation reactions, Apparatus and material of construction, Industrial hydrogenation of fat & oil, manufacture of Methanol from CO_2 & H_2.

- **HYDROLYSIS** **(4 Hours)**
  Definition and types of hydrolysis, Hydrolyzing agents, thermodynamics and kinetics of Hydrolysis, Industrial Hydrolysis of fat, manufacture of ethanol from ethylene (shell process).

- **POLYMERIZATION** **(3 Hours)**
  Introduction & chemistry of polymerization reactions, classifications of polymers methods of polymerization.

(Total Lecture Hours: 42)

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3. Books Recommended:

1. Groggins P. H., "Unit Processes in Organic Synthesis", 5th edition, Tata-McGraw Hill, New Delhi, 2001.
2. Gopalarao. M. , Sitting M., "Dryden's Outlines of Chemical Tech.", 2nd Ed., East-West Pub., New Delhi, 1997.
3. Austin G. T., "Shreve's Chemical Process Industries", 5th Ed. McGraw-Hill Pub., 1994.
4. Kent J.A., "Riggel's Handbook of Industrial Chemistry", 11th Ed.,Van Nostrant Reinhold, 1974.
5. Robert Thronton Morrison, et al., "Organic Chemistry". 7th Edition, Pearson Publications, 2014.

Elective: Chemical Product Design

L	T	P	Credit
3	0	0	03

CH326 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Recognize the importance of Chemical Product Design.
CO2	Analyze the complex issues involved in chemical product.
CO3	Determine relevant product attributes based on property function
CO4	Select and apply tools to design product and devices
CO5	Design novel engineering device based on requirments.
CO6	Design new product structures and evaluate the performance by advanced computing tools (e.g. Molecular Simulation)

2. Syllabus:

- **INTRODUCTION** **(4 Hours)**
  Importance of Chemical product design, Classification of chemical products: Specialty products, formulated products, assembled products; Framework for Chemical product design and development, product introduction and design procedure

- **DESIGN CRITERIA** **(4 Hours)**
  Needs: identifying products, converting needs to specifications; Ideas: Ideas sources, sorting and screening of ideas; Selection: selection criteria based on thermodynamics and kinetics, other criteria; Manufacture

- **PRODUCT DESIGN APPROACHES** **(4 Hours)**
  Experiments, database, Heuristics, Model based approach; Heuristics: hierarchical decomposition method, heuristics to design engineering parameters of a chemical product

- **MODEL-BASED PRODUCT DESIGN APPROACH** **(9 Hours)**
  Molecular dynamics, Mathematical Programming

- **CHEMICAL PRODUCT DESIGN AND PROCESS DESIGN** **(10 Hours)**

- **UNCONVENTIONAL PROCESSING TECHNIQUE**
  Addition/formation techniques: coating, agglomeration such as sintering, and particle agglomeration, and synthesis such as Solvothermal synthesis, coprecipitation, electrolysis process, and emulsion techniques are commonly used for synthesis.
  Removal/ destruction techniques: Etching, Breakage and coalescence, challenges, Introduction to Heuristics and Mathematical Programming for process design

- **DESIGNING PRODUCTS** **(8 Hours)**
  Molecular Products, formulated products, and Microstructure

- **ECONOMIC ANALYSIS:** **(3 Hours)**
  Economic metrics for product development, economics of product development, Sensitivity analysis, challenges

(Total Lecture Hours: 42)

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3. Books Recommended:

1. Cussler, E.L., and G. D. Moggridge, "Chemical Product Design", Cambridge University press, 2nd Ed., 2011.
2. Seider, W.D., Seader, J.D., Lewin, D.R., "Product and Process Design Principles", 4th Ed., Wiley, New York, 2004.
3. Wei, J., "Product Engineering: Molecular structure and properties", 2nd Ed., Oxford University Press, 2007.
4. Selected topics from "Tools for chemical product design", Eds: M. Martin, M. R. Eden, N. G. Chemmangattuvalappil, Chemical aided chemical engineering book, 39. Elsevier
5. Moggridge G. D., Cussler, E.L., and, An Introduction to Chemical Product Design, Chemical Engineering Research and Design, 78 (1) 2000, 5-11

Elective: Fundamentals of Colloid and Interface Science

L	T	P	Credit
3	0	0	03

CH328 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	State and recognize the fundamental principles of colloids and interfacial science
CO2	Identify various types of colloidal dispersions and classify them based on their characteristics
CO3	Calculate surface tension and/or interfacial tension for various systems based on the data given related to various methods
CO4	Classify various types of surfactants based on their characteristics, structure, and applications
CO5	Describe the important concepts of interfacial science,
CO6	Evaluate the stability of interfaces, stability of colloidal dispersions, wetting and spreading of droplets on various substrates, and their applications in chemical engineering

2. Syllabus:

- **INTRODUCTION** **(3 Hours)**
  Introduction to Colloids, Colloidal systems, Thin Films, Surfaces and Interfaces, Characteristics of colloidal systems, Industrial applications.

- **PHENOMENOLOGY OF COLLOIDAL MATERIALS** **(5 Hours)**
  Forces in colloidal systems, Hydrophobic interaction, Stability, Association colloids, DLVO theory, Non-DLVO forces, Brownian motion and Brownian flocculation.

- **INTER-MOLECULAR AND INTER-PARTICLE FORCES** **(8 Hours)**
  Charge-charge interaction, Dipole-dipole interaction, Ion-dipole interaction, van der Waals interaction, Hamaker's approach, Deryaguin's approximation, Lifshitz continuum theory of forces between macroscopic bodies.

- **SURFACTANTS, MICELLES AND SELF ASSEMBLY SYSTEMS** **(8 Hours)**
  Classification of surfactants, Factors affecting behavior of surfactants, Visicles, Micelles, Reverse micelles, Mixed surfactant systems, Monolayers, Bilayers, Applications.

- **EMULSIONS, FOAMS AND GELS** **(4 Hours)**
  Characteristics and applications of Emulsions, Gels, Microemulsions, Stability of Emulsions, Applications of foams, Hydrotropy: theory and applications, Foam stability and foamability, applications

- **ELECTROKINETIC PHENOMENA** **(3 Hours)**
  Electroosmosis, Electrophoresis, etc.

- **INTERFACES AND THIN FILMS** **(3 Hours)**
  Interfaces, Curved interfaces, Interfacial tension and its measurement, Thermodynamics of interfaces, Interfacial rheology, Friction, Lubrication, Adhesion, Macromolecular Surface Films, Charged Films, and Langmuir-Blodgett Layers

- **WETTING AND SPREADING** **(3 Hours)**
  Contact angle, Surface characteristics, Modification of wetting, Capillarity, Thermodynamics of wetting and spreading.

- **SELECTED TOPICS FROM CURRENT LITERATURE** **(5 Hours)**

(Total Lecture Hours: 42)

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3. Books Recommended:

1. Ghosh, P., "Colloid and Interface Science", PHI Learning, New Delhi, 2009.
2. Miller, C. A. and P.Neogi, "Interfacial Phenomena : Equilibrium and Dynamic Effects", 2nd Edn., CRC Press, NY, 2019.
3. Hiemenz, P. C., and R.Rajgopalan, "Principles of Colloid and Surface Chemistry", 3rd Edn., Marcel Dekker, NY, 1997.
4. Adamson, A. W. and Gast, A., "Physical Chemistry of Surfaces", 6th edition, John Wiley and Sons, 1997.
5. Stokes, R. J. and Evans, D.F., "Fundamentals of Interfacial Engineering", Wiley-VCH, N.Y., 1996.

Elective: Corrosion and Electrochemical Engineering

L	T	P	Credit
3	0	0	03

CH332 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Apply laws of electrochemistry to understand mechanism of corrosion
CO2	Estimate the rate of corrosion.
CO3	Differentiate between different types of corrosion.
CO4	Identify the factors causing corrosion and solve problems involving various types of corrosion.
CO5	Assessment of damage caused by corrosion.
CO6	Select suitable technique for corrosion prevention.

2. Syllabus:

- **ELECTROCHEMISTRY OF CORROSION** **(6Hours)**
  Corrosion – introduction and definitions; Electrochemical cells - definitions and principles; Potential measurements - galvanic cells, concentration cells; EMF and Galvanic series - bimetallic couples; Eh-pH diagrams – fundamental aspects; Construction of Eh – pH diagrams; FeH2O-O2 diagram; Copper, Aluminium and general corrosion diagrams

- **CORROSION KINETICS AND APPLICATION OF ELECTROCHEMISTRY** **(10Hours)**
  Overpotential; Activation Polarization; Concentration Polarization; Ohmic Drop; Graphical Presentation of Kinetic Data (Evans Diagrams); Activation Controlled Processes; Concentration Controlled Processes; Examples of Applied Electrochemistry to Corrosion; Electrochemical Polarization Corrosion Testing; Corrosion Monitoring;Cathodic Protection; Anodic Protection; Aluminum Anodizing; Chloride Extraction.

- **FORMS OF CORROSION** **(6 Hours)**
  Recognizing Corrosion; Localized Corrosion (Pitting Corrosion, Crevice Corrosion, Galvanic Corrosion, Intergranular Corrosion, Dealloying, Hydrogen-Induced Cracking, Hydrogen Blistering, etc.); Velocity Induced Corrosion (Erosion–Corrosion, Cavitation, etc.); Mechanically Assisted Corrosion (Stress Corrosion Cracking, Corrosion Fatigue, Fretting Corrosion, etc.).

- **FACTORS AFFECTING CORROSION AND ITS MONITORING** **(8Hours)**
  Effect of ambient conditions;Corrosion by fresh water and other types of water; Corrosion by atmosphere;corrosion in soil; Microbiologically affected corrosion; Corrosion in concrete; corrosion in petroleum industries; Corrosion Test Methods and Testing Procedure; Electrochemical Testing; Corrosion Monitoring and Inspection; Monitoring of Cathodic Protection; Inspection and Monitoring of Process Plants; Monitoring and Testing in Other Environments.

- **RISK ASSESSMENT OF COROSION AND ITS MITIGATION** **(12Hours)**
  Risk Assessment and Analysis; Risk Assessment Methods; Cost of Corrosion;Hazard and Operability; Failure Modes – Effects and Criticality Analysis; Risk Matrix Methods; Fault Tree Analysis; Event Tree Analysis; Industrial Example of corrosion assessment and Damage

Assessment; Cathodic Protection; Sacrificial Cathodic Protection; Impressed Current Cathodic Protection; Protective Coatings; Types of Coatings; Coatings Failure; Economic Aspects of Coating Selection and Maintenance; Organic Coatings; Inorganic (Nonmetallic) Coatings; Metallic Coatings; Coating Inspection and Testing; Surface Preparation.

(Total Lecture Hours: 42)

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3. Books Recommended:

1. Roberge, P.R., 'Corrosion engineering: principles and practice' 1st Edition, New York: McGraw-Hill, 2008.
2. Kelly, R.G., Scully, J.R., Shoesmith, D. and Buchheit, R.G., 'Electrochemical techniques in corrosion science and engineering' 1st Edition, CRC Press, 2002.
3. Bardal, E., 'Corrosion and protection' 1st Edition, Springer Science &Business Media, 2004.
4. Landolt, D., 'Corrosion and surface chemistry of metals' 1st Edition, EPFL press, 2007.
5. Ahmad, Z., 'Principles of corrosion engineering and corrosion control' 1st Edition, Elsevier Science and Technology Books, 2006.

General Chemical Technology

L	T	P	Credit
4	0	2	05

Core – 14: CH401 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Review the practical significance and relevance of processes in chemical industries.
CO2	Prepare organic and inorganic compounds using standard synthetic and purification procedures.
CO3	Recognize the importance of Unit processes and Unit operations in industrial chemical systems.
CO4	Analyze the operation of industrial chemical processes.
CO5	Assess and propose how raw materials are converted into useful products.
CO6	Decide technological solutions to problems arising in industrial plants.

2. Syllabus:

- **INTRODUCTION** **(2 Hours)**
  Chemical Process Industries – Facts and Figures, Types of Chemical Process Diagrams, Preparation of Process Flow Diagrams, Equipment Symbols

- **CHLOR-ALKALI INDUSTRIES** **(5 Hours)**
  Manufacturing of Soda Ash by Solvay Process, Dual salt Process, Natural Soda Ash Process, Manufacturing of Caustic Soda, Chlorine, Hydrogen

- **INORGANIC ACIDS** **(5 Hours)**
  Manufacturing of Sulphuric Acid, Nitric Acid, Hydrochloric Acid, Phosphoric Acid

- **FERTILIZERS** **(4 Hours)**
  Types of Fertilizers, Manufacturing of Ammonia, Urea, Ammonium Nitrates, Ammonium Phosphates, Superphosphates, NPK

- **OILS, FATS, SOAPS, DETERGENTS** **(5 Hours)**
  Vegetable Oils, Animal Fats, Fatty Acids and Alcohols, Extraction Methods, Hydrogenation of Oils, Soaps and Glycerine, Detergents

- **SUGAR & STARCH INDUSTRIES** **(4 Hours)**
  Manufacturing of Sugar from Sugarcane, Starch, Ethanol by Fermentation

- **BIOMASS BASED CHEMICALS & BIOFUELS** **(4 Hours)**
  Concept of Lignocellulosic Biorefinery, Biomass Platform Molecules, Manufacturing of Furan Derivatives, Lignin Derivatives, Biobutanol, Biodiesel

- **PULP & PAPER INDUSTRIES** **(4 Hours)**
  Pulp and Paper, Cellulose and its Derivatives, Rayon

- **PETROLEUM REFINING** **(4 Hours)**
  Types of Crude Oils, Petroleum Refining Products, Refinery Unit Processes

- **PETROCHEMICALS** **(10 Hours)**
  Feedstocks, C_1 Derivatives, C_2 Derivatives, C_3 Derivatives, BTX Derivatives

- **POLYMERS & SYNTHETIC FIBERS** **(4 Hours)**
  Manufacturing of Phenol and Urea Formaldehyde Resins, Polyester, Nylons, Synthetic Rubbers

- **DRUGS & PHARMACEUTICALS** **(5 Hours)**
  Classification of Drugs, Manufacturing of Drugs, Aspirin, Antibiotics, Vitamins

(Total Lecture Hours: 56)

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3. Practicals:

1. Preparation of Boric acid
2. Preparation of $CaCl_2$
3. Preparation of Detergent
4. Preparation of Nitro naphthalene
5. Preparation of Potash alum
6. Preparation of Soap
7. Determination of Kinematic Viscosity of given oil sample
8. Determination of Aniline point
9. Determination of Smoke point
10. Measurement of Softening point
11. Determination of Penetration index
12. Determination of Flash point and Fire point

4. Books Recommended:

1. Gopala Rao M. & Sittig M., "Dryden's Outlines of Chemical Technology", 3rd Ed., Affiliated East-West Press Pvt. Ltd., New Delhi, 1997.
2. Austin G. T., "Shreve's Chemical Process Industries", 5th Ed., Tata McGraw-Hill Education Pvt. Ltd., 2012.
3. Rao B.K.B., "Modern Petroleum Refining Processes", 6th Ed.,Oxford & IBH Publishers, New Delhi, 2017.
4. Mall I.D., "Petrochemical Process Technology", 2nd Ed., Trinity Press, New Delhi, 2017.
5. Mall I.D., "Petroleum Refining Technology", 1st Ed., CBS Publishers, New Delhi, 2017.

Elements of Transport Phenomena

L	T	P	Credit
3	1	0	04

Core – 15: CH403 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Describe basics of momentum, heat and mass transfer
CO2	Write shell balance equations for conservation of momentum, energy, and mass; to obtain desired profiles for velocity, temperature and concentration
CO3	Solve and analyze generalized macroscopic balances for conservation of momentum, energy and mass to obtain engineering quantities of interest
CO4	Solve and analyze appropriate equations of change to obtain desired profiles for velocity, temperature and concentration
CO5	Recognize and apply analogies among momentum, heat and mass transfer
CO6	Explain interphase transport

2. Syllabus:

- **INTRODUCTION** **(1 Hour)**
  Introduction to different transport processes such as momentum, heat and energy.

- **TRANSPORT BY MOLECULAR MOTION** **(12 Hours)**
  Momentum transport by viscosity and momentum-flux. Energy transport by thermal conductivity and heat-flux. Mass transport by diffusivity and mass-flux.

- **TRANSPORT IN ONE DIMENSION (SHELL BALANCE METHODS)** **(16 Hours)**
  Shell momentum balances and velocity distributions. Shell energy balances and temperature distributions. Shell mass balances and concentration distributions.

- **USE OF GENERAL TRANSPORT EQUATIONS** **(6 Hours)**
  Equations of change and their use in momentum transport (isothermal).

- **VELOCITY DISTRIBUTIONS IN TURBULENT FLOW** **(1 Hour)**
  Comparisons of laminar and turbulent flows. Time-smoothed equations of change for incompressible fluids.

- **INTERPHASE TRANSPORT IN ISOTHERMAL SYSTEMS** **(2 Hours)**
  Friction factors for flow in tubes, flow around spheres, and packed columns.

- **MACROSCOPIC BALANCES FOR ISOTHERMAL FLOW SYSTEMS** **(2 Hours)**
  Macroscopic mass balance for steady and unsteady-state problems.

- **INTRODUCTION TO EQUATIONS OF CHANGE FOR NON-ISOTHERMAL SYSTEMS AND MULTICOMPONENT SYSTEMS** **(2 Hours)**
  Energy transport and mass transport.

(Total Lecture Hours: 42 + Tutorial Hours: 14)

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3. Books Recommended:

1. Bird R.B., Stewart W.E. and Lightfoot E.N., "Transport Phenomena", 1st and 2nd Eds., John Wiley & Sons, Singapore, 1960 & 2002.
2. Bird R.B., Stewart W.E., Lightfoot E.N. and Klingenberg D.J., "Introductory Transport Phenomena", John Wiley & Sons, Hoboken, NJ, USA, 2014.
3. Plawsky J.L., "Tranport Phenomena Fundamentals", 3rd Ed., CRC Press, Boca Raton, FL, USA, 2014.
4. Geankoplis C.J., "Transport Processes and Separation Process Principles", 4th Ed., PHI, New Delhi, India, 2009.
5. Welty J.R., Rorrer G.L., and. Foster D.G., "Fundamentals of Momentum, Heat, and Mass Transfer", 7th Ed., John Wiley & Sons, Hoboken, NJ, USA, 2019.

Elective: Sustainability, Green Chemistry and Engineering

L	T	P	Credit
3	0	0	03

CH421

Scheme

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Apply the concepts of sustainability in professional life.
CO2	Explain the importance of twelve principles of green chemistry and engineering.
CO3	Evaluate various techniques based on twelve principles of green chemistry and engineering.
CO4	Appraise novel concepts (new techniques and novel solvents) in processes in line with sustainable and green concepts.
CO5	Infer the given conventional process and operations and recommend modification required in the system.
CO6	Analyze various processes/products based on life cycle assessment.

2. Syllabus:

- **INTRODUCTION** **(2 Hours)**
  Chemistry- from past to future, Importance of sustainability, Need of green chemistry
- **CONCEPT OF SUSTAINABILITY** **(4 Hours)**
  Fundamentals of sustainable development, growth, consumption and natural wealth, Sustainable development at different scales, Ten commandments, Sustainable development goals
- **GREEN CHEMISTRY AND ENGINEERING** **(5 Hours)**
  Principles and applications in green chemistry, green engineering, green extraction
- **SYNTHESIS AND GREEN CHEMISTRY** **(4 Hours)**
  Micro-reactor technology, Solvent-less reactions, Use of green solvents, Role of catalyst
- **ALTERNATE SOLVENTS** **(4 Hours)**
  Green solvents, Water as a solvent, Amphiphillic compounds
- **CONVENTIONAL PROCESS AND OPERATIONS** **(9 Hours)**
  Current status and modification (reactive distillation, divided wall distillation column, heat integration using pinch analysis)
- **NEW DEVELOPMENT IN PROCESSES** **(9 Hours)**
  Overview of green separation processes, Distillation, Chromatography, Membrane processes, Extraction using neoteric solvents, Nanotechnology in separation, etc.
- **LIFE CYCLE ASSESSMENT** **(5 Hours)**
  Basics and case studies

(Total Lecture Hours: 42)

3. <u>Books Recommended:</u>

1. Doble, M., Kruthiventi, A. K., "Green Chemistry and Processes", Academic Press, London, UK, 2007.
2. Manahan S. E., "Green Chemistry and The Ten Commandments of Sustainability", 2nd Ed. Chem Char Research, Inc Publishers, Missouri USA, 2006.
3. Afonso C. A. M., Crespo J. G. (Ed), "Green Separation Processes", Wiley-VCH Verlag GmbH & Co., Weinheim, Germany, 2005.
4. Clark J., Macquarrie D. (Ed), "Handbook of Green Chemistry and Technology", Blackwell Series, UK, 2002.
5. Atkinson G., Dietz S., Neumayer E. (Ed), "Handbook of Sustainable Development", Edward Elgar Publishing Limited, Cheltenham, UK, 2007.

Elective: Advances in Chemical Engineering

L	T	P	Credit
3	0	0	03

CH423

Scheme

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1.	Analyze the effects of pollutants on the environment and health impacts.
CO2	Express the knowledge of basic principles of different characterization methods.
CO3	Analyze treatment technologies for water/wastewater/solid waste.
CO4	Evaluate the usefulness of nanomaterials in treatment technologies.
CO5	Classify different types of smart polymers and membranes for environment.
CO6	Estimate most advanced methods for treatment for water/wastewater/solid waste.

2. Syllabus:

- **ADVANCE SEPARATION TECHNIQUES** **(12 Hours)**
  Reverse osmosis, Forward osmosis (FO), Pressure retarded osmosis (PRO), Osmotic microbial fuel cell (OMFC), benthic microbial fuel cell (BMFC), Osmotic Membrane bio reactor (OsMBR).

- **ADVANCE CHARACTERIZATION METHODS** **(4 Hours)**
  XRD, SEM, TGA, FT-IR, EDX, Gel permeation chromatography (GPC) etc.

- **ADVANCE POLYMER** **(10 Hours)**
  Smart polymer, advanced polymer nanocomposite, Conductive polymer, bio-route prepared nano polymer, Blended polymer, self-cleaning polymer surfaces

- **RECENT ADVANCES IN MEMBRANES** **(11 Hours)**
  Principles of membrane separation, Membrane Materials, Transport phenomena of species, molecular and ionic, in porous or dense, charged or not, membranes, Layer by layer membrane, Proton exchange membrane, biopolymer based membrane, nanocomposite membrane, coated membrane, different subtract and active layer membrane.

- **SMART HYDROGELS** **(5 Hours)**
  Hydrogel, Core and shell hydrogel, shell and core hydrogel, green hydrogel, stimuli responsiveness hydrogel

(Total Lecture Hours: 42)

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3. Books Recommended:

1. Jornitz, M. W. and Meltzer, T. H., "Filtration and purification in biopharmaceutical industry", Second edition by, Informa Healthcare, Vol. 174. 2007.
2. Bungay P.M., Lonsdale H.K. and de Pinho M.N. (Eds.), "Synthetic Membranes: Science, Engineering and Applications", NATO ASI Series, Vol. 181, D. Reidel Publishing Company, Dordrecht, Holland, 1986.
3. Schweitzer P.A. (Ed.), "Handbook of Separation Techniques for Chemical Engineers", 3rd Edition, McGraw-Hill, New York, 1997.
4. Gowariker, V.R. Viswanathan, N.V., and Sreedhar, J., "Polymer Science, Halsted Press (John Wiley & Sons), First Edition, New York, 1986.
5. Ghosh, P. "Polymer science & technology of plastic, rubber, blends and composites", Second Edition, Tata McGraw-Hill, New Delhi, 2008.

Elective: Enzyme Science and Technology

L	T	P	Credit
3	0	0	03

CH425 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Define the enzymes in terms of classifications, characterization, purification methods etc.
CO2	Explain the various mechanisms and kinetics of enzyme action as catalyst in biochemical reactions.
CO3	Recognize the significance of various types of enzyme inhibition and its effect on enzymatic reactions.
CO4	Adapt various methods of enzyme immobilization and their significance.
CO5	Design different types of enzymatic reactors for enzymatic reactions.
CO6	Explain various applications of enzyme in chemical and biochemical industries.

2. Syllabus:

- **INTRODUCTION TO ENZYMES** **(5 Hours)**
  Historical aspects, nomenclature and their classification, cost effective production, purification and characterization of enzymes.

- **MECHANISMS AND KINETICS OF ENZYME ACTION** **(7 Hours)**
  Mechanisms of enzyme action, concept of active site and energetics of enzyme substrate complex formation, specificity of enzyme action, kinetics of single substrate reactions, turn over number, estimation of Michaelis-Menten parameters, factors affecting enzymatic reaction.

- **ENZYMES INHIBITION AND MULTI-SUBSTRATE ENZYME KINETICS** **(7 Hours)**
  Multi substrate reaction mechanisms and kinetics- Random, Ping-Pong, Ordered; Haldane Relationships; types of inhibition- Competitive, Noncompetitive, Uncompetitive, Product, Substrate; allosteric regulation of enzymes, deactivation kinetics.

- **ENZYME IMMOBILIZATION** **(8 Hours)**
  Physical and chemical techniques for enzyme immobilization, adsorption, matrix entrapment, encapsulation, cross-linking, covalent binding etc., examples advantages and disadvantages of different immobilization techniques; Effect on mass transfer resistance.

- **ENZYME REACTORS AND PROCESS DESIGN** **(7 Hours)**
  Types of bioreactors for enzymatic reactions (i.e. continuous, batch, fed-batch etc.)

- **APPLICATIONS OF ENZYMES** **(8 Hours)**
  Commercial applications of enzymes in food, pharmaceutical and other industries, enzymes for analytical, diagnostic and bioremediation applications, enzymes for green technology, enzymes as biosensors.

(Total Lecture hours: 42 hours)

3. Books Recommended:

1. Bisswanger, H., "Enzyme Kinetics: Principles and Methods", 3rd Ed.Wiley-VCH Verlag GmbH, Weinheim, 2017.
2. Marangoni, A.G., "Enzyme Kinetics: A Modern Approach", John Wiley & Sons, Inc., Hoboken, New Jersey, 2003
3. Dutta, R., "Fundamental of Biochemical Engineering", Springer, New York, 2008.
4. Sathishkumar, T., Shanmugaprakash, M. and Shanmugam, S., "Enzyme Technology", 2^{nd} Ed. I.K. International Publishing House, 2012
5. Kirst, H.A., Yeh, W.-K. and Zmijewski, M.J., " Enzyme Technologies for Pharmaceutical and Biotechnological Applications", Marcel DeKKerr, Inc.,2001

Elective: Nanomaterials Synthesis by Chemical Methods

L	T	P	Credit
3	0	0	03

CH427

Scheme

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Recognize the importance of nanomaterials, compare types of synthesis methods and their applications, analyze various fields of applications, enhanced properties, concepts of surface to volume ratio and surface atoms
CO2	Recognize wet chemical methods of nanomaterial synthesis like Colloidal synthesis of various nanostructures, micro emulsion method for nanomaterial synthesis,
CO3	Analyze the nanomaterials prepared with various techniques such as XRD, SEM, TEM, DLS, UV-VIS etc.
CO4	Evaluate aspects involved in Nanomaterial synthesis and thin film preparation methods for energy sectors and aspects and controlling operating parameter
CO5	Apply aspects involved in Nano catalyst preparation methods and applications, Nano catalysts vs heterogeneous catalyst, Evaluate nanomaterials synthesis for other applications of nanomaterials
CO6	Evaluate Optimization technique for finding the best optimum parameters, the effect of each control parameter using DOE, Analyze Issues related to scale-up in nanomaterials synthesis including downstream processing

2. Syllabus:

- **OVERVIEW** **(2 Hours)**
  Importance of nanomaterials, and types of synthesis methods and their applications.

- **FUNDAMENTALS OF CHEMICAL SYNTHESIS AND ENHANCED PROPERTIES** **(3 Hours)**
  Advantages of chemical synthesis methods of nanomaterials and Aspects involved in chemical methods of nanomaterials synthesis, Enhanced Properties at nanoscale and various fields of applications, concepts of surface to volume ratio and surface atoms

- **COLLOIDAL SYNTHESIS OF NANOMATERIALS** **(3 Hours)**
  Colloidal synthesis of various nanostructures. Microemulsion method for nanomaterial synthesis, channels of zeolites, Phase behavior of synthesis systems such as colloidal systems.

- **NANOCATALYSIS: NANOMATERIALS SYNTHESIS FOR NANOCATALYSIS** **(8 Hours)**
  Nanocatalysts vs heterogeneous catalyst, Nano catalyst preparation methods and applications, Aspects involved in aqueous methods of nanomaterials, coprecipitation, observation and measurement of size and structure at the nanoscale by XRD, AFM,TEM, etc.Nano catalyst preparation methods and applications,

- **ENERGY SECTORS: NANOMATERIALS SYNTHESIS** **(9 Hours)**
- Nanomaterials synthesis and thin film preparation for energy sectors, various types of thin film synthesis methods, Coater and CVD, aspects and controlling operating parameter involved, Applications of nanomaterials in Energy sectors such as various types of solar cell,

- **OTHER APPLICATIONS OF NANOMATERIALS: NANOMATERIALS SYNTHESIS** **(8 Hours)**
  Applications of nanomaterials in various types of fuel cell, water splitting, energy storage etc. Nanowires/nanorods/nanotubes synthesis.

- **OPTIMIZATION OF NANOMATERIALS FORMATION** **(8 Hours)**
  Optimization of operating parameters, finding the best optimum parameters, use of DOE

- **SCALE-UP ISSUES IN NANOMATERIALS SYNTHESIS** **(1 Hour)**
  Issues related to scale-up in nanomaterials synthesis including downstream processing

(Total Lecture Hours: 42)

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4. Books Recommended:

1. Hornyak G.L., Tibbals, H.F., Dutta, J., Moorne J. J. "Introduction to Nanoscience and Nanotechnology", CRC Press, Taylor and Francis, US, 2009.
2. Ozin G.A, Arsenault A.C., "Nanochemistry: A chemical approach to nanomaterials", Royal society of chemistry, UK, 2nd Edition, 2015.
3. Philips J. Ross,"Taguchi Techniques for Quality Engineering", McGraw-Hill, 2nd Edition, 1996.
4. Ratner M., Ratner D., "Nanotechnology: A gentle introduction to the next big idea", Prentice-Hall, New Jersey, 2002.
5. Chatopadhyay K. K., Banerjee A. N., "Introduction to Nanoscience and Nanotechnology", PHI Learning Pvt. Ltd., New Delhi, India 2009.

Elective: Biomass & Fuel Cell Technology

L	T	P	Credit
3	0	0	03

CH429 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Describe about the origin of Biomass and its scope.
CO2	Explain the conversion of biomass into liquid as a fuel.
CO3	Explain about basics of fuel cells, and their working principle.
CO4	Estimate various types of fuel cells, their applications and performance parameters.
CO5	Analyse the potential of energy storage devices and new opportunity
CO6	Design the commercialization of fuel cell technology for resource recovery.

2. Syllabus:

- **INTRODUCTION** **(3 Hours)**
  Biomass, formation on the earth, photosynthesis, Chemistry and composition of Biomass, conversion, utilization for energy and its requirement, current scenario and its scope, fuel cell technology systems and their importance, resource recovery and future of fuel cells

- **BIOMASS CONVERSION TECHNOLOGIES** **(5 Hours)**
  Pre-treatment technologies, Biomass to liquid fuels. Biomass degrading enzymes and microorganisms. Bioethanol production from lignocellulosic feed stocks, algae and sea weeds. Algae Biodiesel; Technical challenges in biodiesels production. Biomass to gaseous fuel production, Bio hydrogen Production, Concept of Bio refinery.

- **WASTE AS BIOMASS** **(6 Hours)**
  Types of liquid and solid waste, origin and its current scenario. Conventional treatment systems/schemes and associated problems. Public perception.

- **VARIOUS BIOENERGETICS** **(5 Hours)**
  Glycolysis; TCA (TriCarboxylicacid) Cycle, Respiration, Control Sites in Aerobic Glucose Metabolism, Overview of Biosynthesis, Overview of Anaerobic Metabolism, Overview of Autotrophic Metabolism.

- **OVERVIEW OF FUEL CELLS** **(8 Hours)**
  What is a fuel cell, brief history, classification, how does it work, why do we need fuel cells, Fuel cell basic chemistry and thermodynamics, heat of reaction, theoretical electrical work and potential, theoretical fuel cell efficiency. Types of fuel cells, Microbial fuel cells and their types, Hydrogen fuel cells, their components, conditions, and advancements.

- **FUEL CELL ELECTROCHEMISTRY** **(5 Hours)**
  Electrochemical techniques, Electrochemical impedance spectroscopy (EIS) and its application, cycling voltammetry and linear polarization, galvanostatic intermittent titration, electrode kinetics, types of voltage losses, polarization curve, fuel cell efficiency, Tafel equation, exchange currents. Bio-electrochemistry.

- **ENERGY STORAGE DEVICES** **(5 Hours)**
  Principle of battery, advanced rechargeable battery, Li-ion batteries, nanostructured materials for Li-ion batteries, Power management system, capacitors, and supercapicators.

- **ADVANCEMENT SCHEMES** **(5 Hours)**
  Commercialization aspects of fuel cell technology, stacking, integration and feasibility study. Resource recovery systems.

(Total Lecture Hours: 42)

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3. Books Recommended:

1. Dahiya, A. "Bioenergy: Biomass to Biofuels", Academic Press; 1st Edition, USA, 2014.
2. Rogoff, M.J. and Screve, F., "Waste-to-Energy: Technologies and Project Implementation", Elsevier Store, 2nd Edition, Kindle Edition, USA, 2011.
3. Logan, B.E., "Microbial Fuel Cells", 1st Edition, Wiley, New Jersey, 2007.
4. Hoogers, G, "Fuel Cell Technology Hand Book", CRC Press, New York, 2003.
5. Bard, A.J., Faulkner, L. R. "Electrochemical Methods" 2nd Edition, John Wiley & Sons, New York, 2000.

Elective: Computer Aided Design in Chemical Engineering

L	T	P	Credit
3	0	0	03

CH431 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	**Simulate** steady state process with process simulation program, such as ASPEN PLUS, Decide and select appropriate separation synthesis/process and Decide and select appropriate separation Equipments.
CO2	**Analyze** Multicomponent Distillation, Evaluate Heuristics for best sequence selection, Evaluate retrofitting concepts
CO3	**Design** of Column, **Evaluate** Column Diameter and **Decide** the effect of flooding, weeping, entrainment etc.
CO4	**Perform** heat integration with pinch technology, **Estimate** heat exchanger network design. **Apply** CAD in heat integration of distillation column, **Apply** CAD in heat integration of reactors
CO5	**Develop** process design/synthesis, **create** flow-sheet with input output structure, recycle structure etc.
CO6	**Design** and schedule the batch processes for optimal design.

2. Syllabus:

- **INTRODUCTION** **(3 Hours)**
  Introduction to Computer aided design in chemical engineering, Steady state and dynamic Simulation, Process simulation program (ASPEN PLUS), grass root design and retrofitting.

- **CAD IN CHEMICAL PROCESS EQUIPMENT** **(9 Hours)**
  Multicomponent distillation column design, Methods including Heuristics for Best sequence selection, Column Design for Distillation and Absorption, optimum design, parameter optimization etc. Computer aided design of chemical process equipment's,

- **CHEMICAL PROCESS DESIGN AND FLOW SHEETING** **(4 Hours)**
  Process synthesis/synthesis, Spread sheeting, Flow sheeting, Conceptual Process Design input output structure, Decision for the input output structure, Flow sheet alternatives: guidelines, Number of product streams, Gas recycle and purge.

- **SEPARATION PROCESS SELECTION** **(4 Hours)**
  Separation process selection criteria's and general thumb rules

- **EQUIPMENT SELECTION** **(3 Hours)**
  Equipment selection criteria's and general thumb rules

- **APPLICATION OF CAD IN HEAT EXCHANGER NETWORK DESIGN** **(8 Hours)**
  Pinch technology, Heat integration, and Optimum number of heat exchanger.

- **APPLICATION OF CAD IN HEAT INTEGRATION OF DISTILLATION COLUMN AND REACTORS** **(3 Hours)**
  Characteristics, Appropriate placement of column, Distillation across pinch, Grand composite curve, Design of simple distillation column to improve heat integration, heat integration of reactors

- **DESIGN AND SCHEDULING OF BATCH PROCESSES** **(5 Hours)**
  Design and scheduling of batch processes, transfer policy, size factor and multicomponent process design

- **APPLICATIONS OF CAD IN OTHER AREAS** **(3 Hours)**
  Applications of CAD in other areas such as heat transfer, mass transfer etc.

(Total Lecture Hours: 42)

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3. Books Recommended:

1. Smith R., "Chemical Process Design", McGraw-Hill, New York, 2nd Edition, 2016.
2. Douglas J., "Conceptual Design of Chemical Processes", McGraw-Hill, New York, 1989.
3. Biegler L. T., Grossmann E. I., Westerberg A. W., "Systematic Methods of Chemical Process Design", Prentice-Hall, New Jersey, 1997.
4. Sinnott R. K., "Coulson & Richardson's Chemical Engineering", Vol. 6, 4th Ed., Elsevier Publications, New York, 2005.
5. W.D.Sieder, J. D. Seader, D.R. Lewin, "Product and Process Design Principles", John-Wiley, New York, 4th Edition, 2016.

Elective: Chemical Process Development and Design

L	T	P	Credit
3	0	0	03

CH433 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Interpret concepts of process design and development.
CO2	Develop the process based on the data available.
CO3	Evaluate the sequencing of distillation column.
CO4	Identify the importance of various unit operations and their sequence.
CO5	Describe the importance of the intensification of the process.
CO6	Evaluate the design of process based on the given data.

2. Syllabus:

- **INTRODUCTION** **(2 Hours)**
  Introduction to chemical process design. Product design and development. Product life cycle.

- **PROCESS DEVELOPMENT** **(8 Hours)**
  Process design and development, General considerations for chemical process design, Basics of process scale-up, Process synthesis, Flow sheeting, Process planning and scheduling, Optimization approaches to optimal design.

- **PROCESS INTENSIFICATION** **(8 Hours)**
  Principles of process intensification, process integration. Various ways of process intensification, Process intensification for safety, Methodology, and techniques of process intensification in industrial practice.

- **REACTIVE SEPARATIONS IN FLUID SYSTEMS** **(7 Hours)**
  Techniques of reactive absorption, reactive distillation and reactive extraction and their applications.

- **SEQUENCING OF DISTILLATION COLUMNS** **(6 Hours)**
  Basic features of tall vertical equipments/ towers, Towers/Column Internal, Sequencing of distillation towers, Heat integration in distillation columns.

- **PIPING DESIGN AND RATING** **(8 Hours)**
  Basics of piping design, Pipe sizing for single phase flow and multiphase flow.

- **RADIOGRAPHIC TESTING PROCEDURE FOR PRESSURE VESSELS** **(3 Hours)**
  Surface treatment and radiographic procedure, Quality and sensitivity of radiograph, Typical radiographic examination report.

(Total Lecture Hours: 42)

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3. Books Recommended:

1. Coker A.K., “Ludwig's Applied Process Design for Chemical and Petrochemical Plants”, Vol.1, 4th Ed., Gulf Professional Publishing, 2007.
2. Douglas J., Conceptual Design of Chemical Processes, McGraw Hill, New York, 1989.
3. Soares C., “Process Engineering Equipment Handbook”, McGraw-Hill, New York, 2002.
4. Cheremisinoff N.P., “Handbook of Chemical Processing Equipment”, Butterworth Heinemann, Oxford, 2000.
5. Coulson & Richardson’s Chemical Engineering, Vol. 6, 4th Ed., Elsevier, Oxford, 2006.

Elective: Green Technology

L	T	P	Credit
3	0	0	03

CH435 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Express smart energy, green infrastructure and non-renewable energy challenges.
CO2	Analyse models that simulate sustainable and renewable green technology systems.
CO3	Describe history, global environmental & economic impacts of green technology.
CO4	Develop nanoparticles by various biological methods.
CO5	Classify the usage of microorganism for the bioremediation.
CO6	Propose the green techniques for the production of renewable.

2. Syllabus:

- **GREEN TECHNOLOGY** **(7 Hours)**
  Definition, factors affecting green technologies, co/green technologies for addressing the problems of Water, Energy, Health, Agriculture, phyto-remediation, ecological sanitation, renewable energy technologies, industrial ecology, agro ecology and other appropriate green technologies, reuse, recovery, recycle, raw material substitution, cleaner production, wealth from waste, Some case studies.

- **CLEAN TECHNOLOGY** **(13 Hours)**
  Biotechnology and Microbiology for Degradation – Aerobic and Anaerobic pathway of wastewater degradation, Biogas technology, Microbial and biochemical aspects i,e., microbial fuel cell, forward osmosis, Osmotic microbial fuel cell for industrial waste water treatment. Operating parameters for biogas production.

- **BIOMASS ENERGY** **(10 Hours)**
  Concept of biomass energy utilization, types of biomass energy, conversion processes, Wind Energy, energy conversion technologies, their principles, equipment and suitability in Indian context; Fuel-wood use in rural households. Consequences for ecosystems. Future energy scenario in rural areas. Utilization of biomass in industrial and semi-industrial settings. Future utilization of biomass in India. Future of landscape management: optimal management.

- **GREEN NANOMATERIALS** **(5 Hours)**
  Greener Synthetic Methods for Functionalized Metal Nan particles, Greener Preparations of Semiconductor and Inorganic Oxide Nano particles, green synthesis of Metal nanoparticles, Nanoparticle characterization methods.

- **BIO-POLYMER AND GREEN HYDROGEL FOR WASTEWATER** **(7 Hours)**
  Green materials: biomaterials, biopolymers, bioplastics, and composites. Natural polymer, hydrogel and its application in wastewater treatment, Shell and core hydrogel and core and shell hydrogel.

(Total Lecture Hours: 42)

3. Books Recommended:

1. Heinloth K., Energy Technologies: Renewable Energy, Springer-Verlag Berlin Heidelberg 2006,1st Edition.
2. Hammer, M.J. and Hammer M.J. Jr." Water and Wastewater Technology", 6th Ed. Prentice Hall Inc., 2008. 3. Bhatia, S.C., "Managing Industrial Pollution", Macmillan India Ltd., 2003.
3. Poole C., and Owens F., Introduction to Nanotechnology, John-Wiley, New Jersey, 2003,2nd Edition.
4. Clark J., Macquarrie D., Handbook of Green Chemistry and Technology Blackwell Series, 2002, UK, 1st Edition.
5. Ristinen, Robert Kraushaar, Jack J.A Kraushaar, Jack P. Ristinen, Robert A.,Energy and the Environment, 2nd Edition, John Wiley, 2006. 2. B. R Wilson & W J Jones, Energy, Ecology and the Environment, Academic PressInc, 2005. 3. Sarkar S, Fuels and combustion, 2nd ed., University Press, 2009.

Elective: Process Intensification

L	T	P	Credit
3	0	0	03

CH437 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Identify the scope for process intensification in chemical processes & operations.
CO2	Explain the concept of process intensification and the methodologies for PI.
CO3	Explain the operating principle of intensified technologies and its implementation.
CO4	Analyse the range of potential applications of intensified equipment.
CO5	Analyse the range of potential applications of intensified operation/process.
CO6	Appraise process challenges using intensification technologies and solve case studies.

2. Syllabus:

- **INTRODUCTION & PROCESS INTENSIFICATION TECHNIQUES** **(5 Hours)**
  Historical background & Philosophy, Principles and Domains of Process Intensification (PI), Benefits of Intensified Processes, PI Toolbox – Equipments and Methods, Active and Passive Techniques.

- **COMPACT HEAT EXCHANGERS** **(4 Hours)**
  Heat transfer intensification, Printed circuit heat exchangers, Foam heat exchangers, Micro-heat exchangers etc.

- **HIGH GRAVITY FIELDS** **(5 Hours)**
  Process fundamentals, Rotating packed bed, Design, Applications and Scale-up.

- **INTENSIFIED MIXING & REACTORS** **(10 Hours)**
  PI in stirred tanks, Spinning disc reactors, Structured reactors, Microchannel reactors.

- **REACTIVE SEPARATIONS** **(7 Hours)**
  Reactive distillation, Reactive absorption, Reactive extraction, Reactive membrane separations.

- **ENHANCED FIELDS** **(6 Hours)**
  Energy based intensifications, Sonochemistry, Microwaves, Electrostatic fields.

- **CASE STUDIES-APPLICATION AREAS** **(5 Hours)**
  Methodology and Applications, Typical case studies from industrial sectors.

(Total Lecture Hours: 42)

3. Books Recommended:

1. Reay, D., Ramshaw, C. and Harvey, A., "Process Intensification: Engineering for Efficiency, Sustainability and Flexibility", 2nd Edition, Butterworth-Heinemann , 2013.
2. Boodhoo, K. and Harvey, A., "Process Intensification Technologies for Green Chemistry", John Wiley & Sons, 2013.
3. Stankiewicz, A. and Moulijn, J.A., " Re-Engineering the Chemical Processing Plant: Process Intensification", Marcel Dekker, 2004.
4. Keil, F. J., "Modeling of Process Intensification", WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim, 2007.
5. Andrzej Stankiewicz, Tom van Gerven, Georgios Stefanidis, The Fundamentals of Process Intensification, Wiley VCH 2019.

Elective: Rheology of Complex Fluids

L	T	P	Credit
3	0	0	03

CH439 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Describe the rheological behaviour of various types of fluids like polymeric materials, dispersions, gels, etc.
CO2	Compare different methods of rheological analysis.
CO3	Justify the importance of computational rheology and rheometry.
CO4	Discuss the concepts involved and specific importanceof topics of rheology from literature.
CO5	Express the deformation of viscoelastic materials.
CO6	Estimate the rheological behaviour of complex fluids.

2. Syllabus:

- **INTRODUCTION TO RHEOLOGY AND COMPLEX FLUIDS** **(4 Hours)**
  Features and applications of complex fluids, non-Newtonian behavior, stresses, deformation and flow, Importance of study of rheology, rheological properties, mechanical rheological techniques, use of rheological data for development of new products

- **VISCOELASTIC BEHAVIOR** **(6Hours)**
  Characterization of viscoelastic materials, Linear viscoelasticity. Non-linear viscoelasticity: rate-dependent and time-dependent shear and extensional viscosity, time-dependent superposition,normal stresses in shear. Elementary theories of non-linear viscoelastic behavior.

- **METHODS OF RHEOLOGICAL STUDIES** **(6 Hours)**
  Shear and extensional rheology, compressional rheology and their applications.

- **COMPUTATIONAL RHEOLOGY** **(4Hours)**
  Methods of computational rheology, micro-macro approach, macroscopic approach, applications.

- **RHEOLOGY OF POLYMERIC MATERIALS** **(5Hours)**
  Molecular origin of polymer melts, concentrated solution, rheological behavior of polymer melts, non-linear viscoelasticity of entangled polymers, flexible polymers, linear viscoelasticity of entangled polymers, polymer gels, transient network models, fine-grained theories of polymer dynamics, kinetic theory models for dilute polymer solutions.

- **RHEOLOGY OF DISPERSIONS** **(8Hours)**
  Flow properties of suspensions, emulsions, filled systems, gels, yield stresses of particulate gels, their measurements, and applications.

- **RHEOMETRY** **(3Hours)**
  Shear and extensional rheometry, Measurement of rheology in shearing deformation and flows, techniques of measurement, features of various types of rheometers.

- **SELECTED TOPICS FROM CURRENT LITERATURE** **(6Hours)**

(Total Lecture Hours: 42)

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3. Books Recommended:

1. Larson R.G., "The Structure and Rheology of Complex Fluids",Oxford University Press, New York, 1999.
2. Chhabra R.P., Richardson, J.F., "Non-Newtonian Flow and Applied Rheology: Engineering Applications", 2nd Ed., Butterworth Heinemann, Oxford, 2008.
3. Pal R., "Rheology of Particulate Dispersions and Composites", CRC Press, New York, 2007.
4. Owens R.G., Phillips T.N., "Computational Rheology", Imperial College Press, London, 2002.
5. Malkin, A.Y., Isayev, A.I., "Rheology: Concepts, Methods and Applications",ChemTec Publishing, Canada, 2005.

Elective: Optimization of Chemical Process

L	T	P	Credit
3	0	0	03

CH441 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Relate the basic concept of optimization.
CO2	Formulate various process optimization problems.
CO3	Solve the chemical process optimization problems.
CO4	Relate the significance of numerical methods in linear and nonlinear programming.
CO5	Infer the application of optimization in chemical engineering.
CO6	Summarize the nontraditional optimization techniques and their applications.

2. Syllabus:

- **INTRODUCTION** **(3 Hours)**
  Maximization and minimization problems- examples, Basic concepts of optimization – Convex and concave functions, Necessary and sufficient conditions for stationary points, Degrees of freedom.

- **FORMULATION** **(4 Hours)**
  Economic objective function, Formulation of various process optimization problems and their classification.

- **UNCONSTRAINED AND CONSTRAINED SEARCH** **(13 Hours)**
  Numerical methods for optimization of one-dimensional function, Unconstrained multivariable optimization, direct search methods, Indirect first order and second order methods, Constrained multivariable optimization - necessary and sufficient conditions for constrained optimum.

- **NUMERICAL METHODS IN LINEAR PROGRAMMING AND APPLICATIONS** **(6 Hours)**
  Geometry of linear programs, Basic solution methods, Simplex algorithm and its applications.

- **NUMERICAL METHODS IN NON-LINEAR PROGRAMMING WITH CONSTRAINTS AND APPLICATIONS** **(6 Hours)**
  Quadratic programming, Generalized reduced gradients methods, Successive linear and successive quadratic programming, Dynamic programming, Integer and mixed integer programming.

- **APPLICATION OF OPTIMIZATION IN CHEMICAL ENGINEERING** **(6 Hours)**
  Optimization of staged and discrete processes, Optimal heat exchanger design, Optimal pipe diameter, Optimal design of an Ammonia reactor.

- **NONTRADITIONAL OPTIMIZATION TECHNIQUES** **(4 Hours)**
  Genetic Algorithm, Simulated Annealing.

(Total Lecture Hours: 42)

3. **Books Recommended:**

1. Edger T. F. and Himmelblau D. M., "Optimization of Chemical Process", McGraw-Hill, New York, 2001. (Reprint)
2. Rao S. S., "Engineering Optimization", New Age International, New Delhi, 2009.
3. Deb K., "Optimization for Engineering Design: Algorithms and Examples," Prentice-Hall of India, Delhi, 2012.
4. Loney N.W., "Applied Mathematical Methods for Chemical Engineers", CRS Press, Boca Raton, FL, 2015.
5. Joshi M. C. and Moudgalya K. M "Optimization: Theory and Practice", Alpha Science International Limited, Oxford, UK, 2004.

Elective: Advanced Particle Technology

L	T	P	Credit
3	0	0	03

CH422

Scheme

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Recognize the importance of powder processing and handling
CO2	Analyze the complexities involved in particles characterization
CO3	Analyze and interpret bulk powder behaviour and its interaction with surrounding.
CO4	Select and apply relevant research strategies to study behaviour and performance of particulate materials
CO5	Design particulate product based on learned concepts
CO6	Apply advanced computing techniques to understand, analyse and solve complex powder flow problems

2. Syllabus:

- **PARTICLE PROPERTIES AND MEASUREMENT – I** **(3 Hours)**
  Particle size measurement, analysis, Fine particle statistics, Different types of shape descriptors, Image processing for shape characterization, Particle Packing and Product Porosity, Rheology of Emulsions and Suspensions, dispersion of particles.

- **PARTICLE PROPERTIES AND MEASUREMENT – II** **(6 Hours)**
  Overview of advanced particle measurement techniques, size measurement by Dynamic light scattering, size measurement by sedimentation techniques, Introduction to imaging techniques and surface area measurement, XRD Line broadening analysis to determine crystallite size and strain.

- **FUNDAMENTALS AND ADVANCEMENT IN PARTICULATE MATERIALS HANDLING** **(7 Hours)**
  Powder mixing for particulate product formulations and powder flow characterization, powder flowability index, Pharmaceutical powder formulation and Tabletting operations, Stresses in powder, Storage of powder in silo and silo design.

- **FLUIDIZATION OF FINE POWDERS (MICRONIC AND NANOPARTICLES)** **(4 Hours)**
  Introduction to fundamentals of fluidization, Modified Geldart's powder classification, Modified Richardson-Zaki equation for fine particles and Fluidization of nanoparticlultes assemblies, Fluidization assistance techniques, Flow additives to improve fluidization behaviour of fine powder beds.
- **DISCRETE ELEMENT METHOD (DEM) TO MODEL PARTICULATE PROCESSES** **(9 Hours)**
  Introduction to Discrete Element analysis/simulation and application, General formulation of discrete element method, Governing equation and force models, contact and non-contact forces between particles, fluid-particle interaction forces, constitutive relations for granular materials, Integration schemes and damping algorithms for DEM, Contact Detection models

:Soft contact model, Hertz contact model, Adhesive elastic contact Model, Generalized methodology to run DEM simulation using LIGGHTS (Open source DEM software).

- **ADVANCED PARTICLES PRODUCTION AND STABILIZATION TECHNIQUES** **(5 Hours)**

  Introduction to Powder production techniques. Wet media milling in agitated bead mill and planetary mill, Methods of stabilization of particles dispersion, electrostatic and electrosteric stabilization, Chemical surface modification of particles in suspension, Zeta potential of suspension.

- **PREPARATION OF PARTICULATE PRODUCT** **(8 Hours)**

  Effects of powder and slurry properties on Preparation of advanced Ceramic materials, effects of particle size on Sintering of powders, dry powder inhalers, pigments and paints dispersions.

(Total Lecture Hours: 42)

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3. Books Recommended:

1. Rhodes M. "Introduction to Particle Technology", 2nd Edition, John Wiley & Son, Chichester, (2008).
2. Henk G. Merkus, "Particle Size Measurements: Fundamentals, Practice, Quality", Springer Particle Technology Series, Volume 17 2009.
3. Dietmar Schulze, "Powders and Bulk Solids: Behavior, Characterization, Storage and Flow", Springer-Verlag Berlin Heidelberg 2008.
4. Colin Thornton, Granular Dynamics, Contact Mechanics and Particle System Simulations: A DEM study, Particle Technology Series, Volume 24, 2015
5. Liang-Shih Fan, Chao Zhu, "Principles of Gas-Solid Flow", 1st Edition, Cambridge University Press, New York, 1998.

Elective: Advanced Process Control

L	T	P	Credit
3	0	0	03

CH424

Scheme

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the concept of advanced control schemes used in process control
CO2	Develop control relevant linear perturbation models
CO3	Explain the concept of digital control system
CO4	Focus the use of soft computing techniques in process control
CO5	Analyse interaction in multi loop control
CO6	Analyse stability of digital control system

2. Syllabus:

- **INTRODUCTION AND MOTIVATION** **(4 Hours)**
  Introduction, Application; Plant wide control
- **DIGITAL SAMPLING, FILTERING AND CONTROL** **(5 Hours)**
  Sampling and signal reconstruction, Signal processing and data filtering
- **DEVELOPMENT OF CONTROL RELEVANT LINEAR PERTURBATION MODELS** **(6 Hours)**
  Development of Control Relevant Linear Perturbation Models; Linearization of Mechanistic Models; Introduction to z-transforms and Development of Grey-box models
- **DEVELOPMENT OF LINEAR BLACK-BOX DYNAMIC MODELS** **(10 Hours)**
  Introduction to Stochastic Processes; Development of ARX models; Statistical Properties of ARX models and Development of ARMAX models; Issues in Model Development; Model Structure Selection and Issues in Model Development; Issues in Model Development and State Realizations of Transfer Function Models
- **STABILITY ANALYSIS, INTERACTION ANALYSIS AND MULTI-LOOP CONTROL** **(6 Hours)**
  Stability Analysis of Discrete Time Systems; Lyapunov Functions; Jury's Stability Test.
- **MULTILOOP AND MULTIVARIABLE CONTROL** **(6 Hours)**
  Interaction Analysis and Multi-loop Control; Pairing of controlled and Manipulated Variables; RGA and Singular Value Analysis; Decoupling and Multivariable Control Stratigies
- **STATE ESTIMATION AND KALMAN FILTERING** **(5 Hours)**
  Soft Sensing and State Estimation, Development of Luenberger Observer; Introduction to Kalman Filtering

(Total Lecture Hours: 42)

3. Books Recommended:

1. Astrom, K.J., and B. Wittenmark, "Computer Controlled Systems", Prentice Hall India, 3rd Edition, 1997.
2. Franklin, G.F., Powell, J.D., and M.L. Workman, "Digital Control Systems", Addison Wesley, 3rd Edition, 1997.
3. Seborg, D.E., Edgar, T.F., and Mellichamp, D.A., "Process Dynamics and Control", Wiley, 3rd Edition, 2010.
4. Goodwin, G.C., S.F. Graebe, M.E. Salgado, "Control System Design", Prentice Hall, 2000.
5. Stephanopoulos, G., "Chemical Process Control: An Introduction to Theory and Practice", Prentice Hall India, 2008

Elective: Computational Fluid Dynamics

L	T	P	Credit
3	0	0	03

CH426

Scheme

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain fundamentals of computational methods in fluid flow applications
CO2	Analyze Initial Boundary Value problems and determine various quantities of interest
CO3	Apply appropriate solution strategy and estimate the accuracy of the results for a given flow case
CO4	Select and formulate various CFD problems by considering appropriate boundary conditions
CO5	Adapt to various commercial software for solving numerical problems
CO6	Interpret computational results

2. Syllabus:

- **INTRODUCTION AND GOVERNING EQUATIONS** **(5 Hours)**
  Introduction, Classification of partial differential equations, Navier-Stokes system of equations, Boundary conditions.

- **FINITE DIFFERENCE METHODS** **(5 Hours)**
  Basic aspects of finite difference equations, Derivation of finite difference equations, Accuracy of finite difference solutions,

- **SOLUTION METHODS OF FINITE DIFFERENCE EQUATIONS** **(6 Hours)**
  Methods for Elliptic, Parabolic and Hyperbolic equations, Implicit and explicit schemes, Von Neumann stability analysis, Example problems.

- **INCOMPRESSIBLE VISCOUS FLOWS** **(6 Hours)**
  General, Artificial compressibility method, Pressure correction methods, Vortex methods.

- **COMPRESSIBLE FLOWS** **(6 Hours)**
  Potential equation, Euler equations, Navier-Stokes system of equations, Preconditioning process for compressible and incompressible flows.

- **INTRODUCTION TO FINITE VOLUME METHOD** **(4 Hours)**
  Integral approach, discretisation & higher order schemes.

  INTRODUCTION TO FINITE ELEMENT METHOD **(4 Hours)**
  Finite element formulations, definition of errors, Finite element interpolation functions.

- **APPLICATIONS** **(6 Hours)**
  Chemically reactive flows, Heat transfer and Multiphase flow.

(Total Lecture Hours: 42)

3. Books Recommended:

1. Anderson J.D., "Computational Fluid Dynamics", McGraw-Hill International Editions, 1995.
2. Patankar S.V., "Numerical Heat Transfer and Flow" , McGraw Hill, New York, 2002.
3. Ferziger J. H. and Peric M., "Computational Methods in Fluid Dynamics ", Springer, New York, 2003.
4. Muralidhar K. and Sunderrarajan T., "Computational Fluid Flow and Heat Transfer ", Narosa Publishing House, New Delhi, 2nd Edition, 2003.
5. Chung T. J., "Computational Fluid Dynamics", Cambridge University Press, London, 2nd Edition, 2014.

Elective: Design of Experiments

L	T	P	Credit
3	0	0	03

CH428

Scheme

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the importance of statistical approach in research and experimental planning.
CO2	Select suitable data set for analysis of the results.
CO3	Devise effective ways to conduct experiments and obtain optimum conditions.
CO4	Analyze effect of various factors using analysis of variance.
CO5	Apply various methods of factorial designs (2^K method, Response surface method, Taguchi method) for a given set of parameters.
CO6	Interpret experimental results with softwares.

2. Syllabus:

- **REVIEW OF BASIC STATISTICAL CONCEPTS** **(2 Hours)**
  t-Distribution, F-distribution, Confidence intervals, Hypotheses testing
- **FUNDAMENTALS OF EXPERIMENTAL DESIGN** **(4 Hours)**
  Experimentation, Basic principles of Design, Steps in experimentation, Choice of sample size, Normal probability plot, Rejection of data, Linear regression
- **INTRODUCTION TO THE ANALYSIS OF VARIANCE (ANOVA)** **(6 Hours)**
  Understanding variation, No-way ANOVA, One-way ANOVA, Two-way ANOVA, Three-way ANOVA, Use of relevant software
- **SINGLE, MULTI-FACTORIAL EXPERIMENTS** **(4 Hours)**
  Completely randomized design, Block Design, Latin and Graeco-latin square design, Two-factor experiments, Three-factor experiments, Degree of freedom and sum of squares.
- **2^K FACTORIAL EXPERIMENTS AND DESIGNS** **(5 Hours)**
  2^2 Factorial design, 2^3 Factorial design, 2^k Factorial design, Blocking and confounding
- **RESPONSE SURFACE METHODS** **(5 Hours)**
  Response surface designs (Central composite design; Box-behnken design), Use of relevant software
- **QUALITY LOSS FUNCTIONS** **(2 Hours)**
  Nominal-the better case, Smaller-the better case, Larger-the better case, Estimation of quality loss.
- **TAGUCHI METHOD** **(14 Hours)**
  Development of orthogonal designs, Robust design; Data analysis, Multi-level factor designs, Multi-response optimization, Use of relevant software

(Total Lecture Hours: 42)

3. Books Recommended:

1. Ross P. J., "Taguchi Techniques for Quality Engineering", McGraw-Hill Book Co, New York, U.S.A., 1989.
2. Krishnaiah K., Shahabudeen P., "Applied Design of Experiments and Taguchi Methods", PHI Learning, India, 2012.
3. Taguchi G., Chowdhury S., Wu Y., "Taguchi's Quality Engineering Handbook", John Wiley and Sons, New York, U.S.A., 2005.
4. Montgomery D. C., "Design and Analysis of Experiments", 5th edition, John Wiley and Sons, New York, U.S.A., 2001.
5. Lazic Z. R., "Design of Experiments in Chemical Engineering", Wiley-VCH Verlag GmbH & Co., Germany, 2004.

Elective: Fluidization Engineering

L	T	P	Credit
3	0	0	03

CH432

Scheme

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Recognize the capability of fluidized bed system to conduct different types of chemical engineering operations (e.g. fluid-particle mechanics, bubble mechanics, mass transfer, heat transfer, chemical reaction engineering, drying, mixing, granulation)
CO2	Calculate operating parameters of fluidized bed system (e.g., Pressure drop, minimum fluidization velocity, voidage of bed, voidage and height of fluidized bed at different velocity)
CO3	Identify fluidization regime using process variables.
CO4	Classify different types of fluidized bed system.
CO5	Predict behaviour of gas solid and liquid solid fluidized bed system.
CO6	Design and develop gas-solid contacting system based on different fluidized bed models.

2. Syllabus:

- **INTRODUCTION** **(2 Hours)**
  Introduction to phenomenon of fluidization; Types of fluidization operations; Typical industrial applications of fluidized beds.

- **PARTICLE CHARACTERIZATION AND DYNAMICS** **(2 Hours)**
  Overview of advanced particle measurement techniques, size measurement by Dynamic light scattering, size measurement by sedimentation techniques, Introduction to imaging techniques and surface area measurement, XRD Line broadening analysis to determine crystallite size and strain.

- **FLUIDIZED BED HYDRODYNAMICS** **(6 Hours)**
  Estimation of minimum fluidization velocity; Mapping of Fluidization regimes, Gas distributor types; Fluidity and power consumption

- **BUBBLING BED BEHAVIOUR AND BUBBLE DYNAMICS** **(9 Hours)**
  Bubbles in liquid and fluidized bed, jet penetration and bubble formation, bubble shape, size and stability, models of bubbling beds, Davidson's isolated bubble model, two phase theory of fluidization, coalescence and splitting of bubbles, slugging conditions in fludized bed, Kuni-levenspiel model.

- **ELUTRIATION IN FLUIDIZED BED** **(3 Hours)**
  Basics of elutriation, Estimation of transport disengaging height (TDH), Empirical correlations for estimation of elutriation rate. Estimation of TDH for Geldart's A group powder.

- **FLUIDIZATION OF MICRONIC POWDERS AND NANOPARTICULATE ASSEMBLIES** **(3 Hours)**
  Modified Richardson zaki equation for nanoparticles fluidization, Nanoparticle fluidization and Geldart's classification.

- **HEAT AND MASS TRANSFER IN FLUIDIZED BED** **(4 Hours)**
  General characteristics and correlations of heat transfer in fluidized bed, Heat transfer between gas-particle and bed surfaces, Effects of parameters on rate of heat transfer, General characteristics and correlations of mass transfer in fluidized bed, Mass transfer between different phases of fluidized bed.

- **FLUIDIZED BED REACTOR DESIGN** **(7 Hours)**
  Basics of reactor design, Different approaches of reactor design, Reactor design using Kuni-levenspiel model

- **SCALE UP OF FLUIDIZED BED** **(3 Hours)**
  Generalized scaling laws for fluidized bed system

- **CASE STUDIES ON TYPICAL APPLICATIONS OF FLUIDIZED BED SYSTEMS** **(3 Hours)**
  Coating and granulation, FCC, Gasification.

(Total Lecture Hours: 42)

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3. Books Recommended:

1. Kunii, D. and Levenspiel, O., "Fluidization Engineering", 2nd ed., Elsevier, New Delhi, 2005.
2. Wen-Ching Yang, "Handbook of Fluidization and Fluid-Particle Systems", Marcel Dekker.
3. Davidson, J.F. and Harrison, D., "Fluidized Particle", Book Chapter Cambridge University Press.
4. Gibilaro, L. G., "Fluidization Dynamics, The formulations & applications of predictive", 1st Edition, Butterworth-Heinemann (2001).
5. Howard, J.R. Fluidized Bed Technology: Principles and Applications. 1st ed., CRC press (1989)

Elective: Heterogeneous Catalysis

L	T	P	Credit
3	0	0	03

CH434 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Demonstrate concepts of physical adsorption and chemisorption of gases on metals and oxides
CO2	Evaluate catalyst deactivation and determine structure of catalyst
CO3	Analyze and evaluate performance of catalyst based on characterization techniques (e.g., Surface area, pore size distribution, pore volume; XRD; IR; DTG-TGA)
CO4	Analyze and compare catalysis in different industries (e.g., Petrochemicals, Refining, Fertilizers, etc. Processes)
CO5	Illustrate advance concepts in heterogeneous catalysis
CO6	Identify appropriate catalysts and corresponding operating conditions for a given process

2. Syllabus:

- **ADSORPTION IN CATALYSIS** **(7 Hours)**
  Physical adsorption of gases, chemisorption of gases on metals and oxides, theoretical aspects of catalysis.

- **CHARACTERIZATION OF CATALYTIC MATERIALS** **(10 Hours)**
  Surface area, pore size distribution, pore volume, pore volume, XRD, IR, DTG-TGA, NMR, UV-visible, NH_3 TPD. Catalyst structure: Nature of active site

- **SYNTHESIS OF POROUS SOLIDS** **(2 Hours)**
  Oxides and zeolites.

- **HETEROGENEOUSLY CATALYZED CATALYTIC REACTIONS** **(12 Hours)**
  Catalytic oxidation reactions, catalysis by solid acids, catalysis in production of petrochemicals, catalysis in refining processes, catalyst deactivation and regeneration protocol.

- **CATALYTIC PROCESS ENGINEERING** **(3 Hours)**
  Kinetics, catalytic reactor engineering.

- **NEW DEVELOPMENTS** **(8 Hours)**
  New understanding in catalysis, catalysis in motion, nanoalloy catalysis.

(Total Lecture Hours: 42)

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3. Books Recommended:

1. Catalysis: Principles and Applications, B. Viswanathan, S. Sivasankar, A.V. Ramaswamy (Eds.) Narosa Publishing House, New Delhi, 2002.
2. J.M. Thomas, W.J. Thomas, Principles and Practice of Heterogeneous Catalysis, 2nd Ed., Wiley-VCH, Weinheim, 2015.
3. Green Chemistry and Catalysis, Roger A. Sheldon, Isabel Arands, Ulf Hanfeld, Wiley-VCH, 2007.
4. Chemical Reaction Engineering, Octave Levenspiel, John Wiley & Sons, 3rd Edition, 2008
5. Chemical Reaction Engineering – II, K. A. Gavhane, Nirali Publications, 5th Edition, 2009.

Elective: Interfacial Science and Engineering

L	T	P	Credit
3	0	0	03

CH436

Scheme

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain about interfaces and methods to measure them
CO2	Summarize various types of colloidal dispersions and their stability
CO3	Describe about the surface forces
CO4	Discuss various transport processes at interface
CO5	Describe the criteria for stability of thin films between interfaces
CO6	Solve the problems of stability of thin films based on given conditions

2. Syllabus:

- **INTRODUCTION TO INTERFACIAL SCIENCE AND ENGINEERING** **(2 Hours)**
  Introduction of colloids and interfacial science, applications and scope of interfacial science and engineering.

- **INTERFACIAL TENSION** **(3 Hours)**
  Thermodynamic approach of interfacial tension, mechanical approach of interfacial tension, equilibrium shape of fluid interfaces, methods of measuring interfacial tension.

- **INTERFACES** **(6 Hours)**
  Energy and stress based characterization, Young-Laplace and Kelvin equations for curved interfaces, flux and momentum balances for interfaces, solid-fluid interfaces, free interfaces, interfaces in motion, rheology of interfaces.

- **COLLOIDAL DISPERSIONS** **(7 Hours)**
  Forces in colloidal systems, stability of emulsions and foam, DLVO theory, surfactants, self-assembly, thermodynamics of monolayers, micelles, reverse micelles, vesicles, critical miceller concentration, creaming, flocculation, coalescence, Ostwald ripening, zeta potential, electrophoresis, electro-osmosis, micro-emulsions.

- **PARTICLES AT INTERFACES** **(6 Hours)**
  Pickering emulsions, effects of particles at interfaces, pattern formation, contact angle hysteresis, wetting and spreading, work of adhesion and cohesion.

- **TRANSPORT PHENOMENA AT INTERFACES** **(5 Hours)**
  Interfacial mass transfer, interfacial instability during mass transfer, transport theorem for body containing intersection dividing surfaces, Marangoni flow, stability of moving interfaces with chemical reactions, dynamic interfaces.

- **BUBBLES, DROPS AND THIN FILMS** **(7 Hours)**
  Interactions of bubbles or drops in dispersed systems, interaction forces in interfacial systems, stability of thin films

- **SELECTED TOPICS FROM CURRENT LITERATURE** **(6 Hours)**

(Total Lecture Hours: 42)

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3. Books Recommended:

1. Slattery J.C., Sagis L., and Oh E.-S., "Interfacial Transport Phenomena", 2nd Ed., Springer, New York, 2007.
2. Rosen M.J., "Surfactants and Interfacial Phenomena", 4th Ed., John Wiley & Sons, New Jersey, 2012.
3. Stokes R.J., Evans D.F., "Fundamentals of Interfacial Engineering", Wiley – VCH, New York, 1997.
4. Miller C.A., Neogi P., "Interfacial Phenomena: Equilibrium and Dynamic Effects", 2nd Edition, CRC Press, N.Y., 2019.
5. Israelachvili J.N., "Intermolecular and Surface Forces", 3rd Ed., Academic Press, New York, 2015.

Elective: New Separation Techniques

L	T	P	Credit
3	0	0	03

CH438

Scheme

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Analyze the fundamental concepts of separation processes
CO2	Understand the principles and process of crystallization
CO3	Classify various membrane based separation processes and its applications
CO4	Explain the properties of colloidal separation
CO5	Interpret the surfactant-based separation
CO6	Understand the supercritical fluid extraction

2. Syllabus:

- **FUNDAMENTALS OF SEPARATION PROCESSES** **(4 Hours)**
  Basic definitions of relevant terms, classification, separation processes in chemical process industries, categorization of separation processes, equilibrium and rate governed processes.

- **CRYSTALLIZATION AND REACTIVE SEPARATIONS** **(7 Hours)**
  Concept, Different types of crystallization, phase equilibrium, different techniques, commercial applications, Cavitations and its application in crystallization, Reactive crystallization.

- **MEMBRANE BASED SEPARATION PROCESSES** **(15 Hours)**
  Historical background, physical and chemical properties of membranes, techniques of membrane preparation, membrane characterization, various types of membranes and modules. Details and applications of various membrane separation processes.

- **EXTERNAL FIELD INDUCED MEMBRANE SEPARATION PROCESSES FOR COLLOIDAL PARTICLES** **(6 Hours)**
  Fundamentals of various colloid separations. Derivation of profile of electric field strength. Coupling with membrane separation and electrophoresis.

- **SURFACTANT BASED SEPARATION PROCESSES** **(8 Hours)**
  Cloud point extraction, Micellar enhanced separation processes.

- **SUPERCRITICAL FLUID EXTRACTION** **(2 Hours)**
  Working Principle, Advantages & Disadvantages of supercritical solvents over conventional liquid solvents, commercial applications of supercritical extraction, Applications under research

(Total Lecture Hours: 42)

3. Books Recommended:

1. Wankat P. C., “Rate-Controlled Separations”, Elsevier Applied Science, New York, 1990.
2. Bungay P.M., Lonsdale H.K. & de Pinho M.N. (Eds.), “Synthetic Membranes: Science, Engineering and Applications”, NATO ASI Series, Vol.181, D.Reidel Publishing Company, Dordrecht, Holland, 1986
3. Kaushik Nath, "Membrane Separation Processes" , 1st Edition, PHI pvt.Ltd., New Delhi, 2008.
4. Seader J.D., Henley E.J. & Roper D.K., "Separation Process Principles",4th Edition, John Wiley & Sons, Inc. Hoboken, New Jersey,2016
5. Kulprathipanja S. “Reactive Separation Processes” , Taylor and Francis, New York, 2002.

Elective: Chemical Engineering Plant Design and Economics

L	T	P	Credit
3	0	0	03

CH442

Scheme

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Appraise criteria for selection of a process and explain the importance of plant location and plant layout, cost estimation and profitability analysis of process plants
CO2	Construct flow diagrams for a given reaction with known conditions.
CO3	Recognize the importance of process utilities and auxiliaries for better plant operations.
CO4	Prepare the control strategies for a given process flow diagram with known conditions.
CO5	Compare various equipment's for the same activity based on economy.
CO6	Appraise the concept of optimization in plant operation and importance of project management tools (PERT and CPM) in process industries.

2. Syllabus:

- **INTRODUCTION** **(2 Hours)**
  Basic consideration in chem. Engg. plant design, project identification, preliminary techno-economic feasibility.

- **PROCESS DESIGN ASPECTS** **(4 Hours)**
  Selection of process, factors affecting process selection, types of flow diagrams.

- **SELECTION OF PROCESS EQUIPMENT** **(2 Hours)**
  Standard versus special equipment, materials of construction, selection criteria etc.

- **PROCESS AUXILIARIES** **(3 Hours)**
  Piping design, layout, support for piping insulation, types of valves, process control & instrumentation control system design.

- **PROCESS UTILITIES** **(4 Hours)**
  Process water, boiler feed water, water treatment & disposal, steam, oil heating system, chilling plant, compressed air and vacuum system.

- **PLANT LOCATION AND LAYOUT** **(4 Hours)**
  Factors affecting plant location, use of scale models.

- **COST ESTIMATION** **(6 Hours)**
  Factors involved in project cost estimation, total fixed & working capital, types & methods of estimation of total capital investment, estimation of total product cost, factors involved.

- **DEPRECIATION** **(3 Hours)**
  Types and methods of determination, evaluation.

- **PROFITABILITY** **(4 Hours)**
  Alternative investment & replacement methods for profitability evaluation, economic consideration in process and equipment design, inventory control.
- **OPTIMUM DESIGN** **(2 Hours)**
  General products rates in plant operation, optimum conditions etc.
- **PRODUCTION, PLANNING, SCHEDULING AND CONTROL** **(8 Hours)**
  Introduction, PERTS & CPM

(Total Lecture Hours: 42)

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3. Books Recommended:

1. Peters M.S., Timmerhaus, K.D., "Plant Design and Economics for Chemical Engineers", 4th Ed., McGraw-Hill, Singapore, 1991.
2. Vilbrant F.C., Dryden, C.E., "Chemical Engineering and Plant Design", 4th Ed., McGraw-Hill, New York, 1959.
3. Pant J.C. "CPM and PERT with Linear Programming", Jain Brothers, New Delhi, 1986.
4. Davis, G.S, "Chemical Engineering Economics and Decision Analysis", CENDC, I.I.T., Madras, 1981.
5. Holland, F.A., Watson, F.A and Wilkinson, J.K., "Introduction to Process Economics", Wiley, New York, 1974.

Elective: Safety and Pollution Control in Chemical Process Industries

L	T	P	Credit
3	0	0	03

CH440

Scheme

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Express knowledge about types of pollution, its sources, effects and control
CO2	Classify Industrial Laws and Act.
CO3	Describe different methods of hazard analysis and control of hazards.
CO4	analyze different types of fire and explosions and its control
CO5	Explain about the quantification and analysis of wastewater and treatment.
CO6	Propose various analysis and quantification of hazardous and nonhazardous solid waste, treatment and disposal

2. Syllabus:

- **ENVIRONMENTAL AND POLLUTION IN CHEMICAL INDUSTRIES** **(2 Hours)**
  Definitions, scope and importance, need for public awareness, sources of pollution from Chemical industries

- **ENVIRONMENTAL LAWS AND STANDARDS** **(3 Hours)**
  Laws related to solid, liquid and gases effluents, standards and legislations, Health and environmental effects, case studies for specific industries like petrochemicals, fertilizers, desalination, petroleum refining.

- **POLLUTION PREVENTION THROUGH PROCESS MODIFICATION** **(9 Hours)**
  Recovery of by-products, Energy recovery, Waste utilization and recycle and reuse and waste generation minimization

- **AIR POLLUTION CONTROL** **(5 Hours)**
  Air pollution control through mechanical separation, adsorption, etc

- **WATER POLLUTION CONTROL** **(5 Hours)**
  Water pollution control by physical, chemical and biochemical methods

- **DESIGN OF CONTROL EQUIPMENT AND SYSTEMS** **(6 Hours)**
  Designs to prevent fires and explosions, fire triangles, fault tree analysis, case studies

- **SOLID WASTE TREATMENT AND DISPOSAL** **(4 Hours)**
  Types of solid waste, generation, onsite handling, storage & processing, Disposal techniques, recovery of resources, conversion products and energy

- **SAFETY IN CHEMICAL PROCESS INDUSTRIES** **(8 Hours)**
  Safety and loss prevention, safety systems, Hazardus properties of chemicals, characterization of chemical processes, the nature and impact of chemical plant accidents, occupational safety and industrial hygiene, Toxicology, toxic release, case studies

(Total Lecture Hours: 42)

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3. Books Recommended:

1. Crowl D. A., Louvar J. F., "Chemical Process Safety", Prantice-Hall, 2nd Ed., New York, 2002.
2. Metcalf & Eddy, "Waste Water Engineering: Treatment, Disposal and Reuse", Tata-McGraw-Hill, New Delhi, 2002.
3. MaCarty S., "Chemistry for Environmental Engineering", Tata-McGraw-Hill, New Delhi, 2004.
4. Rao C.S., Environmental Engineering, Wiley Eastern Limited, New Delhi, 1995.
5. Sanders R E., "Chemical Process Safety", Butterworth-Heinemann, New Delhi, 2005.

Elective: SAFETY, HAZARD AND RISK ANALYSIS

L	T	P	Credit
3	0	0	03

CH446 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Recognize the importance of safety in any chemical process industries.
CO2	Adapt the basic fundamentals of chemical process safety, laws of safety.
CO3	Apply various the methods of hazard identification for any chemical process.
CO4	Perform the risk analysis and risk assessment for any system to minimize the hazards.
CO5	Adapt the important learnings from the Case Histories.
CO6	Summarize the characteristics of various causes of incidents like toxic release, fire and explosion etc.

2. Syllabus:

- **SAFETY** **(10 Hours)**
  Safety Programs, Engineering Ethics, Accident Loss Statistics- FAR, OSHA, Fatality rate, Acceptable risk, Public Perceptions, Inherent safety, Nature of the accident process and their steps, Case Studies: Flixborough, England, Bhopal Gas Tragedy, A massive explosion in Pasadena, Leakage of 2,3,7,8-tetrachlorodibenzoparadioxin in Seveso, Related to Static Electricity, Chemical Reactivity, System Designs, Procedures.

- **HAZARDS AND ITS IDENTIFICATION** **(10 Hours)**
  Toxicology: Entry of toxicants in Biological organism (BO), Elimination of Toxicant from BO, Effect of Toxicants in BO, Dose Versus Response, TLVs; **Fire And Explosion**: The fire triangle, Distinction between Fire and explosion, estimation of flammability characteristics of vapor and liquids, Limiting oxygen characteristics and inerting, Detonation and deflagration, BLEVE, Vapor-cloud explosion, Fire extinguisher. **Methods of Hazard Identification**: Process hazard checklists, HAZOP study, Safety Reviews, Other methods, Problem solving.

- **RISK ANALYSIS** **(10 Hours)**
  Review of Probability theory, Probability of Coincidence, Revealed & Unrevealed failures, Fault tree analysis, Cut Sets, Path sets, Reliability diagram, Event tree analysis, Quantitative risk analysis, Layer of Protection analysis, Consequence, Frequency, Problems solving.

- **CASE HISTORIES** **(12 Hours)**
  Static Static Electricity:Tank Car Loading Explosion, Explosion in a Centrifuge, Duct System Explosion; Chemical Reactivity: Bottle of Isopropyl Ether, etc; System Designs: Ethylene Oxide Explosion, Ethylene Explosion, Butadiene Explosion, Pump Failure etc ; Procedures: Leak Testing a Vessel, Man Working in Vessel, Vinyl Chloride Explosion

etc , Dangerous Water Expansion, Phenol-Formaldehyde Runaway Reaction, Conditions and Secondary Reaction Cause Explosion etc .

(Total Lecture Hours: 42 Hours)

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3. Books Recommended:

1. Crowl D. A., Louvar J. F., “Chemical Process Safety”, Prentice-Hall, 2nd Ed., New York, 2002.
2. Sanders R E., “Chemical Process Safety”, Butterworth-Heinemann, New Delhi, 2005.
3. Perry's Chemical Engineers’ Handbook, 8th Edition
4. "Lees' Loss Prevention in the Process Industries: Hazard Identification, Assessment and Control", Butterworth-Heinemann, 2012.
5. Raju, K.S.N., “Chemical Process Industry Safety”, McGraw Hill Education Pvt Ltd. (India), 2014.

B. Tech. IV (Chemical Engineering), Semester - VIII

Innovation, Incubation and Entrepreneurship

L	T	P	Credit
3	0	0	04

HU 402 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the concepts of Entrepreneurship
CO2	Develop skills related to various functional areas of management (Marketing Management, Financial Management, Operations Management, Personnel Management etc.)
CO3	Develop skills related to Project Planning and Business Plan development
CO4	Demonstrate the concept of Innovation, Intellectual Property Rights (IPR) and Technology Business incubation
CO5	Build knowledge about Sources of Information and Support for Entrepreneurship
CO6	Develop Entrepreneurial Culture

2. Syllabus:

- **CONCEPTS OF ENTREPRENEURSHIP** **(10 Hours)**

  Scope of Entrepreneurship, Definitions of Entrepreneurship and Entrepreneur, Characteristics of an Entrepreneur, Entrepreneurial Development models and Theories, Entrepreneurs Vs Managers Classification of Entrepreneurs; Major types of Entrepreneurship – Techno Entrepreneurship, Women Entrepreneurship, Social Entrepreneurship, Intrapreneurship (Corporate entrepreneurship), Rural Entrepreneurship, Family Business etc.; Problems for Small Scale Enterprises and Industrial Sickness; Entrepreneurial Trait Tests; Entrepreneurial Environment – Political, Legal, Technological, Natural, Economic, Socio – Cultural etc. ; Motivation; Business Opportunity Identification

- **FUNCTIONAL MANAGEMENT AREA IN ENTREPRENEURSHIP** **(12 Hours)**

  Marketing Management: Basic concepts of Marketing, Development of Marketing Strategy and Marketing plan, Online Marketing, New Product Development Strategy

  Operations Management: Basic concepts of Operations management, Location problem, Development of Operations strategy and plan

  Personnel Management: Main operative functions of a Personnel Manager, Development of H R strategy and plan

  Financial Management: Basics of Financial Management, Ratio Analysis, Capital Budgeting, Working Capital Management, Cash Flow Statement, Break Even Analysis

- **PROJECT PLANNING** **(6 Hours)**

  Product Development – Stages in Product Development; Feasibility analysis – Technical, Market, Economic, Financial etc.; Project report; Project appraisal; Setting up an Industrial unit – procedure and formalities in setting up an Industrial unit; Business Plan Development

- **PROTECTION OF INNOVATION THROUGH IPR** **(4 Hours)**

  Introduction to Intellectual Property Rights – IPR, Patents, Trademarks, Copy Rights

- **INNOVATION AND INCUBATION** **(6 Hours)**

  Innovation and Entrepreneurship, Creativity, Green Technology Innovations, Grassroots Innovations, Issues and Challenges in Commercialization of Technology Innovations, Introduction to Technology Business Incubations, Process of Technology Business Incubation

- **SOURCES OF INFORMATION AND SUPPORT FOR ENTREPRENEURSHIP** **(4 Hours)**

  State level Institutions, Central Level institutions and other agencies

Tutorial: Case Study Discussion, Group Discussion, Management games and Assignments / Mini projects & presentation on related Topics

(Total Lecture Hours: 42 + Tutorial Hours: 14)

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3. Books Recommended:

1. Desai Vasant, "Dynamics of Entrepreneurial Development and Management", Himalaya Publishing House, India, 6th Revised Edition, 2011
2. Charantimath P. M., "Entrepreneurial Development and Small Business Enterprises", Pearson Education, 3rd Edition, 2018
3. Holt David H., Entrepreneurship: New Venture Creation, Pearson Education, 2016
4. Chandra P., Projects: Planning, Analysis, Selection, Financing, Implementation and Review, Tata McGraw Hill, 9th Edition, 2019
5. Banga T. R. &Shrama S.C., Industrial Organisation& Engineering Economics, Khanna Publishers, 25th Edition, 2015

Teaching Scheme
B.Tech. Civil Engineering

SEMESTER - III

Sr No	Course	Code	Scheme	Exam Scheme				Total	Credit
				Theory		Tuto.	Pract.		
				Hours	Marks	Marks	Marks		
1	Engineering Mathematics -III	MA215	3-1-0	3	100	25	0	125	04
2	Hydraulic Engineering	CE201	4-1-2	4	100	25	50	175	06
3	Basic Transportation Engineering	CE203	3-1-0	3	100	25	0	125	04
4	Mechanics of Solids	CE205	3-1-2	3	100	25	50	175	05
5	Geotechnical Engineering	CE207	3-0-2	3	100	0	50	150	04
		Total		**16**	**500**	**100**	**150**	**750**	**23**

SEMESTER – IV

Sr No	Course	Code	Scheme	Exam Scheme				Total	Credit
				Theory		Tuto.	Pract.		
				Hours	Marks	Marks	Marks		
1	Environmental Engineering I	CE202	3-1-2	3	100	25	50	175	05
2	Concrete Technology	CE204	3-0-2	3	100	0	50	150	04
3	Structural Analysis I	CE206	3-0-2	3	100	0	50	150	04
4	Geomatic Surveying	CE208	3-1-2	3	100	25	50	175	05
5	Building and Town Planning	CE212	4-1-2	4	100	25	50	175	06
		Total		**16**	**500**	**75**	**250**	**825**	**24**

SEMESTER - V

Sr No	Course	Code	Scheme	Exam Scheme				Total	Credit
				Theory		Tuto.	Pract.		
				Hours	Marks	Marks	Marks		
1	Professional Ethics, Economics and Business Management	HU301	4-1-0	4	100	25	0	125	05
2	Estimation and Cost Analysis	CE301	3-1-2	3	100	25	50	175	05
3	Environmental Engineering II	CE303	3-0-2	3	100	0	50	150	04
4	Core Elective 1	CE3AA	3-0-0	3	100	0	0	100	03
5	Institute Elective-1	CE3XX	3-0-0	3	100	0	0	100	03
6	Seminar	CE305	0-0-2	0	0	0	50	50	01
		Total		**15**	**500**	**50**	**150**	**700**	**21**

SEMESTER - VI

Sr No	Course	Code	Scheme	Exam Scheme				Total	Credit
				Theory		Tuto.	Pract.		
				Hours	Marks	Marks	Marks		
1	Structural Analysis II	CE302	3-1-2	3	100	25	50	175	05
2	Highway Engineering	CE304	3-0-2	3	100	0	50	150	04
3	Water Resources Engineering	CE306	4-1-2	4	100	25	50	175	06
4	Design of Steel Structures	CE308	3-1-2	3	100	25	50	175	05
5	Core Elective 2	CE3BB	3-0-0	3	100	0	0	100	03
6	Institute Elective-2	CE3YY	3-0-0	3	100	0	0	100	03
		Total		**19**	**600**	**75**	**200**	**875**	**26**

SEMESTER - VII

Sr No	Course	Code	Scheme	Exam Scheme				Total	Credit
				Theory		Tuto.	Pract.		
				Hours	Marks	Marks	Marks		
1	Heavy Construction and Project Management	CE401	3-1-0	3	100	25	0	125	04
2	Design of Concrete Structures	CE403	3-0-2	3	100	0	50	150	04
3	Core Elective-3	CE4AA	3-0-0	3	100	0	0	100	03
4	Core Elective-4	CE4BB	3-0-0	3	100	0	0	100	03
5	Summer Training	CE405	0-0-4	0	0	0	100	100	02
6	Project Preliminary	CE407	0-0-6	0	0	0	150	150	03
		Total		**12**	**400**	**25**	**300**	**725**	**19**

SEMESTER - VIII

Sr No	Course	Code	Scheme	Exam Scheme				Total	Credit
				Theory		Tuto.	Pract.		
				Hours	Marks	Marks	Marks		
1	Core Elective-5	CE4XX	3-0-0	3	100	0	0	100	03
2	Core Elective-6	CE4YY	3-0-0	3	100	0	0	100	03
3	Core Elective-7	CE4ZZ	3-0-0	3	100	0	0	100	03
4	Innovation, Incubation and Entrepreneurship	HU410	3-0-0	3	100	0	0	100	03
5	Project	CE402	0-0-12	0	0	0	300	300	06
		Total		**12**	**400**	**0**	**300**	**700**	**18**
								Grand Total	**180**

Institute Electives 1 & 2

Sr No	Institute Elective 1 (5th Semester) CE3XX	Institute Elective 2 (6th Semester) CE3YY
1.	CE 361 Industrial safety and Environment	CE362 Environment Health and Risk Management
2.	CE 363 Environmental Management	CE364 Air Pollution and Control
3.	CE 367 Rural Planning and Management	CE366 Smart Cities Planning and Management
4	CE 369 Transportation Safety and Environment	CE368 Climate change studies
5	CE 371 Fundamentals of GIS and Remote Sensing	CE372 Intelligent Transport System
6	CE 373 Building Information Modelling	CE374 Water Infrastructure in Smart cities
7	CE375 Mechanics of Solids	CE 376 Waste to Energy Technology
8	CE 377 Introduction to Earthquake Engineering	CE 378 Disaster Management
9	CE 379 Introduction to Structural Engineering	CE 382 Advanced Mechanics of Solids
10	CE 381 Rehabilitation and Strengthening of Structures	

Core Electives I to 7

Sr. No	Core Elective - 1 (5th Semester) CE3AA	Core Elective 2 (6th Semester) CE3BB
1.	CE 321 Advanced Geotechnical Engineering	CE322 Sustainable Building Planning
2.	CE 323 Engineering Geology	CE324 Housing
3.		CE326 Pavement Analysis and Design
4.		CE328 Transport Economics
5.		CE332 Ground water hydrology
6.		CE334 Channel Hydraulics
7.		CE336 Advanced Surveying
8		CE338 Environmental Ethics Law and Policy
9		CE342 Construction safety Management

Sr. No	Core Elective - 3 (7th Semester) CE4AA	Core Elective - 4 (7th Semester) CE4BB
1.	CE421 Urban Infrastructure Planning and Management	CE 447 Design of Industrial Structures
2.	CE423 Urban Land Management	CE 449 Ground Engineering
3.	CE425 Urban transport Systems Planning	CE 451 Advanced Concrete Technology
4.	CE427 Flood control and River Training works	CE 453 Geosynthetic and Reinforced Soil Structure
5.	CE429Advanced Hydrologic Analysis & Design	CE 455 Introduction to Finite Element Methods
6.	CE431 Advanced Fluid Mechanics	CE 457 Rock Mechanics
7.	CE433 Stochastic Hydrology	CE459 Design of Formwork
8.	CE435 GPS and Applications	
9.	CE437 Industrial Waste Management	
10.	CE439 Building Maintenance	
11.	CE441 Environmental Health and Risk Management	
12.	CE443 Air Pollution and Control	
13.	CE445 Traffic Engineering and Management	

Sr. No	Core Elective – 5 and 6 (8th Semester) CE4XX, CE4YY	Core Elective – 7 (8th Semester) CE4ZZ
1.	CE422 Regional Planning	CE474 Advanced Design of Concrete Structures
2.	CE424 Real Estate management	CE 476 Design of Prestressed Concrete Structures
3.	CE426 Urban Design and Landscape Planning	CE 478 Design of Bridge Structures
4.	CE428 Tourism Planning and Development	CE 482 Design of Tall Structures
5.	CE432 Smart Cities Planning and Management	CE 484 Computer Aided Design of Structures
6.	CE434 Public Transport Systems and Operations	CE 488 Introduction to Geotechnical Earthquake Engineering
7.	CE436 Transportation Safety and Environment	CE 492 Introduction to Wind Engineering
8.	CE438 Waterways Infrastructure Planning & Design	CE 494 Tunnelling Engineering
9.	CE442 Traffic Flow Theory	CE 496 Ground Improvement Techniques
10.	CE444 Advanced Hydraulics Structure	
11.	CE446 Hydraulics of Alluvial Rvers	
12.	CE448 Computational Hydraulics	
13.	CE452 Geospatial Techniques	
14	CE454 Advanced Water and Wastewater Treatment	
15	CE456 Solid and Hazardous Waste Management	
16	CE458 Metro Construction Technology	
17	CE462 Environmental Impact Assessment	
18	CE464 Construction Laws	
19	CE466 Professional Practice	
20	CE468 Advanced Construction Technology	
21	CE472 Operation and Maintenance Management of Pavements	

SEMESTER III

L	T	P	C
3	1	0	4

MA 215 Engineering Mathematics III

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Explain the concept of convergence and divergence of infinite series
CO2	Develop the Fourier series of the periodic functions
CO3	Derive Fourier integral from Fourier series and comprehend the concept of integral transforms with their applications
CO4	Analyse the partial differential equations of second order
CO5	Apply fundamentals of probability and statistics in engineering problem solving

2. Syllabus

- **INFINITE SERIES** **(06 Hours)**
  Introduction, Positive term series, Comparison test, Cauchy's root test, D'Alembert's test, Raabe's test, Logarithmic test, Integral test, Gauss's test, Series with arbitrary terms, Rearrangement of terms.

- **FOURIER SERIES** **(06 Hours)**
  Definition, Fourier series with arbitrary period, in particular periodic function with period 2π. Fourier series of even and odd function, Half range Fourier series.

- **FOURIER INTEGRAL AND FOURIER TRANSFORMS** **(07 Hours)**
  Fourier Integral theorem, Fourier sine and cosine integral complex form of integral, Inversion formula for Fourier transforms, Fourier transforms of the derivative of a function

- **LAPLACE TRANSFORMS** **(07 Hours)**
  Introduction, Definition, Existence conditions, basic properties, Inverse Laplace transform and properties, Convolution Theorem and properties, Applications of Laplace transforms

- **PARTIAL DIFFERENTIAL EQUATION** **(08 Hours)**
  Second order PDE of Mathematical Physics (Heat, wave and Laplace equation, one dimensional with standard boundary conditions, solution by separation of variable method using Fourier series, Solution by Separation of variables and transformation techniques

- **STATISTICS** **(08 Hours)**
  Correlation between two variables, application of correlation, evaluation of coefficients of correlation, Rank correlation, Regression, frequency distribution, Binomial, Poisson's distribution and Normal distribution, application to industrial problem. Test of significance, Chi-square)χ^2 test, student's t- test, application of the t-test, F-distribution

(Total Lectures: 42 hours, Tutorials: 14 hours)

3. Books Recommended

1. E Kreyszig, Advanced Engineering Mathematics, John Wiley, New Jersey. 1995.
2. C R Wiley, Advanced Engineering Mathematics, McGraw-Hill, New York, 1993.
3. Peter O'Niel, Advanced Engineering Mathematics, Thompson, Singapore, 2002.
4. M D Greenberg, Advanced Engineering Mathematics, Pearson, Singapore, 2007.
5. B V Ramana, Higher Engineering Mathematics, The MaGraw-Hill Inc., New Delhi, 2007.

L	T	P	C
4	1	2	6

CE 201 Hydraulic Engineering

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Apply linear momentum and energy equation in fluid flow problems
CO2	Analyse laminar and turbulent flows through close conduits
CO3	Analyze the growth of Boundary layer over flat plate
CO4	Compute and analyse flow in open conduit
CO5	Analyse the flow through pumps and turbines

2. Syllabus

- **FLUIDS PROPERTIES AND HYDROSTATICS** **(08 Hours)**
  Fluid continuum, fluid properties, hydrostatic forces on plain and curved surfaces, stability of floating and submerged bodies,relative equilibrium under linear acceleration and constant rotation and pressure measurements.

- **FLUID KINEMATICS AND DYNAMICS** **(10 Hours)**
  Concept of fluid particles, stream lines, path lines, differential forms of continuity equation, stream function, translation, deformation, rotation, circulation and vorticity of fluid elements, , stream function, potential function, flow net, acceleration of fluid elements; System and control volume including Reynolds transport theorem. Steady linear momentum equation, Euler's equation for one-dimensional flow, Bernoulli's equation including its applications for fluid flow problems.

- **BOUNDARY LAYER THEORY** **(05 Hours)**
  Concept and thickness of laminar and turbulent boundary layers over flat plates, application of integral momentum equation, boundary layer separation and their control, concept of drag and lift including streamlined bodies.

- **LAMINAR AND TURBULENT FLOWS** **(08 Hours)**
  Reynolds experiments, Reynolds number and classification of laminar, transition and turbulent flows, flow development in laminar and turbulent flows, shear stress distribution, Hagen Poiseuille's equation, Coquette flow; characteristics of turbulent flows, Reynolds shear stresses, Prandtl's mixing length theory, velocity distributions in closed conduit flows with hydro dynamically smooth and turbulent flows, friction factor.

- **APPLICATION OF FLUID FLOWS THROUGH PIPES** **(05 Hours)**
  Major and minor head losses, pipes in series and parallel, pipes with equivalent diameter and length, Total energy and hydraulic gradient lines, Two and three reservoir problems, analysis of water distribution network.

- **DIMENSIONAL ANALYSIS** **(04 Hours)**
  Development of functional relationships for fluid flows, pertinent and superfluous variables, Physical model laws, scale effect, distorted and undistorted models.

- **FLOWS AND CONCEPT OF SPECIFIC ENERGY IN OPEN CONDUITS** **(08 Hours)**
  Classification of open conduits flows, velocity and pressure distributions, applications of energy and momentum equations in open channels, development of uniform flows, resistance law, efficient channel section, section factors, specific energy and depth-discharge diagrams, critical flow, transitions in open channel, hydraulic jump, steady gradually varied flow equation, GVF profiles, computation of GVF profiles.

- **HYDRAULIC MACHINES** **(08 Hours)**
  Impact of jet on stationary and moving flat and curved vanes, working principles and design aspects of Pelton, Francis and Kaplan Turbines, unit quantities, specific speed, Characteristics of turbines, classification of pumps, working principles and components of pumps, velocity vector diagram and work done by pumps

3. Practicals

1. Determination of metacentric height.
2. Estimation of hydraulic coefficients for orifice.
3. Calibration of rectangular and triangular notches.
4. Calibration of Venturi meter and orifice meter.
5. Verification of Bernoulli's principle.
6. Friction factors for laminar and turbulent flows for single and multiple pipes.
7. Characteristics of Forced and free vortex.
8. Characteristics of free and forced Vortex.
9. Measurement of velocity distribution using Pitot tube and Current meter.
10. Development of specific energy diagram.
11. Characteristics of Hydraulic jump.
12. Main characteristics of turbines.
13. Operating Characteristics of centrifugal pump.

(Total Lectures: 56 hours, Tutorial: 14 hours)

4. Books Recommended

1. W R Fox and A T McDonald, Introduction to Fluid Mechanics, Wiley and Sons Inc., New York, 1998.
2. A K Jain, Fluid Mechanics including Hydraulic Machines, Khanna Publishers, New Delhi, 2000.
3. K G Ranga Raju, Flow through Open channel, Tata McGraw-Hill Publishing Company Ltd, New Delhi, 1997.
4. K Subramanya, Flow in Open Channels, Tata McGraw-Hill Publishing Company Ltd, New Delhi, 1998.
5. F M. White, Fluid Mechanics, The McGraw Hill Companies, New York,2008

CE 203 Basic Transportation Engineering

L	T	P	C
3	1	0	4

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Explain the basic modes of transportation and their importance in selecting the effective transportation mode considering the socio-economical and geographical aspects.
CO2	Analyse the various parameters including surveys for planning of new transportation systems (Railway, Waterway and Airways).
CO3	Identify the forces and stresses to be considered while designing various transportation structures like railway track, harbour components, runway, bridge and tunnels.
CO4	Design the layout pf terminal facilities like railway stations, yards for railways, docks and harbours for waterways and airport for airways.
CO5	Design the layout of terminal facilities like railway stations, yards for railways, docks and harbours for waterways and airport for airways.

2. Syllabus

- **INTRODUCTION TOTRANSPORTATION SYSTEMS** **(02 Hours)**
  Transport Systems - Introduction, development of road transport, air transport, waterways, Comparison of various modes of transportation.

- **RAILWAYS** **(14 Hours)**
  Permanent Way - Preliminary survey, reconnaissance survey, location survey, development, gauges, uniformity of gauges, types and functions of various components such as rails, sleepers, ballast, rail, fastening etc., coning of wheels, gradient and grade compensation, Track Modulus and Track Design, various stresses Points and Crossings - Terminology, various types of track junctions, turnout and diamond crossing, Construction and Maintenance - Plants and laying, material requirements, construction methods, Stations and yards.

- **TRANSPORTATIONSTRUCTURES** **(08 Hours)**
  Types – Culverts, Bridge, fly-overs, tunnels, components, classification, requirements, site selection, alignment, bridge sub structure, Bridge Super Structure - Super structure elements, bridge flooring, slab bridges and girder bridges, bridge bearings, joints in bridges, piers, abutments, wing walls and approaches, loads and stresses.

- **DOCKS AND HARBOURS** **(08 Hours)**
  Harbours and Ports: Classification of ports, requirements of a good port, classification of harbour, harbor planning, requirements of harbour, Docks and Spillways - Introduction, advantages of docks, moles, shape of docks and basins, dock entrance, entrance docks, quays, jetties and wharves, tide, wind and wave, dry dock, types of breakwaters.

- **AIR TRANSPORT** **(10 Hours)**
  Airportplanning,Surveysforsiteselection,Windrosediagramanditsutility,RunwayDesign, Taxiway, Apron, Hanger, Radar, Planning of terminal area of airport, Classification of airports, Instrument Landing System, Air Traffic Control, Design of Air field Pavement, Pavement Classification Number. Various bodies and their role in air transportation: ICAO, FAA, AAI.

(Total Lectures: 42 hours, Tutorials: 14 hours)

3. Books Recommended

1. V N Vazirani and C D Chandola, Transportation Engineering – Vol. I to IV, Khanna Publishers, New Delhi, 1999.
2. R Horenjeff, Planning and Design of Airports McGraw Hill Book Co., NewDelhi, 1985.
3. S C Saxena and K L Arora, Railway Engineering, Dhanpat Rai and Sons, New Delhi, 1995
4. S P Bindra, Bridge Engineering, Dhanpat Rai and Sons, New Delhi, 1997.
5. S Chandra and M M Agarwal, Railway Engineering, Second Edition, Oxford University Press, New Delhi, 2013

CE 205 Mechanics of Solids

L	T	P	C
3	1	2	5

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Apply the knowledge of mechanical/elastic/thermal properties of materials and constitutive relationships to solve elementary level determinate and indeterminate problems.
CO2	Analyze the response of structural elements subjected to axial force, bending, shear and torsion or in combination and graphically represent the distribution.
CO3	Evaluate strain energy and principal stresses-strains for subsequent applications of failure theories.
CO4	Design and analyze columns, springs, thin cylinders and spherical shells.
CO5	Evaluate strain energy and principal stresses-strains for subsequent applications of failure theories

2. Syllabus

- **STRESSES AND STRAINS** **(06 Hours)**
  Concept of stresses and strains – Types of stresses – Hook's Law – Lateral strain – Poisson's ratio – Elongation due to own weight – Tapering sections – Varying cross sections – Composite sections – Relation between Modulus of Elasticity, Modulus of Rigidity and Bulk Modulus – Thermal Stresses – Eccentric load – Limit of eccentricity – Core /Kernel of the section.

- **SHEAR FORCE DIAGRAM AND BENDING MOMENT DIAGRAM** **(05 Hours)**
  Types of beams – Types of supports – Types of loads – shear force – Bending moment – Sign conventions – Overhanging beams – Point of contra-flexure – Varying loads – Relation between SF and BM.

- **STRESSES IN BEAMS** **(04 Hours)**
  Theory of simple bending – Moment of Resistance – Beam of Uniform strength – Flitched beams – Shear stress concept – Derivation of shear stress – Shear stress variation in rectangular, circular, T-section and I – section

- **TORSION** **(04 Hours)**
  Basic theory of Torsion – Solid shaft – Hollow shaft – Power transmitted by shaft – Composite shafts

- **STRAIN ENERGY** **(04 Hours)**
  Strain energy – Resilience – Strain energy due to Tension and compression - Strain energy due to freely falling load

- **PRINCIPAL STRESSES** **(04 Hours)**
  Principal plane – Principal stress – Tangential and normal stress – Derivation of Major and Minor principal stresses for different cases – Mohr's circle graphical method

- **THEORIES OF FAILURE** **(03 Hours)**
  Strain energy – Resilience – Strain energy due to Tension and compression - Strain energy due to freely falling load.

- **COLUMN AND STRUTS** **(04 Hours)**
  Euler's theory for columns – Different end conditions – Rankine's formula – Limitations of Euler's theory. Direct and bending stresses in columns. Limit of eccentricity.

- **SPRINGS** **(04 Hours)**
  Types of springs – Close coiled helical spring subjected to axial load and twist – Leaf springs – Semi elliptical and Quarter elliptical leaf springs

- **THIN CYLINDERS** **(04 Hours)**
  Stresses in cylinders – Thin cylinders and thin spheres – Volumetric strain – Wire wound thin cylinders

(Total Lectures: 42 hours, Tutorial: 14 hours)

3. Practicals

1. To determine the elasticity and various stresses for mild steel and cast iron specimens conducting tension test.
2. To determine the various stresses and modulus of rigidity for mild steel specimen conducting torsion test.
3. To determine the toughness of various materials using Charpy impact test
4. To determine the flexural strength and elasticity of wooden beam conducting transverse test.
5. To determine the compressive strength of cast iron column conducting compression test.
6. To determine the shear strength of mild steel and aluminium.
7. To determine the shear strength of mortar
8. To determine the shear strength of concrete specimen.
9. To determine the shear strength of timber specimen.
10. To determine the hardness of metal conducting hardness test.

4. Books Recommended

1. S Timoshenko and D H Young, Elements of Strength of Materials, Tata McGraw Hill, New Delhi, 2006.
2. G H Ryder, Strength of Materials, English Language Book Society, New Delhi, 2006.
3. S S Bhavikatti, Strength of Materials, Vikas Publication House, New Delhi, 2007.
4. P Egar. Popov and T A Balan, Engineering Mechanics of Solids, 2nd Edition, Pretice Hall of India Pvt Ltd, New Delhi, 2002.
5. F. P. Beer and Johnston S J, Strength of Materials, Tata McGraw Hill, New Delhi, 2004.

CE 207 Geotechnical Engineering

L	T	P	C
3	0	2	4

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Classify and identify soils and their engineering properties
CO2	Interpret the laboratory and field testing results
CO3	Evaluate the permeability, seepage and compaction characteristics of soil
CO4	Apply the knowledge of effective stress and consolidation to determine settlement of soil
CO5	Analyze the shear strength parameters of various types of soil

2. Syllabus

- **INTRODUCTION** **(3 Hours)**
  Need for Soil Engineering Studies - Soil as an Engineering Material -Scope of Geotechnical Engineering, Introduction to Engineering Geology

- **BASIC PROPERTIES OF SOIL** **(5 Hours)**
  Elementary properties and their measurements - Constituents of soil - Phase diagram – Definitions of varies parameters and their Interrelationship – In-situ determination of density

- **SOIL CLASSIFICATION, CONSISTENCY LIMITS AND CLAY MINERALOGY** **(5 Hours)**
  Grain size analysis-Hydrometer method, Particle size distribution curve - Relative density-Soil consistency limits - Soil indices –IS Classification of soil - Clay Mineralogy

- **COMPACTION** **(4 Hours)**
  Definition - objectives - Laboratory tests- Zero air void Line -Factors affecting compaction- Effect of compaction on properties of soil - Field compaction control - Relative compaction

- **PERMEABILITY AND SEEPAGE** **(5 Hours)**
  Permeability - Darcy's law - Laboratory tests - Field tests - Permeability of stratified deposits– Laplace's equation - Seepage - Flow net

- **EFFECTIVE STRESS ANALYSIS** **(4 Hours)**
  Effective stress principle- Effect of water table fluctuation on effective stress-Effective stress in soil mass due to hydrostatic conditions, capillary action and steady seepage conditions-Effect of surcharge on effective stress-Quick sand condition

- **CONSOLIDATION** **(5 Hours)**
  Significance of Consolidation - Initial, primary and secondary consolidation - Spring analogy for primary consolidation- Consolidation test- Various parameters - Terzaghi's theory of one dimensional consolidation - Coefficient of consolidation – Preconsolidation pressure – Secondary consolidation-Field consolidation curve.

- **SHEAR STRENGTH** **(5 Hours)**
  Shear parameters –Mohr-Coulomb's Failure Criterion – Various laboratory tests and their merits and demerits - Drainage conditions- Modified failure envelop– Pore Pressure Parameters.

- **SOIL EXPLORATION AND BEARING CAPACIT** **(6 Hours)**
  Objectives and methods of explorations-Sampling and its design features, SPT, Cone penetration test and in-situ vane shear test, Bearing Capacity

(Total Lectures: 42 hours)

3. Practicals

1. Determination of moisture content, Specific gravity, In-situ density- Core cutter method, Sand replacement method.
2. Sieve Analysis
3. Hydrometer analysis
4. Consistency limits of soil
5. Compaction test on soil
6. Determination of coefficient of permeability of soil
7. Estimation of shear strength of non-cohesive soil by direct shear test.
8. Estimation of shear strength of cohesive by Vane shear test and Unconfined Compressive tests.
9. Computation of consolidation parameters
10. Demonstration of Triaxial shear test
11. Site Visit and Interaction with the practitioners in Geotechnical Engineering

4. Books Recommended

1. K R Arora, Soil Mechanics and Foundation Engineering (Geotechnical Engineering), Standard Publishers Distributors, Delhi, 2008.
2. K Terzaghi, R B Peck, G Mesri, Soil Mechanics in Engineering Practice, John Wiley and Sons, New Jersey, 1996.
3. J E Bowles, Foundation Analysis and Design, McGraw-Hill, New Delhi, 1996.
4. B M Das, K Sobhan, Principles of Geotechnical Engineering, Cengage Learning, Boston, 2018.
5. D P Coduto, M R Yeung, W A Kitch, Geotechnical Engineering: Principles and Practices, 2nd Ed, Pearson Education, Singapore, 2017.

SEMESTER IV

L	T	P	C
3	1	2	5

CE 202 Environmental Engineering I

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Analyze water quality and quantity requirements for given uses
CO2	Design water treatment plant based on the source water quality
CO3	Design simple water distribution networks
CO4	Analyse rural water supply demand and treatment methods
CO5	Explain air pollutants, their effects and control strategies

2. Syllabus

- **QUALITY AND QUANTITY OF WATER** **(10 Hours)**
  Water quality parameters – physical, chemical and microbiological, principles of their analysis. Drinking water quality standards. Water demand – types of demand, variation in demand, population forecast. Sources of water - Intake structures

- **WATER TREATMENT** **(15 Hours)**
  Need for water treatment. Process details and design considerations of treatment units such as aeration, sedimentation, coagulation and flocculation, filtration, disinfection, and water softening. Introduction to advanced water treatment methods such as adsorption, ion exchange and reverse osmosis.

- **WATER DISTRIBUTION SYSTEMS** **(5 Hours)**
  Pumps and pumping stations. Pipes, Pipe appurtenances. Testing of water main - Distribution reservoirs - Distribution methods – Introduction to pipe network analysis -Planning of water supply project

- **RURAL WATER SUPPLY AND TREATMENT** **(2 Hours)**
  Water demand and treatment techniques for rural areas, protected water supplies. Packaged treatment plants. Household water treatment methods

- **AIR POLLUTION AND CONTROL** **(10 Hours)**
  Air pollution sources and effects. Meteorology, Control of gaseous and particulate air pollutants, Noise pollution and control

(Total Lectures: 42 hours, Tutorials: 14 hours)

3. Practicals

1. Determination of Turbidity.
2. Determination of Chloride.
3. Determination of Hardness.
4. Determination of pH, Carbonate, Bicarbonate and Hydroxide Alkalinity.
5. Determination of Chlorine Demand and Chlorine Residual.
6. Determination of Fluorides
7. Determination of optimum coagulant dosage
8. Bacteriological Analysis of water.
9. Demonstration of air pollution monitoring equipment.

11. Demonstration of noise level meter.

4. **Books Recommended**

1. M L Davis, Water and Wastewater Engineering, McGraw-Hill, New Delhi, 2010.
2. Manual on Water Supply and Treatment 3rd Ed. Central Public Health and Environmental Engineering Organization, Ministry of Urban Development, Govt. of India, New Delhi, 1999.
3. R L Droste, Theory and Practice of Water and Wastewater Treatment, John Wiley and Sons, New York, 1997.
4. T J McGhee, Water Supply and Sewerage, McGraw-Hill, New Delhi, 1991.
5. B C Punmia, A Jain and A Jain, Water Supply Engineering, Laxmi Publications, New Delhi, 2015.

CE 204 Concrete Technology

L	T	P	C
3	0	2	4

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Evaluate the physical and mechanical properties of ingredients of concrete.
CO2	Conduct the experiments on fresh concrete and carry out destructive and non-destructive test on hardened concrete.
CO3	Produce a concrete mix compatible to design stipulations.
CO4	Apply the knowledge of special concrete and concreting methods to field.
CO5	Assess in-situ strength of concrete performing the various non-destructive tests.

2. Syllabus

- **PROPERTIES OF CEMENT** **(Hours – 6)**
  Manufacturing of Portland cement - Chemical composition of Portland cement - Hydration of cement and action of gypsum - Setting of cement - Physical and chemical test for cement as per IS:4031, IS:269 - Different types of cement - Chemical composition - Important properties and applications - Admixtures – Accelerators - Retarder water reducing agents – Plasticizers - Water proofing compounds - Pumping aids.

- **PROPERTIES OF AGGREGATES** **(Hours – 6)**
  Classification of aggregates - Important physical properties - Mechanical properties - Specific gravity, bulk density - Moisture content - Water absorption of aggregates - Sieve analysis - Grading curves - Fineness modulus - Gap Grading, Deleterious Substances in aggregates, alkali aggregate reaction, Maximum size of aggregates.

- **FRESH CONCRETE** **(Hours – 6)**
  Definition of workability, factors affecting workability - Measurement of workability - Slump test, compacting factor test -, Segregation and blending of concrete - Mixing of concrete - Types of mixtures - Vibration of concrete - Types of vibrators - Internal external surface and table vibrators - Concreting in hot and cold weather - Ready mixed concrete - Pumped concrete - Pre placed aggregate concrete - Vacuum processed concrete - Shotcrete or Gunitting.

- **STRENGTH OF CONCRETE** **(Hours – 6)**
  Factors affecting strength of concrete - Different methods of Curing and Steam Curing at Atmospheric Pressure and High Pressure Curing - Warm water method.

- **TESTING OF HARDENED CONCRETE** **(Hours – 6)**
  Need for testing, Compression test – Cube, cylinder - Prism and equivalent cube test - Effects of various factors on test results e.g. end conditions – Capping - Moisture content - Height/Diameter ratio - Shape of specimen - Rate of loading - Size of specimen - Comparison of strength of cubes and cylinders - Flexure test - Split tensile test - Non-destructive testing, needs and applications - Rebound hammer test – Ultrasonic Pulse Velocity test – Core test.

- **MIX DESIGN** **(Hours – 6)**
  Definition and need for designing mixes - Methods of mix design - IS method of mix design in detail with examples.

- **SPECIAL CONCRETE** **(Hours – 6)**
  Polymer Concrete - Fibre Reinforced Concrete - Light Weight Concrete - High Density Concrete - Use of Silica Fume and Metacaoline in Concrete - Fly ash Concrete

(Total Lectures: 42 hours)

3. Practicals

1. To determine fineness of cement.
2. To determine initial and final setting time of cement.
3. To determine soundness of cement.
4. To determine compressive strength of cement.
5. To determine mechanical properties of fine aggregates.
6. To determine mechanical properties of coarse aggregates.
7. To design a concrete mix of two different grades.
8. To determine workability of concrete and study of effect of super-plasticizers on it.
9. To determine setting time of concrete.
10. To conduct destructive and non-destructive tests on standard concrete cubes.
11. To determine elastic modulus and split tensile strength of concrete.
12. To determine flexural strength of plain concrete.

4. Books Recommended

1. A M Neville, Properties of Concrete, Pitman Publishing Company, Bath, U.K., 1973.
2. M S Shetty, Concrete Technology, Theory and Practice" 2nd ed., S. Chand and Company, New Delhi, 1986.
3. M L Gambhir, Concrete Technology, Tata McGraw Hill Company, New Delhi, 1986.
4. Shanthakumar, Concrete Technology, Tata McGraw Hill Company, New Delhi, 2006.
5. G E Troxell and H E Davis, Composition and Properties of Concrete, Mc Graw Hill Publication, 1998.

CE 206 Structural Analysis I

L	T	P	C
3	0	2	4

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1. Course Outcomes (COs)

At the end of course the students will be able to:

CO1	Explain unsymmetrical bending and shear centre
CO2	Apply the concepts of ILD and moving loads on determinate structures
CO3	Analyse displacement of statically determinate trusses and beams.
CO4	Analyze statically determinate structures.
CO5	Analyze statically indeterminate structures.

2. Syllabus

- **BASIC INTRODUCTORY CONCEPTS** **(Hours -4)**
  Structural Systems – Degrees of Freedom - Determinate and indeterminate structures- Unsymmetrical bending – Shear centers for thin walled open sections
- **ANALYSIS OF STATICALLY DETERMINATE STRUCTURES** **(Hours -5)**
  Analysis of Beams with internal hinges – Analysis of frames.
- **ANALYSIS OF SPACE TRUSSES** **(Hours -5)**
  Basic Principles – Types of support – Method of tension coefficient
- **INFLUENCE LINES** **(Hours - 5)**
  Concept of Influence lines – Influence lines for reactions, shear force and bending moment in beams – load position for maximum shear force and bending moment at a section in beam – Absolute maximum bending moment in beams- Influence lines for member forces in Trusses – Mriller Bresalay's Principle.
- **DISPLACEMENT OF STATICALLY DETERMINE STRUCTURES** **(Hours 10)**
  Determination of slope and deflections of beams using successive integration method – Macaulay's Method- Conjugate Beam Method- Determination of deflection of trusses using virtual work method – Application of Castigliano' s theorem for computing deflection of beam and trusses
- **ANALYSIS OF INDETERMINATE TRUSSES** **(Hours - 10)**
  Statically indeterminate structures – Method of consistent deformations for the analysis of trusses

(Total Lectures: 42 hours)

3. Practicals

1. Deflection of Cantilever Beam
2. Deflection of Simply Support Beam
3. Deflection of overhanging Beam
4. Shear Centre for Unsymmetrical Sections
5. Study of different models for two and three dimensional structures
6. Force Determination and deflection study of 2D and 3D truss
7. Verification of energy based deflection method for indeterminate truss.

8. Verification of energy based deflection method for indeterminate beam.
9. Boundary conditions effects on determinate and indeterminate structures.

4. Books Recommended

1. R C Hibbler, Structural Analysis, 6th edition, Pearson Prentice Hall, New Delhi, 2006.
2. A Gali, A M Newville, T G Brown, Structural Analysis – A Unified Classical and Matrix Approach, Sixth Edition, Spon Press, UK, 2009.
3. H S Patil, Y D Patil, and J B Patel; Structural Analysis-I, Synergy Knowledge ware Publisher, Mumbai, 2016.
4. P S Gahlot, D Gehlot, Fundamentals of Structural Mechanics, CBS Publisher, New Delhi, 2012.
5. T S Thandavamoorthy, Structural Analysis, Oxford University Press, New Delhi, 2011.

CE 208 Geomatic Surveying

L	T	P	C
3	1	2	5

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Establish horizontal control points and preparation of topographic map of hilly region
CO2	Estimate area using concept of geospatial technology and total station survey.
CO3	Compute and measure relief displacement, development of mosaic etc. using principle of photogrammetry.
CO4	Estimate area and volume by field measurement as well as using formulae.
CO5	Compute and analyze area and volume by field measurement as well as using formulae.

2. Syllabus

- **TACHEOMETRIC SURVEY** **(06 Hours)**
  Purpose, Principles of Tacheometry, Different Systems of Tacheometry, Various instruments, stadia constants, analytic lens, subtense bar, field work in tacheometry, reduction of readings, errors and precisions, Tacheometric Traversing,

- **GEODETIC SURVEYING** **(06 Hours)**
  Principles - Classification if triangulation systems - Selection of stations - Signals and towers - Baseline measurement and correction - Extension of base - base net - Satellite station - Reduction to center - Introduction to theory of errors and technical terms

- **GEOSPATIAL TECHNOLOGY** **(12 Hours)**
  GIS: Overview of GIS, data input and output, data management; GPS: Introduction to GPS, Geodesy, Working principle of GPS, Measurement and mapping techniques; Remote Sensing: concepts and fundamentals of remote sensing, Energy sources, Energy interactions, ideal and real remote sensing systems

- **TOTAL STATION SURVEY** **(05 Hours)**
  Principle, Data observations, Software

- **COMPUTATION OF AREAS AND VOLUMES** **(06 Hours)**
  Areas from field measurements and plans, Different methods, Trapezoidal and Simpson's rule, Plannimeter, Volume by trapezoidal and prismoidal formula, Calculation of earthwork in cutting and embankment for civil engineering works, Mass haul diagram, Volume by spot levels, Capacity of reservoir.

- **PHOTOGRAMMETRIC SURVEY** **(07 Hours)**
  Introduction, Technical terms, Aerial photogrammetry, Types of photographs, Vertical photographs, Uses of aerial photographs, Flying height and scale, Relief displacement, Stereoscopy, Measurement of parallax and height determination, Mosaic preparation

(Total Lectures: 42 hours, Tutorials: 14 hours)

3. Practicals

1. Measurement of Vertical Angle with Vernier Theodolite.
2. Measurement of Vertical Angle with Digital Theodolite.
3. Tacheometric Exercise with different types of Theodolites I.
4. Tacheometric Exercise with different types of Theodolites II.
5. Determination of Tacheometric constant K and C.
6. Exercise on Triangulation Work including satellite Station.
7. Introduction of Area Measuring Equipment – Planimeter (Mechanical and Digital).
8. Evaluation of Area of map with irregular boundary.
9. Demonstration of total station and its uses.
10. Comparison between aerial photographs and map.
11. Determination of height of objects from aerial photographs.
12. Demonstration of GPS and its uses.
13. Remote sensing data analysis and Demonstration on GIS software.

4. Books Recommended

1. W Schofield, Engineering Surveying, Butterworth-Heinemann Publication, New Delhi, 2001.
2. K R Arora, Surveying and Levelling, Vol. II and III, Standard Publications, Delhi, 2000.
3. T M Lille sand and R.W. Kiefer, Remote Sensing and Image Interpretation, 4th Edition, John Wiley and Sons, New York, 2002.
4. N K Agrawal, Essentials of GPS, Spatial Network Pvt. Ltd., Hyderabad, 2006.
5. A M Chandra and S K Ghosh, Remote Sensing and Geographical information System, Narosa Publishing House, New Delhi, 2006.

CE 212 Building and Town Planning

L	T	P	C
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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Explain household requirements and role of engineer in planning
CO2	Explain building regulations and plan approval process in urban area
CO3	Plan buildings and preparation of approval drawings
CO4	Prepare architectural and perspective drawings
CO5	Explain fundamentals of Town Planning

2. Syllabus

- **PLANNING APPROACH:** **(08 Hours)**
  Basic areas in residential buildings, Process of planning, Family requirements and analysis, Conceptual plan outlines, Principles and techniques of functional planning, Planning for building services, Stakeholders' role in changing surrounding area.

- **BUILDING SYSTEMS:** **(03 Hours)**
  Concept of art and creativity, Load-bearing, framed and composite structural systems and functional classification of buildings, Residential building forms.

- **RESIDENTIAL BUILDINGS PLANNING:** **(08 Hours)**
  Plan preparation for residential units, Structural components, Space forms and analysis, Activity space, Elements of human scale, Size and dimension decisions, Furniture layouts

- **PUBLIC BUILDINGS PLANNING:** **(08 Hours)**
  Approach of activity analysis for public buildings, hostels, schools, offices, primary health centers -Space norms, basic areas, functional setting areas

- **ARCHITECTURAL COMPOSITION:** **(03 Hours)**
  Mass Composition, Principles of elevation development-techniques, Impacts of colour and structure character, landscaping

- **BUILDING BYE LAWS:** **(02 Hours)**
  Building byelaws, Provisions in developed and developing Built-Environment, Plan approval process.

- **BUILDING DRAWINGS:** **(08 Hours)**
  Key plan, Site plan, Working and approval drawings, One and two Perspective drawings, Foundation, Fundamentals of electrical and plumbing layouts, Building drawing software applications.

- **TOWN PLANNING PRACTICES:** **(02 Hours)**
  Town Planning: What, Why and How? Issues and national perspectives.

(Total Lectures: 42 hours, Tutorials: 14 hours)

3. Practicals

1. Plan sketches on site visits.
2. Study of Building forms and building layout for public schemes.
3. Study of Building forms and building layout for private schemes.
4. Planning of residential buildings.
5. Planning of public buildings.
6. Preparation of drawings for foundation
7. Preparation of drawings for electrical and plumbing
8. Planning of public buildings.
9. Preparation of landscape layout.
10. Preparation of perspective drawings.

4. Books Recommended

1. Comprehensive General Development Control Regulations, Urban Development and Urban Housing Department, GoG, 2017.
2. M G Shah, C M Kale and S Y Patki, Building Drawing: With an Integrated Approach to Built Environment, Tata McGraw-Hill Education, New Dehi, 2002.
3. National Building Code, Bureau of India Standard, New Delhi, 2016.
4. S M Patil, Building Services, Sachin Printers, Mumbai, 2004.
5. Y S Sane, Planning and Designing of Building, Allies Book Stall, Poona, 1990.

SEMESTER V

HU 301 Professional Ethics, Economics and Business Management

L	T	P	C
4	1	0	5

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Identify application of ethics in society and development of understanding regarding Professional ethical issues related to Civil engineering
CO2	Develop managerial skills to become future engineering managers
CO3	Develop skills related to various functional areas of management (Marketing Management, Financial Management, Operations Management, Personnel Management etc.)
CO4	Build knowledge about modern management concepts (ERP, SCM, e-CRM, etc.)
CO5	Apply knowledge of Economics and Business management aspects in Civil engineering

2. Syllabus

- **PROFESSIONAL ETHICS** **(14 Hours)**
  Introduction, Approaches to Ethics, Meaning of Ethics, Major attributes of Ethics, Business Ethics, Factors influencing Ethics, Importance of Ethics, Ethics in Management, Organizational Ethics, Ethical aspects in Marketing, Mass communication and Ethics - Television, Whistle blowing, Education – Ethics and New Professional, Intellectual Properties and Ethics, Introduction to Professional Ethics, Engineering Ethics, Ethical issues related to Civil Engineering

- **ECONOMICS** **(8 Hours)**
  Introduction To Economics, Micro and Macro Economics, Applications and Scopes Of Economics, Demand Analysis, Demand Forecasting, Factors Of Production, Types Of Cost, Market Structures, Break Even Analysis

- **MANAGEMENT** **(12 Hours)**
  Introduction to Management, Features Of Management, Nature Of Management, Development of Management Thoughts – Scientific Management By Taylor and Contribution of Henry Fayol, Coordination and Functions Of Management, Centralization and Decentralization, Decision Making; Fundamentals of Planning; Objectives and MBO; Types of Business Organizations: Private Sector, Public Sector and Joint Sector; Organizational Behavior: Theories of Motivation, Individual and Group Behavior, Perception, Value, Attitude, Leadership

- **FUNCTIONAL MANAGEMENT** **(18 Hours)**
  Marketing Management: Core Concepts Of Marketing, Marketing Mix (4p), Segmentation – Targeting – Positioning, Marketing Research, Marketing Information System, Concept of International Marketing, Difference Between Domestic Marketing and International Marketing; Operations Management: Introduction to Operations Management, Types of Operation Systems, Types of Layouts, Material Handling, Purchasing and Store System, Inventory Management; Personnel Management: Roles and Functions of Personnel Manager, Recruitment, Selection, Training, Industrial Dispute, Collective Bargaining; Financial Management: Goal of Financial Management, Key Activities In Financial Management, Organization of Financial Management, Financial Institutions, Financial Instruments, Sources of Finance

- **MODERN MANAGEMENT ASPECTS** **(4 Hours)**
  Introduction To ERP, e – CRM, SCM, RE – Engineering, WTO, IPR Etc.

Tutorial: Case Study Discussion, Group Discussion, Management games and Assignments / Mini projects and presentation on related Topics

(Total Lectures: 56 hours, Tutorials: 14 hours)

3. Books Recommended :

1. V Balachandran and Chandrasekaran, Corporate Governance, Ethics and Social Responsibility, PHI, 2nd Edition, 2011.
2. L M Prasad, Principles and Practice Of Management, Sultan Chand and Sons, 8th Edition, 2015.
3. T. R. Banga and S C Shrama, Industrial Organisation and Engineering Economics, Khanna Publishers, 25th Edition, 2015.
4. E. Everett, Adam, R J Ebert, Production and Operations Management, Prentice Hall of India, 5th edition, 2012.
5. P Kotler, K L Keller, A Koshi and M Jha, Marketing Management – A South Asian Perspective, Pearson, 14th Edition, 2014.

CE 301 Estimation and Cost Analysis

L	T	P	C
3	1	2	5

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Explain significance of estimation and specification.
CO2	Interpret BIS code of measurement cost indices.
CO3	Analyse cost estimation of civil structures.
CO4	Prepare rate analysis, specification and abstract of building items.
CO5	Explain the government procedure for BOQ and tender.

2. Syllabus

- **GENERAL:** **(02 Hours)**
  Significance of estimation and specification, role of civil surveyors, types of estimates, working drawing details, BS codes for measurements, Cost Indices.

- **QUANTITY ANALYSIS OF BUILIDNGS:** **(12 Hours)**
  Estimation of earthwork and masonry, flooring, walls, openings, RCC components, staircase, timber and steel work, load bearing and framed structures.

- **QUANTITY ANALYSIS OF SPECIAL STRUCTURES:** **(10 Hours)**
  Estimation of roads and CD works, earthen dams, irrigation channels, urban services estimation, electrical fixtures, approximate estimation of infrastructural elements.

- **BRIEF SPECIFICATIONS:** **(05 Hours)**
  Basic principles and purpose, types and details

- **RATE ANALYSIS:** **(10 Hours)**
  Factors affecting rates of building items, output of work force, building and typical civil engineering items, schedule of rates.

- **ABSTRACTING:** **(03 Hours)**
  BS methods of abstracts, abstract statements, cost analysis, BOQ and tenders

(Total Lectures: 42 hours, Tutorials: 14 hours)

3. Practicals

1. Conduct Market survey of building materials
2. Estimation of building units
3. Estimation of road and C.D. works
4. Estimation of earthen dam and irrigation channel
5. Estimation of steel roof truss.
6. Estimation of plumbing and electrical services.
7. Drafting of specifications.
8. Rate analysis.

4. Books Recommended

1. A Aggarwal and A K Upadhyay, Civil Estimating, Costing and Valuation, Kataria and Sons, New Delhi, 1994.
2. B N Dutta, Estimating and Costing, S. Dutta and Co., Lucknow, 1995.
3. G S Birdie, Estimating and Costing, Dhanpat Rai and Sons, Delhi, 1996.
4. P L Basin, Quantity Surveying, S. Chand and Co., New Delhi, 1990.
5. S C Rangwala, Elements of Estimating and Costing, Charotar Publishing Pvt Ltd., Anand, 1998.

L	T	P	C
3	0	2	4

CE 303 Environmental Engineering II

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Describe the need of collection and treatment of municipal wastewater
CO2	Summarize the Physical, Chemical and Biological characteristics of wastewater
CO3	Design an appropriate sewerage system.
CO4	Differentiate various unit operations and processes with design applications
CO5	Explain municipal solid waste sources, its characteristics and treatment options

2. Syllabus

- **WASTEWATER GENERATION, COLLECTION AND CONVEYANCE** **(10 Hours)**
  Wastewater Quantity - Classification of wastewater - Sewerage system for domestic wastewater and storm water - Collections, and appurtenances - Design and layout of sewerage systems - Maintenance of sewerage systems - Physical, Chemical and Biological characteristics and their significance.

- **PRIMARY TREATMENT OF WASTEWATER** **(5 Hours)**
  Objectives of Wastewater treatment- Treatment methods: Unit Operations and Processes Design criteria - Design of primary treatment System

- **SECONDARY TREATMENT OF WASTEWATER** **(10 Hours)**
  Concepts of Biological treatment and removal mechanism – Aerobic and Anaerobic systems - Design of suspended and attached growth processes – Introduction to extended aeration processes and waste stabilization pond - Design of anaerobic system.

- **WASTEWATER DISPOSAL AND SLUDGE HANDLING** **(07 Hours)**
  Alternative disposal methods - Self purification of stream - Standards for disposal alternatives, natural purification of polluted streams. Quantity and quality of sludge, Methods of sludge treatment: sludge digestion and drying beds , Disposal of sludges. House drainage system - traps and sanitary fitting - Low cost sanitation Systems

- **MUNICIPAL SOLID WASTES** **(10 Hours)**
  Sources and collection of municipal solid wastes, characteristics of solid wastes, treatment and disposal

(Total Lectures: 42 hours)

3. Practicals

1. Determination of solids in wastewater.
2. Determination of pH of water and wastewater.
3. Measurement of colour.
4. Determination of carbonate, bi-carbonate and hydroxide alkalinity.
5. Determination of oil and grease in water.
6. Determination of phosphorus as PO_4^{-3}.

7. Determination of sulphate.
8. Determination of Biochemical Oxygen Demand of wastewater.
9. Determination of Chemical Oxygen Demand of a given sample.
10. Determine MLSS and MLVSS.

4. Books Recommended

1. Metcalf and Eddy, Wastewater Engineering: Treatment and Reuse, Tata McGraw-Hill, New Delhi, 2003.
2. G L Karia and R A Christian, Wastewater Treatment Concepts and Design Approach, Prentice Learning Private Ltd., New Delhi, 2013.
3. Manuel of Sewerage and Sewage Treatment, CPH and EE organization, Ministry of Works and Housing, Govt. of India, New Delhi, 2006.
4. S R Qasim, and G Zhu, Wastewater Treatment and Reuse, CRC Press, Taylor and Francis Group, New York, 2018.
5. M L Davis, Water and Wastewater Engineering, McGraw-Hill, New Delhi, 2010.

CE 321 Advanced Geotechnical Engineering

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Classify the various soil exploration and stabilization methods
CO2	Analyze the stress distribution, slope stability and earth pressure
CO3	Evaluate the load carrying capacity and settlement of shallow foundation
CO4	Analyse the soil condition and design foundation system
CO5	Evaluate the load carrying capacity of pile foundation

2. Syllabus

- **GEOTECHNICAL INVESTIGATION** **(03 Hours)**
  Sub soil exploration by Geo Physical methods – Seismic method, Electrical resistivity method – Borelog sheet– Sub soil Investigation report.

- **STRESS DISTRIBUTION** **(05 Hours)**
  Causes of stress in soil- Geostatic stress- Boussinesq's equation-Stresses due to different types of loading- Isobar diagram and pressure bulb- New-mark's influence chart, Approximate methods-Contact pressure distribution

- **EARTH PRESSURE AND RETAINING STRUCTURES** **(08 Hours)**
  Definition - Active - Passive and Earth pressure at rest conditions, Rankine's theory- Coulomb's theories of earth pressure - Graphical Method - Types of Retaining walls- Principle of design of retaining walls - Analysis and Design of Retaining structures.

- **STABILITY OF SLOPE** **(06 Hours)**
  Types of slope failures-Different factors of safety-Infinite slope - Finite slope –Wedge failure--Friction Circle Method- - Taylors stability number- Swedish method-Applications to design of earth dam, choice of shear parameters - Total and effective stress analysis.

- **BEARING CAPACITY OF SOIL** **(05 Hours)**
  Introduction – Basic definitions – Bearing capacity theories – Types of shear failure – Effect of water table – Bearing capacity from field tests - plate load test, Penetration tests.

- **FOUNDATION SETTLEMENT** **(03 Hours)**
  Settlement of Foundations – Components of Settlement – Cause of Settlement – Computation of Immediate settlement– Computation of magnitude of consolidation settlement – Time rate settlement – Differential settlement.

- **DESIGN OF SHALLOW FOUNDATIONS** **(03 Hours)**
  Types of Shallow Foundations – Depth of Footing – Foundation loading – Principle of design of footings – Proportioning for equal settlement – combined footings –mat foundation

- **DEEP FOUNDATIONS** **(06 Hours)**
  Deep foundations – Necessity of pile foundation – Classification of piles – Load carrying capacity of piles – Pile load test – Negative skin friction – Settlement of pile – Group efficiency , Introduction of caisson and well foundation

- **INTRODUCTION TO SOIL STABILIZATION** **(03 Hours)**
  Mechanical Stabilization – cement Stabilization – Lime Stabilization –Bituminous Stabilization – Chemical Stabilization– Stabilization by geosynthetics

(Total Lectures : 42 hours)

3. Books Recommended

1. J E Bowles, Foundation Analysis and Design, McGraw-hill, New Delhi, 1997.
2. K R Arora, Soil Mechanics and Foundation Engineering (Geotechnical Engineering), Standard Publishers Distributors, Nai Sarak, Delhi, 2008.
3. B M Das, N Sivakugan, Principles of Foundation Engineering, Cengage learning, Boston, 2018.
4. D P Coduto, M R Yeung, W A Kitch, Foundation Design: Principles and Practices, 3rd Ed, Pearson Education, USA, 2016.
5. S R Kaniraj, Design Aids in Soil Mechanics and Foundation Engineering, Tata McGraw Hill Education Private Limited, New Delhi, 2009.

CE 323 Engineering Geology

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Explain the fundamental principles and processes in geology
CO2	Identify different type of rocks, their formation and mineral composition
CO3	Analyze the effect of different structural features on the design of civil engineering structures
CO4	Analyze geological data by using DIPS software and its applications
CO5	Design the structures under the given geological conditions

2. Syllabus

- **INTRODUCTION** **(10 Hours)**
  General geology, Earth and Earth processes, Origin, Interior and age determination of Earth, Physical geology, Mineralogy, Petrology. Study of Igneous, Sedimentary, and Metamorphic rocks, Silicate structures, Symmetry elements, Mineral characteristics and Families of minerals.

- **PROCESSES IN GEOLOGY** **(10 Hours)**
  Igneous processes, Bowen's reaction principle, textures and structures of plutonic and volcanic rocks, Weathering processes, Sedimentary processes, Structures of sedimentary rocks, Effects of pressure and temperature, Metamorphic rocks and structures, Geological work of Rivers, Sea/Oceans, Glaciers, Wind and Deposits

- **STRUCTURAL GEOLOGY** **(15 Hours)**
  Structural features, Beds, Folds, Joints, Faults and their Influence on Civil structures, Rockmass description, Plate tectonics and Sea floor spreading, Continental drift, Mechanical behavior of soils and rocks, Principles of stratigraphy, Standard stratigraphic Time Scale, Indian stratigraphy, Distribution of various economic minerals, their composition and mode of occurrence.

- **SITE INVESTIGATION** **(07 Hours)**
  Geophysical Methods: Resistivity and Seismic Refraction methods, Earthquakes, Landslides, Subsidence, Erosion, Karst formations, Engineering properties of Rocks, Site selection for Slopes, Tunnels and Foundations, Rock as a construction material

(Total Lectures: 42 hours)

3. Books Recommended

1. L G de Vallejo, M Ferrer, Geological Engineering. CRC Press, Balkema, 2011.
2. M P Billings, Structural Geology, 4th Edition. Pearson India, New Delhi, 2016.
3. F G Bell, Fundamentals of Engineering Geology, Elsevier, Amsterdam, 2016.
4. S Gangopadhyay, Engineering Geology, Oxford University Press, New Delhi, 2013.
5. A C Mclean, C D Gribble, Geology for Civil Engineers, 2nd Edition. E and FN Spon, London, 1995.

CE361 Industrial Safety and Environment

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Analyze water quality and quantity requirements for given uses
CO2	Apply knowledge of accident theories to prevent accidents
CO3	Analyze technologies for construction safety
CO4	Assess standards and acts for construction safety
CO5	Design and audit for safety management system

2. Syllabus

- **OVERVIEW OF CONSTRUCTION SAFETY MANAGEMENT** **(06 Hours)**
  Terminologies related to safety management, safety management systems, safety climate, safety organization structure, safety culture and performance management, roles and Responsibilities of various persons for managing safety in construction, project management techniques for safety management in construction

- **PREVENTION OF ACCIDENTS** **(08 Hours)**
  Accident and incident cause theories, causes of major injuries, cost of accident, safety during construction, accidents of different stages of construction, accidents during receiving, unloading, shifting and storage, safety guidelines for storage, safety facilities at sites, coordination interface between civil and erection works, hazardous material and atmosphere

- **SAFETY TECHNOLOGIES** **(08 Hours)**
  Personal protective equipment, emergency rescue equipment, safety aids, first aid health care, site hoardings, safety training on site, prevention and protection equipment for working on heights, modern scaffolding technology, advance technologies and computer applications in safety management

- **SAFETY TRAINING AND EDUCATION** **(06 Hours)**
  Introduction to safety training and education, need of safety training and education, importance of training and education, requirements of safety training and education, frequency of safety training, safety audit and inspection education, training of rules and acts of safety management, safety reporting training

- **STANDARDS AND ACTS FOR CONSTRUCTION SAFETY** **(08 Hours)**
  Construction safety related acts and rules (central act, central and state rules), building and other construction workers (BOCW) act, 1996 and central rules, 1998, the explosives act and rules, the motor vehicle act and rules, the public liability insurance act and rules, the water (prevention and control of pollution) act and rules, the air (prevention and control of pollution) act and rules, battery management and handling rules, gas cylinder rules, hazardous wastes (management and handling) rules, contract labour (RandA) act and rules, workman compensation acts

- **SAFETY MANAGEMENT SYSTEM** **(06 Hours)**
  Policy regarding safety in organization, safety organization and persons, policy documentations, safety budget, investment in safety, training and education systems and schedules, induction programs, safety plan, investigation and analysis of incident, analysis of safety data

(Total Lectures: 42 hours)

3. Books Recommended

1. R E Levitt and N M Samelson, Construction Safety Management, John Wiley and Sons, New York, 1993.
2. S Rowlinson, Construction Safety Management Systems, Routledge, London, 2004.
3. H Lingard and S M Rowlinson, Occupational Health and Safety in Construction Project Management, Routledge, Oxford, 2004.
4. C D Reese and J V Eidson, Handbook of OSHA Construction Safety and Health, CRC Press, New York, 2006.
5. A Griffith and T Howarth, Construction Health and Safety Management, Routledge, London, 2014.

CE 363 Environmental Management

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Analyze local and global environmental impact issues like water pollution, air pollution, noise pollution, global warming
CO2	Evaluate important Indian and global environmental protection acts and protocols.
CO3	Describe EIA, Environmental Audit and ISO: 14001 and their methodologies.
CO4	Apply legal provisions and statutory requirements for environmental protection
CO5	Understand Government Environmental Policy and Guidelines

2. Syllabus

- **ENVIRONMENT AND POLLUTION CONTROL** **(09 hours)**
  Environment and ecology; Causes, effects and control measures for various types of pollution like air, water, land, noise; Global Warming, Climate Change, Green House Gas Effect, Acid Rains, Ozone Layer Depletion.

- **ENVIRONMENTAL MANAGEMENT AND POLICY** **(09 hours)**
  Sustainability and sustainable development; Environmental management plan; Disaster management; Environmental Audit; Life cycle assessment; National environmental policy; Beyond environmentalism and sustainability issues.

- **ENVIRONMENTAL IMPACT ASSESSMENT** **(12 hours)**
  Significant impacts of human activities / large projects; Evolution of EIA; EIA at project; regional and policy levels; Environmental clearance procedure in India; Rapid and Comprehensive EIA; significance of public participation / hearing in EIA; Post project monitoring; Resettlement and rehabilitation issues. EIA case studies / histories for different types of projects.

- **INDIAN ENVIRONMENTAL STANDARDS AND LEGISLATION** **(09 hours)**
  Significance of environmental standards, Various environmental standards such as water, waste water discharge, air emission, ambient air quality, noise etc; Significance and importance of legislation for environmental protection; Role of government, non-government organizations and citizens; Hierarchal structure of Governmental pollution control organizations in India; Important Indian environmental legislation and acts.

- **GLOBAL ENVIRONMENTAL STANDARDS** **(03 hours)**
  ISO 14000 introduction – General description of ISO 14001 – Environment Management System (EMS) – Key elements of ISO 14001 and EMS

(Total Lectures: 42 hours)

3. Books Recommended

1. G M Masters and W P Ela, Introduction to Environmental Engineering and Science, Pearson Prentice Hall Inc, New Delhi, 2008.
2. H S Peavy and G Tchobanoglous, Environmental Engineering, McGraw Hill Co, New Delhi, 2004.
3. LW Canter, Environmental Impact Assessment, Tata McGraw Hill Co, Singapore, 1996.
4. K Thakur, Environmental protection law and policy in India, Deep and Deep publishers, New Delhi, 1997.
5. S K Dhameja, Environmental Engineering and Management, S. K. Kataria and Sons, Delhi. 2004.

CE367 Rural Planning and Management

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Learn rural settlement significance in national perspective.
CO2	Study Physical and Social Infrastructure needs
CO3	Cultural planning, Low-cost building and Smart village amenities.
CO4	Explain the role of rural institutional setup and Government schemes and policies.
CO5	Preparation of Planning and management of common facilities for village clusters

2. Syllabus

- **INTRODUCTION** **(04 Hours)**
  Introduction: Meaning and Scope and overview of rural development: Historical perspective –Rural Development Programmes in India. Problem / perception and identification; Public Rural Area Planning – Programmes / Policies / Schemes for rural development, their coverage and outcomes;

- **RURAL INFRASTRUCTURE DEVELOPMENT** **(10 Hours)**
  Improvement of core physical infrastructure and social infrastructure and augmentation of housing stock, water supply, sanitation, solid waste health and educational facilities. Conservation of rural environment, form and structure, its art and architecture.

- **TECHNOLOGY MISSIONS** **(06 Hours)**
  Five year plans on rural planning and development, various sectoral development programmes, interdependence and efficacy of socio-economic and infrastructural sectors.

- **SETTLEMENT PLANNING AND ANALYSIS** **(08 Hours)**
  Definitions need growth, distribution and classification of rural settlements, size from function and morphology of rural settlements. Types, activity, environment and economic interface in rural habitat, technology in rural settlement; Mobility between rural and Urban Areas. Planning of village center. Planning and management of village clusters planning. Low cost and Vernacular CONSTRUX for the development of rural area. Concept of Ru-Urban.

- **ECO AND EFFICIENT TECHNOLOGY** **(04 Hours)**
  ICT in rural development, Rural Information system, Weather forecasting, disaster minimization, market information, etc. E-Panchayats, energy efficient technologies and alternative technologies.

- **AGRICULTURAL ASPECT** **(04 Hours)**
  Allied activities, agriculture land uses economic system and occupation productivity, expenditure and framing system Impact of modern technology, transport facilities, media and communication and trends at national and International level on agriculture.

- **INSTITUTIONS AND ORGANISATIONS** **(06 Hours)**
  Rural bank, Co-operatives, marketing and public administration Zila Parishad, Block Semity and Gram-Panchayat, powers and function

(Total Lectures: 42 hours)

3. Books Recommended

1. G P H Panel of Experts, Rural Development: Indian Context, Gullybaba Publishing House, 2015.
2. K Singh, Rural development: Principles, policies and management, Sage Texts, New Delhi, 2009.
3. M D Afsar-Alam, Planning and Rural development, Rajat Publication, 2011.
4. S Singh and K K Ali, Environmental Planning for Rural development, Sarup and Son, 2012.

CE369 Transportation Safety and Environment

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Analyse the present scenario about transport safety and environment with a multidisciplinary approach
CO2	Examine factors affecting road safety engineering and crash investigation, human factors relating to crashes/accidents, crash/accident.
CO3	Predict hazard identification related to the transport safety and environment and take management measures for improving safety and environment
CO4	Create awareness about empathetic and improving the present practices related to the Transportation Safety Audit
CO5	Explain the importance of Environmental Impact Assessment for transportation projects

2. Syllabus

- **INTRODUCTION** **(08 Hours)**
  Transportation Safety scenario in India and World, Accident Characteristics, Distribution among different modes. Need of Planning for Network, Land Use and Road Environment for Safety, Designing for Safety: Road Link Design, Junctions. Introduction to Road Safety Engineering and Crash Investigation, Human Factors Relating to Crashes/Accidents, Crash/Accident

- **ROAD SAFETY DIAGNOSIS** **(06 Hours)**
  Investigation and Crash Problem Diagnosing, Crash Problems into Solutions and Crash, Investigation Reporting, Crash/Accident, Costing, Economic Appraisal. Safety at Construction Site: Safety provisions for workers at construction site, Construction Zone markings, signs.

- **ROAD SAFETY AUDIT** **(06 Hours)**
  Road Safety Auditing: An Introduction, Concept and need of Road Safety Audit (RSA). Procedures in RSA, design standards, audit tasks, stages of road safety audit, Road Safety Audit Types, key legal aspects, process, audit team and requirements, Checklist, how to use Checklists Road Safety inspection.

- **TRANSPORT AND ENVIRONMENT ISSUES** **(08 Hours)**
  Introduction to transport and the environment: Context, mechanisms and sustainability; Air Pollution: Mechanisms, technology solutions, modelling and social costs; Traffic Noise: Units, sources, and impacts Climate Change: Transport contribution, potential impacts, regulatory framework and policies.

- **MEASUREMENT AND MODELLING** **(07 Hours)**
  Environmental planning and assessment practices, Measurement of environmental impacts of transport: Emissions, air quality and noise, Modelling of environmental impacts of transport: Emissions, air quality and noise, Land use transport relationships.

- **IMPACT ASSESSMENT** **(07 Hours)**
  Environmental Impact Assessment for Transportation Projects: Basic Concepts, Objectives, Transportation Related Environmental Impacts; Vehicular Impacts; Safety and Capacity Impacts; Roadway Impacts, Construction Impacts, Environmental Impact Assessment, Environmental Impact Statement, Environment Audit, Typical case studies.

(Total Lectures: 42 hours)

3. Books Recommended

1. R Lamm, B P Sarianos and T Mailaender, Highway Design and Traffic Safety Engineering Handbook, McGraw Hill Publishing, New York, 1999.
2. G John, TRiki and A Chadwick, Introduction to Environmental Impact Assessment, Routledge, Oxon, 2007.
3. C Larry, Environmental Impact Assessment, McGraw Hill Inc. Singapore, 1996.
4. J G Rau and D C Wooten, Environmental Impact Assessment, McGraw Hill Pub. Co., New York, 1996.
5. Relevant IRC and NHAI guidelines.

CE371 Fundamental of GIS and Remote Sensing

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Explain the fundamentals of Remote Sensing
CO2	Identify digital image processing.
CO3	Explain fundamentals and processes of GIS.
CO4	Create different types of database.
CO5	Solve complex civil engineering problems using GIS and RS

2. Syllabus

- **INTRODUCTION** **(04 Hours)**
  Basics of GIS and Remote Sensing, Usefulness in Civil Engineering

- **FUNDAMENTAL OF REMOTE SENSING** **(07 Hours)**
  Components of Remote Sensing, Principles of Remote Sensing, Energy Sources, Active and Passive Remote Sensing System, Electro Magnetic Radiation (EMR) and the Electromagnetic Spectrum, Interaction of EMR with the Earth's Surface and the Atmosphere, Various types of images and their uses

- **IMAGE INTERPRETATION AND DIGITAL IMAGE PROCESSING** **(07 Hours)**
  Interpretation Procedure, Strategies, Keys, Equipments, Digital Image Processing, Rectification and Restoration, Enhancement of Image, Image Transformation, Classification and Analysis

- **GEOGRAPHICAL INFORMATION SYSTEM** **(07 Hours)**
  Input data to GIS, Digitization and scanning from maps, Input from satellite images and from GPS, Registration of Image, Thematic layers and Projection System of Layers

- **DATA MODELS** **(07 Hours)**
  Spatial Data Models and Structures, Raster and Vector Data, Conversion, Storage and Compression Techniques, Database creation, Spatial and non-spatial Data, Database retrieval and management, Query from database

- **SOFTWARE** **(05 Hours)**
  GIS and Image interpretation Software, Salient features, Capabilities and Limitations

- **APPLICATIONS** **(05 Hours)**
  Application of Remote Sensing / GIS in Civil Engineering, Case studies, Integration of GIS and Remote Sensing, Management and Monitoring of various pollution, conservation of natural sources and coastal zone management

(Total Lectures: 42 hours)

3. Books Recommended

1. T M Lillesand and R W Kiefer, Remote Sensing and Image Interpretation, John Willey, New York, 2015.
2. P A Burrough and R A McDonnel, Principles of Geographic Information Systems, Oxford university press, 1998.
3. A M Chandra and S K Ghosh, Remote Sensing and Geographical information System, Narosa Publishing House, New Delhi, 2006.
4. B Bhatta, Remote Sensing and GIS, Oxford University Press, New Delhi, 2008.
5. Stan Aronoff, Geographical Information Systems, WDL Publications, Ottawa, Canada, 1989.

CE 373 Building Information Modelling

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Apply concepts of BIM in traditional construction practice
CO2	Prepare basic modelling of buildings
CO3	Design advanced modelling of building components and elements
CO4	Illustrate nD modelling in BIM
CO5	Conduct advanced analysis on BIM models

2. Syllabus

- **INTRODUCTION OF BIM** **(06 Hours)**
  Introduction to BIM process and integrated project delivery, nD modelling, BIM software systems and guidelines to choosing different BIM software systems

- **BASIC MODELLING** **(08 Hours)**
  Introduction of modelling environment and tools, modelling approaches to producing plans, 3D models, views and sections of buildings, creating an initial sample of 3D BIM model using a BIM authoring software, modelling of building including basic and vital elements, production of plans, views and 3D models, annotations and preparations of sheets for printing and publishing

- **ADVANCED MODELLING** **(06 Hours)**
  Model customizations, elements and materials, creation of internal components, external elements, massing and site modelling, Elements visibility, visualization and walkthroughs, model/information exchange and merging of models

- **nD MODELLING** **(08 Hours)**
  Introduction to aspects of nD modelling, scheduling and quantity take-offs using BIM-enabled systems and export to spreadsheets, Production of 4D program in 4D BIM software, cost estimation, producing cost estimates in 5D BIM software

- **INTEROPERABILITY IN BIM** **(07 Hours)**
  Basics about interoperability, export formats and applications, exchange of information through IFC, COBie, BIM 360 Glue, mobile BIM

- **ADVANCED BIM** **(07 Hours)**
  Clash detection, overview of clash detection tools, use of software to detect/resolve clashes in a BIM model, project collaboration using cloud/mobile BIM systems and common data environments

(Total Lectures: 42 hours)

3. Books Recommended

1. R Sacks, C Eastman, G Lee and P Teicholz, BIM Handbook: A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers and Contractors, Third Edition, John Wiley and Sons, Hoboken, 2018.
2. B Hardin and D McCool, BIM and Construction Management: Proven Tools, Methods, and Workflows, John Wiley and Sons, Hoboken, 2015.
3. W Kymmell, Building Information Modeling: Planning and Managing construction Projects with 4D CAD and Simulations: Planning and Managing Construction Projects with 4D CAD and Simulations, McGraw Hill Professional, New York, 2008.
4. B Kumar, A Practical Guide to Adopting BIM in Construction Projects, Whittles Publishing, Glasgow, 2015.
5. K Kensek and D Noble, Building Information Modeling: BIM in Current and Future Practice, John Wiley and Sons, Hoboken, 2014.

CE 375 Mechanics of Solids

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Apply knowledge of the fundamental properties of various materials and analyse the elastic member using basic principles.
CO2	Analyse the beam to construct the shear force and bending moment diagram considering various loadings
CO3	Analyse different types of springs
CO4	Evaluate the problems related to structural member subjected to axial forces, torsion and bending
CO5	Apply concept of failure theories while designing structural members.

2. Syllabus

- **STRESSES AND STRAINS** **(05 Hours)**
  Concept of stresses and strains – Types of stresses – Hook's Law – Lateral strain – Poisson's ratio – Elongation due to own weight – Tapering sections – Varying cross sections – Composite sections – Relation between Modulus of Elasticity, Modulus of Rigidity and Bulk Modulus – Thermal Stresses – Eccentric load – Limit of eccentricity – Core /Kernel of the section.

- **SHEAR FORCE DIAGRAM AND BENDING MOMENT DIAGRAM** **(06 Hours)**
  Types of beams – Types of supports – Types of loads – shear force – Bending moment – Sign conventions – Overhanging beams – Point of contra flexure – Varying loads – Relation between Shear Force and Bending Moment.

- **STRESSES IN BEAMS** **(05 Hours)**
  Theory of simple bending – Moment of Resistance – Beam of Uniform strength – Flitched beams – Shear stress concept – Derivation of shear stress – Shear stress variation in rectangular, circular, T-section and I – section, Eccentric load – Limit of eccentricity – Core /Kernel of the section.

- **COLUMN AND STRUTS** **(05 Hours)**
  Euler's theory for columns – Different end conditions – Rankine's formula – Limitations of Euler's theory.

- **TORSION** **(04 Hours)**
  Basic theory of Torsion – Solid shaft – Hollow shaft – Power transmitted by shaft – Composite shafts

- **SPRINGS** **(04 Hours)**
  Types of springs – Close coiled helical spring subjected to axial load and twist – Leaf springs – Semi elliptical and Quarter elliptical leaf springs.

- **PRINCIPAL STRESSES** **(04 Hours)**
  Principal plane – Principal stress – Tangential and normal stress – Derivation of Major and Minor principal stresses for different cases – Mohr's circle graphical method

- **THIN CYLINDERS** **(03 Hours)**
  Stresses in cylinders – Thin cylinders and thin spheres – Volumetric strain – Wire wound thin cylinders

- **STRAIN ENERGY** **(03 Hours)**
  Strain energy – Resilience – Strain energy due to Tension and compression - Strain energy due to freely falling load

- **THEORIES OF FAILURES** **(03 Hours)**
  Various hypotheses: Maximum principal stress theory, maximum strain theory, maximum shear stress theory, maximum strain energy theory, maximum shear strain energy theory. Problem based on above all theories.

(Total Lectures: 42 hours)

3. Books Recommended

1. S Timoshenko and D H Young, Elements of Strength of Materials, Tata Mc Graw Hill, New Delhi, 2006.
2. G H Ryder, Strength of Materials, English Language Book Society, New Delhi, 2006.
3. S S Bhavikatti, Strength of Materials, Vikas Publication House, New Delhi, 2007.
4. E P Popov and T A Balan, Engineering Mechanics of Solids, 2nd Edition, Prentice Hall of India Pvt Ltd, New Delhi, 2002.
5. F P Beer and S J Johnston, Strength of Materials, Tata Mc Graw Hill, New Delhi, 2004.

CE377 Introduction to Earthquake Engineering

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Explain ground motion, magnitude, intensity, frequency, plate tectonics and various terminologies related to earthquake
CO2	Compute ground motion intensity measures and attenuation relationships.
CO3	Explain theory of seismic analysis and its philosophy
CO4	Apply the building code provisions in the design of structural systems.
CO5	Analyse the structures subjected to earthquakes using basics of structural dynamics

2. Syllabus

- **INTRODUCTION** **(02 Hours)**
  Inner and Outer core of earth plate tectonics and its circulation – Earthquake types – Types of faults – Different types of seismic waves – Measuring instruments of earthquake – Strong ground motion and its characteristics - Magnitudes intensity of earthquake.

- **SEISMIC TECTONIC / SEISMIC ENVIRONMENT OF INDIAN REGION** **(02 Hours)**
  Seismic Geography and tectonic features of India – Seismic zones earthquake in India

- **SEISMIC EFFECT ON STRUCTURES** **(06 Hours)**
  Inertia force in structures and its foundation deformations in structure – Horizontal and vertical movement of structures - Drift - Twisting of structures during earthquake – Building codes – Importance of Architectural features – Building layout and its configuration, Crumple joints, IS: 4326, ponding effect, elephant foot effect.

- **SEISMIC DESIGN PHILOSOPHY** **(10 Hours)**
  Earthquake Design philosophy – Acceptance damage and ductility of building and capacity design concept – Quality control – Importance of Flexibility of structures – Indian seismic codes, IS: 1893, IS : 16700, IS :13920, water tank, building, chimney etc.

- **SEISMIC EFFECTS ON MASONRY STRUCTURES** **(06 Hours)**
  Behaviour of Brick Masonry and stone masonry under earthquake engineering – Construction aspects to improve the behaviour of masonry wall – selection of building materials – Structure configuration of masonry buildings – Earthquake resistant features of masonry work, Earthquake Structure.

- **SEISMIC EFFECT ON REINFORCED CONCRETE BUILDING** **(10 Hours)**
  Reinforced concrete buildings – Role of slab and masonry works – Behaviour R C Beams under seismic loadings, infill wall effect, shear wall position and effect.

- **BEHAVIOUR OF BEAM and COLUMN JOINTS** **(02 Hours)**
  Behaviour of RC Beams column joints – Seismic effect on Open – Ground storey building – Behaviour of short column – Energy absorption of FRC joint under cyclic loading.

- **BASE ISOLATION SYSTEM** **(04 Hours)**
  Introduction to seismic dampers – Viscous damper – Friction dampers – Yielding devices, active isolation method, snubber for power reactor pipe lines, Auxiliary mode of vibration.

(Total Lectures: 42 hours)

3. Books Recommended

1. P Agrawal and M Sprikhande, Earthquake Resistant Design of Structures, 1st edition, Prentice Hall of India Pvt Ltd, New Delhi, 2004.
2. Indian seismic codes, IS: 1893, IS : 16700, IS :13920.
3. R I Skinner and W H Robinson, An Introduction to seismic Isolation John Wiley and sons, New York, 1999.
4. J S Ambrose and D Vergun, Design for Earthquakes, John Wiley and Sons INC, New York, 1999.
5. T Paulay and M J N Priestley, Seismic Design of reinforced Concrete and Masonry buildings, John Wiley and Sons, New York, 1999.

CE 379 Introduction to Structural Engineering

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Describe the materials and structural behaviour in analyzing and design of structures.
CO2	Illustrate and evaluate the forces and distribution of stresses due to various types of mechanical forces
CO3	Explain the concepts of strength through mass, i.e. behaviour of slabs, beams, columns, plates etc. under the different load conditions
CO4	Hypothesize the concepts of strength through form i.e. behaviour of shells, folded plates, tensegrity structures, etc. under different loading
CO5	Analyse the structure based on geometry forces.

2. Syllabus

- **STRUCTURE FORCES, MOMENT AND EQUILIBRIUM** **(08 Hours)**
  Review of forces, moment, couples, loads – Equilibrium conditions – Supports – Simple beam –Cantilever beam – Trusses – Cables.

- **STRESS AND STRAIN**
  (08 Hours)
  Axial (tension and Compression) – Bending – Shear – Torsion – Shear force and bending moment diagrams– Failure Criteria

- **STRENGTH THROUGH MASS** **(10 Hours)**
  Approximate analysis and Conceptual design of slabs – Plates – Beams – Columns – Case studies –towers – frames

- **STRENGTH THROUGH FORMS/SHAPES** **(10 Hours)**
  Various types of shells – Folded Plates – Tensigrity Structures – Introduction to 3-dimension space structures – Innovative case studies

- **MATERIALS FOR DESIGN** **(06 Hours)**
  Steel - Concrete – Composite – Fiber Reinforced Plastic Composite – Innovative materials

(Total Lectures: 42 hours)

3. Books Recommended

1. J P Parikh, Understanding concept of Structural Analysis and Design, Charotar Publishing House, Anand, 2000.
2. Beer and Johnston, Mechanics of Materials, 3rd Edition, Mc Graw Hill Publication Inc., New Delhi 2004.
3. N Subramanian, Principles of Space Structures, 2nd Edition, Wheeler Publishing, New Delhi, 1999.
4. G Levis, Selection of Engineering Materials, Prentice Hall college division, Singapore, 1989.
5. G S Ramaswamy, M Eekhout and G.R.Suresh, Analysis, Design and Construction of Steel Space Frames. Thoma Telford, London, 2002.

CE 381 Rehabilitation and Strengthening of Structures

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Illustrate the various distress and damages to concrete structures and understand the importance of maintenance of structures
CO2	Evaluate the damage to structures using various tests and how to conduct field monitoring and non-destructive evaluation of concrete structures..
CO3	Compare the various repair techniques and strategies of damaged/corroded structures and its mechanisms
CO4	Describe the basic concepts of serviceability and durability of concrete structures
CO5	Evaluate the damage in structure and apply preventive measures.

2. Syllabus

- **CAUSES FOR DISTRESS IN STRUCTURE** **(08 Hours)**
  Philosophy and definition, causes of failure, failure in ancient time and recent times - deficiency in design drag, material production, maintenance etc.- failure related problems; manmade and natural failure or damage; diagnosis of failure; change in appearance on an exposure, chemical deterioration, mechanical deterioration - cracking in buildings. failure of flat roofs, balconies, trenches, dams, piles abutments piers, silos, chimney, cooling towers, reinforced cement concrete (rcc) frames, failure information and analysis. format of investigation - shear, torsion compression failure, erection difficulty, failure in tanks silos, space frame, precast assemblies prestressed concrete structure, formwork failure, case studies.

- **MAINTENANCE AND REPAIR OF STRUCTURES** **(08 Hours)**
  Need for maintenance and repairs, Inspection of structures for repairs and maintenance, methods for repairs, Material and methodology for repairs, cost of repair and maintenance, repair techniques for various structural elements

- **REHABILITATION OF DISTRESS STRUCTURES** **(09 Hours)**
  Inspection and testing of distressed structures, condition assessment using destructive and non-destructive tests, techniques for rehabilitation of concrete structures, retrofitting of structures.

- **STRUCTURE ASSESSMENT AND LEGAL ASPECTS** **(08 Hours)**
  Art of structure assessment, method of testing, Indian standard (I.S.) code provisions for testing of materials, safety assessment, legal aspects in connection to failure a repair.

- **PREVENTIVE MEASURES FOR DURABILITY OF STRUCTURES** **(09 Hours)**
  Proper selection and specification of materials, construction quality, quality assurance, the use of modern techniques for construction, proper design, better workmanship.

(Total Lectures: 42 hours)

3. Books Recommended

1. T Kay, Assessment and Renovation of Concrete Structures (Concrete Design and Construction Series), Longman Scientific & Technical, 1992.
2. K S Rakshit, Construction Maintenance and Repair of Highway Bridge, M/s. New Central Book Agency (P) Ltd., New Delhi, 2008.
3. R N Raiker, Learning from failures, Deficiencies in Design, Construction and Service, New Bombay, India: R and D Centre, Structwel Designers and Consultants, 1987.
4. P C Varghese, Maintenance, Repair and Rehabilitation and Minor works of Buildings, PHI Learning Private Limited, New Delhi, 2014.
5. J Bhattacharjee, Concrete Structures Repair, Rehabilitation and Retrofitting, CBS Publishers and Distributors, New Delhi, 2018.

SEMESTER VI

CE 302 Structural Analysis - II

L	T	P	C
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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Analyse displacements and internal forces of statically indeterminate beams by classical, iterative and matrix methods
CO2	Analyse Axial force, Shear force and Bending moment in frames subjected to lateral loads using approximate methods
CO3	Analyse internal forces and reactions for two hinged and three hinged arches
CO4	Analyse steel structure using Plastic design concept
CO5	Determine internal forces and reactions in indeterminate beams subjected to moving Loads using influence lines.

2. Syllabus

- **ANALYSIS OF INDETERMINATE BEAMS** **(04 Hours)**
  Concept of fixed and propped cantilever beams

- **ANALYSIS OF INDETETERMINATE STRUCTURES WITH DISPLACEMENT BASED METHODS** **(10 Hours)**
  Slope Deflection Method – Moment Distribution method for continuous beam and rigid frame with and without support settlement with and without sway

- **ANALYSIS OF THREE AND TWO HINGED ARCHES** **(08 Hours)**
  Parabolic and Circular Arch with Support at same and different level - Influence line of Arches

- **APPROXIMATE METHODS OF ANALYSIS** **(03 Hours)**
  Cantilever Method and Portal Method

- **MATRIX METHOD OF ANALYSIS** **(08 Hours)**
  Introduction to force and displacement method of analysis-stiffness method of analysis using direct element approach

- **PLASTIC ANALYSIS OF STRUCUTRE** **(05 Hours)**
  Plastic hinge concept. Shape factor-Static and kinematic method for beams and frames with portal and sway mechanism

- **ANALYSIS FOR MOVING LOADS FOR INDETERMINATE BEAMS** **(04 Hours)**
  Construction of influence line for beams, Application of Mueller Breslau Principle

(Total Lectures: 42 hours, Tutorials: 14 hours)

3. Practicals

1. Introduction to computer aided analysis and overview of STAAD-Pro. Connect edition
2. Features of STAAD-Pro Connect edition, axis (local and global) and sign conventions, steps for static analysis
3. Analysis of cantilever, simply supported and overhang beam
4. Analysis of fixed and propped cantilever beams
5. Analysis of continuous beams
6. Analysis of continuous beams with varying stiffness along length and
7. subjected to support rotation and settlement
8. Analysis of portal Frames
9. Analysis of portal Frames with varying stiffness along length and
10. Subjected to support rotation and settlement
11. Analysis of plane (2D) truss (Determinate and Indeterminate)
12. Analysis of space (3D) truss
13. Analysis of 3 hinged and 2 hinged arches with various boundary conditions
14. Analysis of beams subjected to moving loads
15. Design of steel beam, truss and column as per Indian codes

4. Books Recommended

1. C S Reddy, Basic Structural Analysis, 2nd Edi, Tata Mc Graw Hill, New Delhi, 2007.
2. C K Wang, Indeterminate Structural Analysis, Mc Graw Hill, Singapore, 1989.
3. A S Meghere and S K Deshmukh, Matrix method of Structural Analysis, Charotar Publishing House, Anand, 2003.
4. L S Negli and R S Jangid, Structural Analysis, Tata Mc Graw Hill, New Delhi, 1999.
5. S B Junarkar and H J Shah, Mechanics of Structures, Vol-2, Charotar Publishing House, Anand, 1996.

CE 304 Highway Engineering

L	T	P	C
3	0	2	4

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Design the geometry of roads with proper alignment.
CO2	Plan and conduct traffic studies for traffic management.
CO3	Design and construct the pavement by selecting appropriate materials and design approach.
CO4	Propose the maintenance strategies based on evaluation of pavement.
CO5	Propose the maintenance strategies based on evaluation of pavement.

2. Syllabus

- **HIGHWAY PLANNING AND ADMINISTRATION** **(03 Hours)**
  History of road development, Road planning in India, Highway administration, Highway project preparation, surveys and investigations, project estimates.

- **HIGHWAY GEOMETRICS** **(06 Hours)**
  Design controls and criteria, Cross sectional elements, Sight distance considerations, Design of horizontal and vertical alignment.

- **HIGHWAY MATERIAL AND CONSTRUCTION** **(09 Hours)**
  Sub grade soil investigation and properties, Desirable properties of aggregates and bitumen, Testing of aggregates, binders and mixes, IRC specifications for materials, Construction of low-cost roads, WBM, WMM, Types of bituminous surfaces and C.C. roads, IRC specification for construction, Tools, Equipment and Plants, Highways in hilly region, waterlogged areas and other area specific issues.

- **PAVEMENT DESIGN** **(09 Hours)**
  Types of pavements, Design factors and analysis, Design of flexible and rigid pavements, various design methods, IRC code of practice.

- **HIGHWAY MAINTENANCE** **(04 Hours)**
  Pavement evaluation, Surface and sub-surface drainage, Maintenance of bituminous and concrete roads, Concepts of overlay design, Pavement Management System.

- **TRAFFIC ENGINEERING** **(11 Hours)**
  Basic parameters, Traffic studies, Different traffic control devices, Signs, markings, signals, Traffic management and regulation, Concepts of at-grade and grade separated intersections, highway capacity, level of service

(Total Lectures: 42 hours)

3. Practicals

1. Determination of C.B.R. value of Subgrade soil.
2. Determination of Abrasion value and Shape Index.
3. Determination of Impact and Ten percent fines value.
4. Determination of soundness of aggregate.
5. Determination of ductility.
6. Determination of softening point.
7. Determination of penetration value.
8. Determination of viscosity.
9. Determination of bitumen content in bituminous mix by centrifuge extraction.
10. Mixed Traffic Volume Study.
11. Spot speed study
12. Speed and delay study
13. Origin and Destination survey

4. Books Recommended

1. S K Khanna, C E G Justo and A Veeraragavan, Highway Engineering, Nem Chand and Bros., Roorkee, 2015.
2. L R Kadiyali and N B Lal, Principles and Practices in Highway Engineering (including Expressway and Airport Engineering), Khanna Publishers, New Delhi, 2017.
3. E J Yoderand and M W Witczak, Principles of Pavement Design, Wiley India Pvt. Ltd., New Delhi, 2012.
4. L J Pignataro, Traffic Engineering-Theory and Practice, Prentice Hall, New Jersey, 1973.
5. Relevant IRC and IS Codes of Practices
   a) IS 5421-1981,
   b) IS 1498-1970(Reaffirmed 1997),
   c) IS:5421-1983 (Reaffirmed 1995),
   d) IS 2720 (Part4,,5,6,7,8,10,11,13,16)
   e) IS 1498-1970(Reaffirmed 1977),
   f) IS 4332 (Part IV,V),
   g) IS 2386 (Part I, III, IV),
   h) IS 5640,
   i) IS 383,
   j) IS 6241,
   k) IS 1203,
   l) IS 73,
   m) IS 1202,
   n) IS 1205,
   o) IS 1206 (Parts I,II,III),
   p) IS 1208,
   q) IS 8887,
   r) IS 3117,
   s) IS 217,
   t) IS 1209,
   u) IS 15462,
   v) IRC 14, 15,17,23, 37,48, 58,94,
   w) IRC SP 53,
   x) AASHTO 283,
   y) ASTM:D 2041-03a

CE 306 Water Resources Engineering

L	T	P	C
4	1	2	6

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Estimate precipitation and abstractions.
CO2	Compute runoff and hydrographs and groundwater flow.
CO3	Analyze irrigation water requirements.
CO4	Explain different aspects of reservoirs.
CO5	Design important hydraulic structures.

2. Syllabus

- **INTRODUCTION TO WATER RESOURCES ENGINEERING** **(02 Hours)**
  Introduction, importance of water resources engineering, need of water resources projects

- **PRECIPITATION AND ABSTRACTIONS** **(11 Hours)**
  Mechanism of precipitation, types and forms of precipitation, measurement techniques, rain gauge network, variability in precipitation, estimation of missing data, test for consistency of rainfall record, rainfall hyetograph, rainfall mass curve, areal average rainfall, intensity duration curves, evaporation, factors affecting evaporation, estimation of evaporation, evapotranspiration, measurement of evapotranspiration, initial loss, infiltration and infiltration indices.

- **RUN-OFF AND HYDROGRAPH** **(09 Hours)**
  Direct runoff and base flow; run off characteristics of streams, computation of runoff, rainfall-runoff relationships, components of hydrograph and factors affecting shape of hydrograph, base flow separation, effective rainfall hyetograph, unit hydrograph theory, derivation of unit hydrograph of different duration, synthetic unit hydrograph, IUH

- **GROUND WATER HYDROLOGY** **(06 Hours)**
  Occurrence, distribution of ground water, specific yield of aquifers, flow of groundwater, Darcy's law, permeability, safe yield of a basin, compressibility of aquifer, storage coefficient, specific storage, hydraulics of wells under steady and introduction to unsteady condition in confined and unconfined aquifers, yield of wells, pumping and recuperation tests, types of tube wells.

- **WATER REQUIREMENTS OF CROPS** **(08 Hours)**
  Classes and availability of soil water, available moisture depth, frequency of irrigation, relationship between duty, delta and base period, factors affecting duty, methods of improving duty, irrigation efficiencies, command areas, kharif, rabi and perennial crops, crop rotation, irrigation water requirement, design discharge of canal and storage capacity of reservoir based on irrigation requirement, types and methods of irrigation

- **WATER LOGGING AND DRAINAGE** **(03 Hours)**
  Definition, effects, causes and remedial measures of water logging, types of land drains, layout and spacing of tile drains.

- **RESERVOIR PLANNING AND SEDIMENTATION** **(07 Hours)**
  Types of reservoirs, investigations for reservoir planning; site selection, storage zones, yield, mass inflow curve, determining capacity of reservoir, apportionment of total cost of a multipurpose reservoir, determination of life of reservoir, control of reservoir sedimentation, reservoir losses, flood routing

- **HYDRAULIC STRUCTURES** **(10 Hours)**
  Necessity, location and types of dams, spillways, energy dissipation structures, canal falls, cross regulators, head regulators, canal escapes, canal outlets, cross drainage works. Important aspects of design of hydraulic structures.

[Total Lecturers: 56 hours, Tutorials: 14 hours]

3. Practicals

1. Study of recording and non-recording rain gauges.
2. Study of pan evaporimeter.
3. Study of infiltrometers.
4. Study of rainfall runoff relationship for given duration of storm.
5. Preparation of runoff hydrograph using rainfall simulator.
6. Study of rate of ground water recharge.
7. Study of Hele-Shaw apparatus.
8. Computation of water requirement of crops.
9. Computation of reservoir capacity.
10. Study of aspects of design of hydraulic structures.

4. Books Recommended

1. V P Singh, Elementary Hydrology, Prentice Hall, Englewood Cliffs, 1992.
2. K Subramanya, Engineering Hydrology, Tata Mc-Graw-Hill, New Delhi, 2013.
3. S K Garg, Irrigation Engineering and Hydraulic Structures, Khanna Publishers, New Delhi, 2011.
4. B C Punmia, Irrigation and Water Power Engineering, Laxmi Publications, New Delhi, 2016.
5. G L Asawa, Irrigation and Water Resources Engineering, New Age International, New Delhi, 2014.

CE 308 Design of Steel Structures

L	T	P	C
3	1	2	5

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Evaluate steel as building material, and composition of steel
CO2	Illustrate IS Codes, different loads and combination of loads, design philosophy
CO3	Analyze design philosophy for creating steel structure members (Design of tension, compression, flexure members) connection etc.
CO4	Apply knowledge for creating innovative steel structure and typical roof structure
CO5	Analyze the various industrial structures and design.

2. Syllabus

- **INTRODUCTION** **(04 Hours)**
  Steel as structural material, Eng. Structures, Philosophy of Design, Property of steel material specification, Limit state design

- **LOADING** **(04 Hours)**
  Various load on structure, Load calculation, Load combination.

- **CONNECTIONS** **(08 Hours)**
  General Design consideration introduction to welded, Bolted connections semi rigid and rigid connection, Beam to beam and beam to column connection, moment resistant connection.

- **DESIGN OF STRUCTURAL MEMBERS** **(15 Hours)**
  Design of tension members - Design of compression members, built of compression members, -Design of flexural members-Design of slab base gusseted base foundation, Introduction to plate girder.- Introduction to plate girders.

- **INDUSTRIAL ROOF** **(05 Hours)**
  Analysis and design of typical industrial roof trusses with gantry girder

- **INNOVATIVE STEEL STRUCTURES STUDY** **(06 Hours)**
  Design of steel foot over bridge

(Total Lectures: 42 hours, Tutorials: 14 hours)

3. Practicals

1. Design of Industrial roof with the entire necessary infrastructure.
2. Drawing of Industrial roof with the entire necessary infrastructure.
3. Design and drawing of office steel multi-storeyed building.
4. Drawing of office steel multi-storeyed building.

4. Books Recommended

1. N Subramanian, Steel Structure Design Practice, Oxford Press, Oxford, 2013.
2. S K Duggal, Design of Steel Structure, 2nd Edition, Tata Mc Graw Hill Publication, New Delhi, 2007.
3. P Dayaratnam, Design of Steel Structures, S. Chand and Company, Delhi, 2003.
4. S S Bhavikatti, Design of Steel Structures, I K International Publishing House, Delhi, 2009.
5. Ramchandra and V. Gehlot, Design of Steel Structures, Seventh Edition, Standard Book House, New Delhi, 2017.

CE 322 Sustainable Building Planning

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Explain environmental impact on buildings and its assessment.
CO2	Interpret sustainable building planning policies for implementation.
CO3	Apply modern architecture, green building concept and global practices.
CO4	Apply modern eco-friendly material practices for national rating systems.
CO5	Explain energy conservation and its importance for urban sustainability.

2. Syllabus

- **SUSTAINABLE DEVELOPMENT AND PLANNING:** **(04 Hours)**
  Concept, perspectives, need and importance, Environmental impact of building sector, current situation of environmental policies for building sector, concept and elements of sustainable planning for building industry, past perspectives on planning, situating sustainable planning within planning theory, Planners roles

- **SUSTAINABLE BUILDING PLANNING:** **(14 Hours)**
  Policies and exploring implementation gaps, urban design, Environment protection, site planning, energy conservation through planning and modeling, water use reduction, passive solar design, building technologies, indoor air quality, barriers to implementation of sustainable building measures, checklist for sustainability, policy recommendations for sustainable buildings. Innovative building material for rural and urban areas, Low Cost Infrastructure in rural Areas and Cost Cutting of housing Infrastructure.

- **URBAN HOUSING AND INFRASTRUCTURE:** **(08 Hours)**
  Vernacular Architecture; Urban climate and effect of built environment, Impact of urbanization on sustainability, growth and issues related to sustainability.

- **GREEN BUILDINGS:** **(06 Hours)**
  Concept and need, design principles, growth at International and national level, benefits, construction techniques, green materials, planning and case studies of residential, commercial and industrial buildings. Green building Evaluation Systems, LEED Certification, Green Globe Certification.

- **BUILDING PERFORMANCE ASSESSMENT:** **(10 Hours)**
  Concept, tools at international and national level, process of green building certification, comparison of different tools like LEED INDIA, GRIHA, IGBC, SB Tool etc. Recent researches on sustainable building development and assessment tools.

(Total Lectures: 42 hours)

3. Books Recommended

1. S M Wheeler, Planning for Sustainability: Creating Liveable, Equitable and Ecological Communities, Routledge, Taylor and Francis group, New York, 2004.
2. N Maiellaro, Towards sustainable building, Kluwer academic publishers, Netherlands, 2001.
3. Sustainable building design manual: Sustainable building design practices, The Energy and Resources Institute, New Delhi, 2009.
4. T Hasegawa, Environmentally sustainable buildings: challenges and policies, Organization for economic co-operation and development (OECD) publications, Paris, 2003.
5. T E Glavinich, Green Building Construction, Wiley, New Jersey, 2008.

CE 324 Housing

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Explain environmental impact on buildings and its assessment.
CO2	Interpret sustainable building planning policies for implementation.
CO3	Apply modern architecture, green building concept and global practices.
CO4	Apply modern eco-friendly material practices for national rating systems.
CO5	Explain energy conservation and its importance for urban sustainability.

2. Syllabus

- **PLANNING OF RESIDENTIAL AREAS:** **(15 Hours)**
  Household and housing, housing requirement for different sections of society, building byelaws, development controls, housing projects layouts, Neighbourhood planning, design standards and their significance in housing process, socio-economic and aesthetic, environmental factors affecting layouts, various concepts of layout planning, row and multi storied housing, layout optimization techniques, appropriate DU design.

- **HOUSING FOR URBAN POOR:** **(08 Hours)**
  Process of slum formation, causes and consequences, approaches to tackle the Challenge of slums. Housing Evaluation for urban Poor, Aerial and cluster standards, materials, social amenities and services, locational parameters, Policies. Housing schemes, housing demand etc.

- **HOUSING POLICIES AND FINANCE:** **(06 Hours)**
  Housing policies, Co-operative housing, Role of Central, State, Urban Local Bodies private and public sectors, financing institutes and their role, Housing Boards, HUDCO, NHB, HFIs, various international donor/financing agencies, micro finance institutions, rural housing finance, housing demand models

- **HOUSING MARKETS** **(08 Hours)**
  Concepts and definitions of housing market, area, the purpose and nature of housing market studies; factors affecting housing prices, housing market behaviour, estimation of housing need, housing demand, The formal and informal housing markets and their impact on urban poor, public, Co-operative and private sector.

- **CASE STUDIES** **(05 Hours)**
  Case studies of housing projects at National and International Level, Housing for different climatic conditions, institute housing, Mass Housing, Affordable Housing, Transit and Temporary Shelters, Integrated Housing Schemes energy efficient design, methodology for formulation of housing projects.

(Total Lectures: 42 hours)

3. Books Recommended

1. A K Jain, Urban Housing and Slums, Read worthy Publication Pvt. Ltd., 2009.
2. Comprehensive General Development Control Regulations, Urban Development and Urban Housing Department, GoG, 2017.
3. G C Mathur, Low cost housing in developing countries, Oxford and JBH publishing Co. Private Ltd., 2014.
4. P Smets, Housing finance and the urban poor, Rawat publication, 2012.
5. Y S Sane, Planning and Designing of Building, Allies Book Stall, Poona 4, 1990.

CE 326 Pavement Analysis and Design

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Identify key parameters to be considered for analysis and design of pavement
CO2	Analyse the pavement using various multi-layer theories
CO3	Design the pavement using various methods with different approaches
CO4	Design the overlay for existing pavement
CO5	Design the pavement using various methods with different approaches

2. Syllabus

- **FUNDAMENTALS OF PAVEMENT** **(05 Hours)**
  Types of pavement. Pavement composition and the function of each component. Factors governing design and analysis of pavement. Introduction to various approaches to design the pavement.

- **PAVEMENT ANALYSIS** **(12 Hours)**
  Stresses and strains in flexible and rigid pavement. Analysis of flexible pavement. Analysis of rigid pavement.

- **DESIGN OF FLEXIBLE PAVEMENT** **(09 Hours)**
  Design of flexible pavement as per guidelines given by IRC and AASHTO.

- **DESIGN OF RIGID PAVEMENT** **(10 Hours)**
  Design of rigid pavement as per guidelines given by IRC and AASHTO.

- **INTRODUCTION TO OVERLAY DESIGN** **(06 Hours)**
  Strengthening of flexible pavement by overlay - Flexible overlay, Rigid overlay. Strengthening of rigid pavement by overlay – Flexible overlay over rigid pavement, Rigid overlay over rigid pavement, Unbonded rigid overlay, Partially bonded rigid overlay.

(Total Lectures: 42 hours)

3. Books Recommended

1. L R Kadiyali and N B Lal, Principles and Practices in Highway Engineering (including Expressway and Airport Engineering), Khanna Publishers, New Delhi, 2017.
2. Y H Huang, Pavement Analysis and Design, Pearson Prentice Hall, New Delhi, 2013.
3. E J Yoder and M W Witczak, Principles of Pavement Design, Wiley India Pvt. Ltd., New Delhi, 2012.
4. R B Mallick and T El-Korchi, Pavement Engineering – Principles and Practice, CRC Press, Taylor and Francis Group, Boca Raton, Florida, 2013.
5. Relevant IRC and AASHTO Codes of Practices.

CE 328 Transport Economics

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Estimate road user cost and time value of money.
CO2	Perform economic analysis of a transportation project.
CO3	Evaluate alternate transportation project proposals.
CO4	Carryout life-cycle cost analysis of transportation projects.
CO5	Analyse the risk involved in financing a highway project.

2. Syllabus

- **INTRODUCTION TOTRANSPORTATION ECONOMICS** **(10 Hours)**
  Basic components of transport economics, review of engineering economics, elements of engineering economics, and microeconomics, principles of economic analysis, Depreciation and Inflation, Consumer and Social Surplus.

- **TRANSPORT COSTS AND BENEFITS** **(10 Hours)**
  Fixed and variable cost - Cost of improvement - Maintenance cost - Cost estimating methods- Pavement cost analysis - Direct benefits - Reduced vehicle operation costs - Value of travel time savings - Value of increased comfort and convenience - Cost of accident reduction - Reduction in maintenance cost.

- **ECONOMICEVALUATION TECHNIQUES** **(12 Hours)**
  Generation and screening of project alternatives - Different methods of economic analysis: - Discounting and Non discounting criteria methods – NPV - IRR, Benefit/Cost analysis. Applicationeconomictheoryintrafficassignmentproblem-Breakevenanalysis, Road User Cost Study (RUCS) models for costs and benefits.

- **TRANSPORTATION PROJECT APPRAISALANDEVALUATION** **(10 Hours)**
  Feasibility and evaluation, cost, impacts and performance levels, evaluation of alternatives, analysis techniques, cost benefit analysis, social and financial benefits, prioritization of projects, multi-criteria decision assessment, Life Cycle Cost Analysis (LCCA) of different pavement types, Role of Highway Development and Maintenance (HDM) in feasibility studies.

(Total Lectures:42 hours)

3. Books Recommended

1. J L Riggs, D D Bedworth and S U Randhawa, Engineering Economics, Tata McGraw Hill, Delhi, 2009.
2. S Mishra, Engineering Economics and Costing, 2nd Edition, Prentice Hall of India, New Delhi, 2010.
3. IRC: SP: 30-2009, Manual on Economic Evaluation of Highway Projects inIndia, Indian Roads Congress, New Delhi, 1993.
4. P K Sarkar and V Maitri, Economics in Highway and Transportation Planning, Standard Publisher, New Delhi,2010.
5. C G Swaminathan and L R Kadiyali, Road User Cost Study in India, Central Road Research Institute, New Delhi,1983.

CE 332 Grounwater Hydrology

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Explain the occurrence of ground water
CO2	Explain the principles of well hydraulics and computation of aquifer yield
CO3	Identify Artificial recharge of ground water and Groundwater modeling techniques
CO4	Analyse the problem of salt water intrusion
CO5	Assess transport of pollutants in ground water

2. Syllabus

- **INTRODUCTION** **(08 Hours)**
  Occurrence of ground water, geological formations as aquifers; types of aquifers, ground water movement, Darcy's law, permeability and its measurement, tracing of ground water movement, fundamental equations for steady and unsteady ground water flow, flow nets.

- **WELL HYDRAULICS** **(15 Hours)**
  Steady and unsteady flow in confined, semi-confined and unconfined aquifers, radial flow, superposition; multiple well system. Different methods of well construction; construction of well casings and screens, natural and artificial gravel packed wells. Safe yields, estimation, pumping and recuperation tests, Infiltration galleries

- **ARTIFICIAL RECHARGE OF GROUND WATER** **(04 Hours)**
  Ground-water replenishment, artificial recharge of ground water, different methods, merits, demerits, selection criteria for various methods, cone of depression

- **GROUNDWATER MODELING TECHNIQUES** **(08 Hours)**
  Porous media models, analog models, electric analog models, digital computer models

- **SALT WATER INTRUSION** **(03 Hours)**
  Concept, interface and its location, control of intrusion.

- **TRANSPORT OF POLLUTANTS IN GROUND WATER** **(04 Hours)**
  Pollutant transport, Plume Transport, source identification, tracer methods.

(Total Lectures: 42 Hours)

3. Books Recommended

1. D K Todd and L W Mays, Groundwater Hydrology, Third edition, John Wiley publishers, New York, 2011.
2. J Bear, Hydraulics of Groundwater, Dover Publications, 2007.
3. H M Raghunath, Groundwater and Well Hydraulics, Wiley Eastern Ltd, New Delhi, 1992.
4. A K Rastogi, Numerical Groundwater Hydrology, Penram International Publishing Mumbai, 2007.
5. F G Driscoll, Groundwater and Wells, Second edition, St. Paul, Minnesota, 1995.

CE 334 Channel Hydraulics

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Analyse uniform flow in open channels
CO2	Analyse non-uniform flow in open channels
CO3	Analyse spatially varied flow
CO4	Analyse unsteady flow in channels
CO5	Apply numerical methods for unsteady flow calculations

2. Syllabus

- **UNIFORM FLOW** **(06 Hours)**
  Specific energy, Specific energy curve and its limitations, critical depth and section factor for critical flow computations, open channel flow transitions, standing wave, venture flumes, control sections and hydraulic exponent for critical flow computations.

- **NON-UNIFORM FLOW** **(08 Hours)**
  Rapidly varied flow, specific force curve and its application in the analysis of hydraulic jump, hydraulic jump characteristics Assumptions in GVF analysis, dynamic equation of GVF, classification of channel slopes, GVF profiles, its identification and computation, applications

- **SPATIALLY VARIED FLOW** **(08 Hours)**
  Basic principles and assumptions, differential equations, analysis of flow profiles and flow through side weirs and bottom racks.

- **UNSTEADY FLOW** **(06 Hours)**
  Waves, classification of waves, waves celerity, occurrences of unsteady flow, height and celerity of gravity waves, governing equations for one dimensional flow, St. Vennant equation and numerical methods.

- **UNSTEADY FLOW NUMERICAL METHODS** **(08 Hours)**
  Method of characteristics, Finite difference methods, explicit and implicit finite difference schemes, consistency, stability.

- **TWO-DIMENSIONAL FLOW** **(06 Hours)**
  Governing equations, Mac Cormack scheme, Gabutti scheme, artificial viscosity, finite volume scheme, applications.

(Total Lectures: 42 Hours)

3. Books Recommended

1. G L Asawa, "Fluid Flow in Pipes and Channels", CBS Publishers, New Delhi, 2014.
2. H M Chaudhary., Open Channel flow, Prantice-Hall of India Pvt. Ltd. New Delhi, 1993.
3. V T Chow, Open Channel Hydraulics, McGraw-Hill Book Company, International editions, New Delhi, 1973.
4. K Subramanya, Flow in open channels, Sixth edition, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2001.
5. R Srivastava, Flow through open channels, Oxford Higher Education, Oxford University Press, Jericho, 2007.

CE 336 Advanced Surveying

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Explain advanced surveying techniques including EDM and Terrain Data Collection
CO2	Identify the techniques of triletration for establishment of Horizontal Control
CO3	Analyze the problem and its remedial measures pertaining to hydrographic Survey, curve setting and Trilateration.
CO4	Compute and detail Azimuth, Declination etc. of celestial bodies using principle of astronomy.
CO5	Utilize the theory of error with measured quantities in surveying

2. Syllabus

- **ELECTRONICS DISTANCE MEASUREMENT** **(06 Hours)**
  Introduction, Electromagnetic Waves, Basic Definitions, Phase and Types of Waves, Distance Measurement by Transit time and by Phase difference, Electro-optical, Infrared and Microwave EDM Instrument, Slope and Height Corrections

- **TERRAIN DATA COLLECTION** **(06 Hours)**
  Airborne laser thematic mapper (ALTM), LIDAR, Profiles, Digital Elevation Models

- **TRILATERATION** **(06 Hours)**
  Introduction, use of triletration, Advantages and Disadvantages of Triletration, Comparison of Triletration with Triangulation, Reconnaissance, Geometrical Figures and Precision in Triletration, Adjustment of Triletration

- **HYDROGRAPHIC SURVEYS** **(06 Hours)**
  Objects, Applications, Establishing controls, Shore line survey, Sounding, Sounding equipment, Methods of locating soundings, conventional and using GPS, Reduction of soundings, Plotting of soundings, Nautical sextant and its use, Three point problem and its use, solution of three point problem by all methods, Tides and tide gauges, determination of MSL

- **SETTING OUT CURVE** **(07 Hours)**
  Introduction, classification of curves, Definition and Notations, Simple Circular Curves, Methods of Setting out Curves, Compound Curve, Transition Curves, Vertical Curves

- **PRINCIPLES OF FIELD ASTRONOMY** **(05 Hours)**
  Introduction, purposes, astronomical terms, determination of azimuth, latitude, longitude and time corrections to the observations.

- **THEORY OF ERRORS** **(06 Hours)**
  Introduction, types of errors, definitions, laws of accidental errors, laws of weights, theory of least squares, rules for giving weights and distribution of errors to the field observations, determination of the most probable values of quantities

(Total Lectures: 42 hours)

3. Books Recommended

1. K R Arora, Surveying and Levelling, Vol. III, Standard Publications, Delhi, 2000.
2. T P Kanitkar and S V Kulkarni, Surveying and Levelling, Vol. III, Vidyarthi Gruh Prakashan, Pune, 1995.
3. R Subramanian, Surveying and Leveling, Oxford University Press, New Delhi
4. J M Anderson and A M Mikhail, "Surveying theory and practice" 7th Edition by Tata McGraw Hill, New Delhi, 2012.
5. B C Punmia, Surveying and Levelling, Vol. II & III, Laxmi Publications Pvt. Ltd., New Delhi, 2006.

CE 338 Environmental Ethics, Law and Policy

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Analyse local and global environmental impact issues.
CO2	Explain the significance of environmental ethics in today scenario.
CO3	Analyse different national environmental policy and guidelines.
CO4	Explain the concepts of environmental auditing, monitoring and reporting.
CO5	Evaluate important Indian and global environmental protection acts and protocols.

2. Syllabus

- **CURRENT PERSPECTIVES OF ENVIRONMENTAL PROTECTION** **(06 Hours)**
  Present perspectives on practical environmental issues; Current practices of environmental solutions through engineering, technology, legislation etc; Need for environmental ethics in today's scenario; Introduction to Environmental Ethics; Pollution - the scientific vs. philosophical view

- **ENVIRONMENTAL MANAGEMENT** **(09 Hours)**
  Moral Psychology, the environment and ethics; Religious and cultural views; ethics and law; Important Indian environmental legislation and acts such as Water Act-1974, Air Act-1981; Important rules under Environment Protection Act (EPA) – 1986 such as Biomedical Waste Rules-1998, EIA Rules-1994, Coastal Regulation Zone-1999, Municipal Solid waste rules, Hazardous Waste Rules-2008 etc.

- **ENVIRONMENTAL POLICY** **(09 Hours)**
  Sustainability and sustainable development; Environmental management plan; Disaster management; Environmental Audit; Life cycle assessment; National environmental policy; Beyond environmentalism and sustainability issues.

- **INTERNATIONAL ISSUES AND ETHICS AND LAWS** **(12 Hours)**
  Solution of international global and local issues through environmental ethics; Ethics & Social Responsibility; Global Ecology and the Shadow of Development; The Global Ecological Crisis; Holistic Environmental Ethics; Towards Global Justice and Planetary Health International environmental laws and protocols such as Stockholm Conference, Montreal Protocol, Rio Earth Summit, Kyoto Summit; Role of UN authorities in protection of global environment; Global environmental issues and environmental laws to control global warming, ozone depletion, acid rain, hazardous waste;

- **ENVIRONMENTAL POLICY** **(06 Hours)**
  National Environmental policy; environmental guidelines and regulations; environmental auditing, monitoring and reporting, environmental labeling studies by Central / State bodies; theory of corporate strategies; beyond environmentalism and sustainability issues.

(Total Lectures: 42 hours)

3. **Books Recommended**

1. G Singh, Environmental law in India, Macmillan India, New Delhi, 2005.
2. K Thakur, Environmental protection law and policy in India, Deep and Deep publishers, New Delhi, 1997.
3. Relevant MoEF Notifications and CPCB / GPCB Acts & Rules.
4. H Rolston, A New Environmental Ethics: The Next Millennium for Life on Earth, Routledge, London, 2011.
5. P Pojman and L P Pojman, Environmental Ethics, Cengage Learning, New York, 2011.

CE 342 Construction Safety Management

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Assess construction safety performance
CO2	Apply knowledge of accident theories to prevent accidents
CO3	Analyze technologies, standards and acts for construction safety
CO4	Design and audit for safety management system
CO5	Develop safe working environment in construction

2. Syllabus

- **OVERVIEW OF CONSTRUCTION SAFETY MANAGEMENT (06 Hours)**
  Terminologies related to safety management, safety management systems, safety climate, safety organization structure, safety culture and performance management, roles and Responsibilities of various persons for managing safety in construction, project management techniques for safety management in construction

- **PREVENTION OF ACCIDENTS (08 Hours)**
  Accident and incident cause theories, causes of major injuries, cost of accident, safety during construction, accidents of different stages of construction, accidents during receiving, unloading, shifting and storage, safety guidelines for storage, safety facilities at sites, coordination interface between civil and erection works, hazardous material and atmosphere

- **SAFETY TECHNOLOGIES (08 Hours)**
  Personal protective equipment, emergency rescue equipment, safety aids, first aid health care, site hoardings, safety training on site, prevention and protection equipment for working on heights, modern scaffolding technology, advance technologies and computer applications in safety management

- **SAFETY TRAINING AND EDUCATION (06 Hours)**
  Introduction to safety training and education, need of safety training and education, importance of training and education, requirements of safety training and education, frequency of safety training, safety audit and inspection education, training of rules and acts of safety management, safety reporting training

- **STANDARDS AND ACTS FOR CONSTRUCTION SAFETY (08 Hours)**
  Construction safety related acts and rules (central act, central and state rules), building & other construction workers (BOCW) act, 1996 and central rules, 1998, the explosives act and rules, the motor vehicle act and rules, the public liability insurance act and rules, the water (prevention and control of pollution) act and rules, the air (prevention and control of pollution) act and rules, battery management and handling rules, gas cylinder rules, hazardous wastes (management and handling) rules, contract labour (R&A) act and rules, workman compensation acts

- **SAFETY MANAGEMENT SYSTEM** **(06 Hours)**
  Policy regarding safety in organization, safety organization and persons, policy documentations, safety budget, investment in safety, training and education systems and schedules, induction programs, safety plan, investigation and analysis of incident, analysis of safety data

(Total Lectures: 42 hours)

3. Books Recommended

1. R E Levitt and N M Samelson, Construction Safety Management, John Wiley & Sons, New York, 1993.
2. S Rowlinson, Construction Safety Management Systems, Routledge, London, 2004.
3. H Lingard and S M Rowlinson, Occupational Health and Safety in Construction Project Management, Routledge, Oxford, 2004.
4. C D Reese and J V Eidson, Handbook of OSHA Construction Safety and Health, CRC Press, New York, 2006.
5. A Griffith and T Howarth, Construction Health and Safety Management, Routledge, London, 2014.

CE 362 Environmental Health and Risk Management

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Explain the significance of health and hygiene
CO2	Describe health issues related with occupational and societal factor.
CO3	Correlate epidemiology with environmental exposures and diseases.
CO4	Integrate health and sanitation approach.
CO5	Design risk management tools and program.

2. Syllabus

- **INTRODUCTION** **(12 Hours)**
  Dimensions of environmental health – Causative agents of diseases – Social factors – Urban problems – Housing and health – Economy and health – Climate and other atmospheric elements – Violence – Chronic and communicable diseases – Occupational health – Epidemiological data – Occupational health hazards – Environmental exposure and diseases – industrial toxicants – Ergonomics – Controlling stress of life.

- **ASSESSMENT OF ENVIRONMENTAL HEALTH** **(08 Hours)**
  Epidemiology – Out break Epidemiology –Disease control – disease prevention – morbidity and mortality – Foodborne and waterborne diseases outbreaks – Integrated Approach to Health and Sanitation.

- **ELEMENTS OF ENVIRONMENTAL RISK ASSESSMENT** **(10 Hours)**
  Hazard identification and accounting – Fate and Behaviour of toxics and persistent substances in the environment – Receptor exposure to Environmental Contaminants – Dose Response Evaluation – Exposure Assessment – Exposure Factors, Slope Factors – Dose Response calculations and Dose Conversion Factors – Risk Characterization and consequence determination – Vulnerability assessment – Uncertainty analysis – Event tree and fault tree modelling and analysis.

- **TOOLS FOR RISK MANAGEMENT** **(12 Hours)**
  HAZOP and FEMA methods – Risk communication and Risk Perception – comparative risks – Risk based decision making – Risk based environmental standard setting – Design of risk management programs – Case studies on risk assessment and management programme.

(Total Lectures: 42 hours)

3. Books Recommended

1. J X Kasperson and R E Kasperson, Global Environmental Risks, V N University Press, New York, 2003.
2. S L Cutter, Environmental Risks and Hazards, Prentice Hall of India, New Delhi, 1999.
3. J F Louvar and B D Louver, Health and Environmental Risk Analysis Fundamentals with applications, Prentice Hall, New Jersey, 2007.
4. A Ramaswami, A Milford and J B Small, Integrated Environmental Modelling - Pollutant Transport, Fate, and Risk in the Environment , John Wiley & Sons, New Jersey, 2005.
5. B Taylor, Effective Environmental, Health, and Safety Management Using the Team Approach, Culinary and Hospitality Industry Publications Services, New York, 2005.

CE364 Air Pollution and Control

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Understand the concepts of air pollution sources and air pollutants.
CO2	Explain standards and legislation pertaining to air and noise pollution.
CO3	Understand the fate of pollutants through meteorology.
CO4	Explain the use of different air quality models for predicting air quality
CO5	Design air pollution control devices for particulate pollutants.

2. Syllabus

- **SOURCES, MEASUREMENT AND ANALYSIS** **(05 Hours)**
  Important air pollutants, their sources, characteristics and effects. Sampling and Analysis, Ambient air sampling, stack sampling, Air quality standards.
- **AIR QUALITY AND STANDARDS** **(05 Hours)**
  Ambient air sampling, stack sampling, Air quality standards.
- **AIR POLLUTION METEOROLOGY AND DISPERSION MODELS** **(15 hours)**
  Atmospheric motion, lapse rate, atmospheric stability, inversion, atmospheric dispersion, maximum-mixing depth, diffusion models, plume rise, effective and minimum stack height.
- **AIR POLLUTION CONTROL** **(12 hours)**
  Characteristics of particulates. Filters, gravitational, centrifugal-multiple type cyclones, prediction of collection efficiency, pressure drop, Wet collectors, Electrostatic Precipitator theory-particle charging-particle collection-ESP design procedure. Control of gaseous pollutants. adsorption, absorption. Emission control in coal-fired power plants and other important industries. Condensation and incineration
- **OTHER TOPICS** **(05 hours)**
  Noise pollution and control, odour pollution and control, indoor air pollution

(Total Lectures: 42 hours)

3. Books Recommended

1. H D Nevers, Air Pollution Control Engineering, McGraw-Hill, New York, 2000.
2. K Wark, C F Warner and W Davis, Air Pollution: Its Origin and Control, Harper and Row, New York, 1998.
3. M N Rao, Air Pollution, Tata McGraw Hill, New Delhi, 2004.
4. R D Griffin, Principles of Air Quality Management, CRC Press, Boca Raton, 2006.
5. H S Peavy, D R Rowe and G Tchobanoglous, Environmental Engineering, McGraw-Hill , New Delhi, 2004.

CE 366 Smart Cities Planning and Management

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Explain concept and global practices.
CO2	Study performance benchmarks, practice codes and national mission.
CO3	Design Smart Cities and draft relevant project management schemes.
CO4	Explain phases of Implementation and monitoring, Finance and Governance.
CO5	Explain phases of Implementation and monitoring, Finance and Governance.

2. Syllabus

- **INTRODUCTION** **(04 Hours)**
  Concept and practice of Smart Cities across the world, Purpose and importance of Smart Cities, Role of different stake-holders

- **FRAMEWORK** **(10 Hours)**
  Human framework, Institutional framework, Energy framework, Data Management framework and technology framework, Present practice of road map for planning and benchmarking their performance for Indian context, accelerate impact, scaling up and across

- **PLANNING AND MANAGEMENT** **(16 Hours)**
  Planning and management for area-based development, PAN city solutions and retrofitting of existing area, greenfield development, integrated planning approach

- **SMART SOLUTIONS** **(08 Hours)**
  ICT in Smart City, Smart monitoring, Technology, Challenges, solutions and work around, replication and upscaling, Smart Infrastructure for building, mobility, energy, water and solid waste

- **FINANCE AND GOVERNANCE** **(04 Hours)**
  E-finance, E-governance, balancing top-down and bottom-up approach

(Total Lectures: 42 hours)

3. Books Recommended

1. J Borsboom-van Beurden, Smart City Guidance Package for Integrated Planning and Management, NTNU, 2017.
2. Ministry of Urban Development Government of India, Smart Cities: Mission Statement & Guidelines, 2015.
3. T M V Kumar, E-Democracy for Smart Cities, Springer Nature, Singapore, 2019.
4. T M V Kumar, Smart Metropolitan Regional Development: Economic and Spatial Design Strategies, Springer Nature, Singapore, 2019.

CE 368 Climate Change Studies

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Explain basics of weather, climate, climate variability, climate change and its impact
CO2	Explain various layers of atmosphere, heat balance of earth atmosphere system, variation of temperature and soil temperature, thermal time and thermal extremes and carbon cycle.
CO3	Explain the extreme climate events and modelling of climate change
CO4	Apply statistical methods in hydro-climatology
CO5	Outline observed and projected impacts, vulnerability and adaptation for Asia

2. Syllabus

- **INTRODUCTION** **(05 Hours)**
  Greenhouse effect. Weather. Climate. Climate variability. ENSO, IOD and climate change. Impacts of climate change.

- **FUNDAMENTALS OF CLIMATE CHANGE STUDY** **(08 Hours)**
  Overview of earth's atmosphere. Layers of atmosphere. Temperature, radiation and variation. Heat-balance of earth atmosphere system. Temporal variation of air temperature. Temperature change in soil. Thermal time and temperature extremes. Carbon cycle. Urban heat island.

- **EXTREME CLIMATE EVENTS** **(05 Hours)**
  Floods. Droughts. Drought indicators. Heat waves. Climate extremes.

- **CLIMATE CHANGE** **(05 Hours)**
  Introduction. Causes of climate change. Modelling of climate change. General circulation models. IPCC scenarios.

- **STATISTICAL METHODS IN HYDRO-CLIMATOLOGY** **(07 Hours)**
  Trend analysis. Empirical orthogonal functions. Principal component analysis. Canonical correlation. Downscaling and statistical downscaling with regression.

- **OBSERVED AND PROJECTED IMPACTS, VULNERABILITY AND ADAPTATION FOR ASIA** **(12 Hours)**
  Sub-region diversity. Observed impacts. Projected impacts. Vulnerability to key drivers and adaptation options for freshwater resources. Terrestrial and inland water systems. Coastal systems and low lying areas. Food production systems and food security. Human settlements. Industry and infrastructure and human health. Security. Livelihoods and poverty. Economics of climate change.

(Total Lectures: 42 hours)

3. Books Recommended

1. G B Bonan, Ecological Climatology, Cambridge University Press, Cambridge, 2002.
2. G G Campbell and J M Norman, An Introduction to Environmental Biophysics, Springer-Verlag, New York, 1998.
3. H V Storch and A Navarra, Analysis of Climate Variability, 2nd Edition, Springer-Verlag, Berlin Heidelberg, 1995.
4. V Storch and F W Zwiers, Statistical Analysis in Climatic Research, Cambridge, 1999.
5. P P Mujumdar and D N Kumar, Floods in a Changing Climate: Hydrologic Modeling, Cambridge University Press, Cambridge, 2012.

CE 372 Intelligent Transportation Systems

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Describe various components of Intelligent Transportation Systems (ITS) and supporting technologies.
CO2	State the role of ITS and its applications for improving the performance of the transportation system.
CO3	Construct ITS related strategies for varying roadway and traffic conditions using design and control parameters.
CO4	Describe ITS related strategies for improving the sustainability, efficiency and safety of transportation system.
CO5	Evaluate effectiveness of measures for improving traffic safety and efficiency.

2. Syllabus

- **INTRODUCTION TO ITS** **(05 Hours)**
  Definition Objectives, Historical Background, Benefits of ITS – Introduction to Automatic Vehicle Location (AVL), Automatic Vehicle Identification (AVI), Geographic Information Systems (GIS), Traffic control and monitoring aspects, components of ITS.

- **ADVANCED TRAVELER INFORMATION SYSTEMS (ATIS)** **(04 Hours)**
  Trip Planner and its impact, Traffic density measurement, Variable message signs, Parking guidance, Weather information and variable speed limits, Impacts of ATIS.

- **ADVANCE VEHICLE MONITORING SYSTEMS** **(04 Hours)**
  Security CCTV systems, Wireless Sensor Network and RFID, Blue-tooth and Wi-Fi sensors, inductive loop detectors and image processing techniques, Impacts of AVMS
- **COMMERCIAL VEHICLE OPERATIONS (CVO)** **(02 Hours)**
  Emergency vehicle notification systems, Automatic road enforcement, Variable speed limits, Collision avoidance systems, Dynamic Traffic Light Sequence, Cooperative systems on the road, Automatic number plate recognition by Image processing, Impacts of CVO.

- **ITS APPLICATIONS** **(05 Hours)**
  Advanced Traffic Management Systems (ATMS) Advanced Vehicle Control Systems (AVCS), Advanced Public Transportation Systems (APTS), Advanced Rural Transportation Systems (ARTS), Automated Highway Systems, and Framework for evaluating ITS related strategies.

- **ITS PROGRAMS IN THE WORLD** **(04 Hours)**
  Overview of ITS implementations in developed countries, ITS in developing countries, Potential applications of offline and online real time measurement of traffic flow characteristics.

- **INTELLIGENT SUPPORTING TECHNOLOGIES** **(18 Hours)**
  Wireless communications, Standards and Cellular Technology, ITS Data acquisition and processing, Hardware and Software--Micro-Controllers, PLC, Embedded systems, Ubiquitous Computing, Sensing

Technologies, Detectors/Detection Techniques— Triangulation Technique, Inductive loop detection, Video vehicle detection, Microwave detection, etc. Global Positioning System (GPS). Case studies.

(Total Lectures: 42 hours)

3. Books Recommended

1. S Ghosh and T Lee, Intelligent Transportation Systems, CRC Press, Boca Raton, 2010.
2. C Drane and C R Drane, Positioning Systems in Intelligent Transportation Systems, Artech House Publishers, London, 1997.
3. J M C Queen and B McQueen, Intelligent Transportation System and Architecture, Artech House Publishers, Artech House, London, 1999.
4. A J Khattak, Intelligent Transportation Systems: Planning, Operations, and Evaluation, CRC Press, United Sates, 2014.
5. M A Chowdhury and A Sadek, Fundamentals of Intelligent Transportation Systems Planning, Artech House, London, 2010.

CE 374 Water Infrastructure in Smart Cities

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Analyze Water Distribution Network
CO2	Design Storm Water Network
CO3	Design Sewerage and Effluent Collection Network
CO4	Apply the integrated flood management practices
CO5	Apply the smart water technologies and resolve the conflicts.

2. Syllabus

- **URBAN WATER ISSUES** **(03 Hours)**
  Water requirement, water availability, water budget, water balance, Zero liquid discharge concept and implementation
- **WATER DISTRIBUTION NETWORK** **(07 Hours)**
  Life cycle cost of distribution network, design and analysis of water distribution network.
- **SEWERAGE AND EFFLUENT COLLECTION NETWORK** **(09 Hours)**
  Design of sewerage network, Design of effluent collection network
- **STORM WATER NETWORK AND INTEGRATED FLOOD MANAGEMENT** **(08 Hours)**
  Selection of IDF, Design of Storm water network with innovation, Flood plain delineation, integrated flood management practice
- **SMART WATER MANAGEMENT TECHNOLOGIES** **(08 Hours)**
  Human-machine interface, wireless sensors, remote monitoring solution, SCADA
- **CONFLICTS IN WATER RELATED INFRASTRUCTURE AND ITS SOLUTIONS** **(07 Hours)**
  Priority of water related infrastructure, conflicts, resolution of conflicts based on hydraulics of flow

(Total Lecture: 42 Hours)

3. Books Recommended

1. Ronald L. Rossmilller, Storm water design for sustainable development, Mc.Graw-Hill Education, USA ISBN: 978-0-07-181652-6.
2. P R Bhave and R Gupta, Analysis of Water Distribution Networks, Narosa Publishing House Pvt. Ltd., New Delhi, ISBN-123:978-81-7319-778-9.
3. L.W. Mays, Water Resources Engineering (second ed.), John Wiley and Sons., New Jersey, USA ISBN:: 978-0-470-46064-1.
4. Central Public Health and Environmental Engineering Organization (CPHEEO), Manual on Sewerage and Sewage Treatment Part A: Engineering, MoUD, New Delhi, 2002.
5. Central Public Health and Environmental Engineering Organization (CPHEEO), Manual on Water Supply and Treatment, MoUD, New Delhi, 2008.

CE 376 Waste-to-Energy Technologies

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Analyze characteristics of solid wastes with respect to waste-to-energy technologies.
CO2	Compare between different waste-to-energy technologies with respect to its applicability.
CO3	Design simple systems based on anaerobic digestion process.
CO4	Design simple thermal waste to energy systems.
CO5	Explain the limitations and applications of different waste to energy options.

2. Syllabus

- **CHARACTERIZATION OF SOLID WASTES** **(10 hours)**
  Wastes and their classification, Important quality parameters, Wastes suitable for energy production, Municipal solid wastes and their availability in India, Characterisation of solid wastes, proximate and ultimate analysis, leaching properties, Energy content and heating value

- **INCINERATION AND GASIFICATION** **(10 hours)**
  Incineration scope and application, Mechanism, air requirements, Performance factors, Feedstock characteristics, Incinerator working, Environmental impacts and issues, Basics of gasification, gasification products, syngas, gasifier types, Gasifiers for biomass and wastes, Comparison between incineration and gasification, Syngas utilization
- **PYROLYSIS, GAS PURIFICATION** **(08 hours)**
  Mechanism, types, operating conditions, end products, properties of biooil, Densification of solids, efficiency improvement of power plant and energy production from waste plastics. Properties of gas produced through different routes, Gas clean up, removal of particulates

- **ANAEROBIC PROCESSES** **(08 hours)**
  Anaerobic processes fundamentals, microbiology, pathways, pre-treatment, types and operation of anaerobic digester, Design of anaerobic digesters, Introduction to microbial fuel cells. Energy production from wastes through fermentation

- **ALGAL BIOMASS FROM WASTEWATER AND ENERGY PRODUCTION** **(06 hours)**
  Characteristics of algal biomass, Cultivation and growth of algae, Reactor systems and harvesting, Biooil production from algal biomass Conversion processes, factors affecting yield, homogeneous and heterogeneous catalyst.

(Total Lectures: 42 hours)

3. **Books Recommended**

1. M J Rogoff and F. Screve, Waste-to-Energy: Technologies and Project Implementation, Elsevier, Amsterdam, 2019.
2. G C Young, Municipal Solid Waste to Energy Conversion Processes, John Wiley and Sons, New Jersey, 2010.
3. J H Harker and J R Backhusrt, Fuel and Energy, Academic Press Inc., Cambridge, 1981.
4. H S Peavy, D R Row and G Tchobanoglous, Environmental Engineering, McGraw-Hill International Edition, New Delhi, 2012.
5. G Tchobanoglous and F Kreith, Handbook of Solid Waste Management, McGraw-Hill, New York, 2002.

CE 378 Disaster Management

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Identify the various features of natural and manmade disaster and safety measures for them.
CO2	Formulate the structure of disaster management (NDMA and GSDMA).
CO3	Design mitigation preparedness, early warning system for various disasters.
CO4	Evaluate disaster management plan for any system.
CO5	Explain various disaster plan and apply the knowledge in field.

2. Syllabus

- **TYPES OF DISASTERS** – its dimensions – Impact of Disasters – Forecasting – Role of Remote Sensing and Geographical Information System in Disaster management – Vulnerability **(07 Hours)**
- **DISASTER REDUCTION STRATEGIES** **(07 Hours)**
  Multi Hazard Mapping– Losses from Global Disaster s and Expenses in Reconstruction and Retrofitting of structures
- **ROLE OF NGO, GOVERNMENT BODIES** and Public, Social and Economic Development of Disaster Prone areas – Emergency Planning. **(06 Hours)**
- **STRUCTURE OF DISASTER MANAGEMENT IN INDIA** **(10 Hours)**
  NDM and Surat Disaster Management
- **DISASTER MANAGEMENT** – Process and Main streaming **(10 Hours)**
- **VARIOUS CASE STUDIES** **(02 Hours)**
  Examples of cyclone disaster management, Fire Disaster Management, Industrial disaster management, Medical disaster management and earthquake disaster management

(Total Lectures: 42 hours)

3. Books Recommended

1. R Gaur, Disaster Management, 1st Edition Saujanay Books, Delhi, 2008.
2. G K Gosh, Disaster Management, Saujanay Books, Delhi, 2015.
3. S Modh, Citizen's Guide to Disaster Management: How to Save Your Own Life and Help, Macmillan India Ltd., Bangalore, 2006.
4. D P Coppola, Introduction to International Disaster Management, 3rd Edition, Butterworth-Heinemann, Oxford, 2015.
5. Disaster Management in India, Ministry of Home Affairs, Government of India, New Delhi, 2011.

CE 382 Advanced Mechanics of Solids

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Annotate the fundamental properties of various materials.
CO2	Analyse the problems related to structural members subjected to tension, compression, torsion and bending using fundamental concepts of stress and strain.
CO3	Implement concepts of failure theories for designing structural members.
CO4	Derive the relations between stress and strain for structural members.
CO5	Analyse the beam by various theories on elastic foundation.

2. Syllabus

- **INTRODUCTION** **(03 hours)**
  Review of basic concepts and equations in mechanics, Classification of materials, Outline of general techniques to solve boundary value problems

- **KINEMATICS** **(04 hours)**
  Seismic Geography and tectonic features of India – Seismic zones earthquake in India

- **EQUILIBRIUM EQUATIONS** **(04 hours)**
  Derive equilibrium equations in Cartesian and cylindrical polar coordinates

- **CONSTITUTIVE RELATIONS** **(04 hours)**
  Restrictions on constitutive relations, General relationship between Cauchy stress and Cauchy Green strain for isotropic materials, General Hooke's law and its reduction for isotropic and orthotropic materials.

- **BOUNDARY VALUE PROBLEMS** **(04 hours)**
  Formulation, Displacement method, Stress method, Airy's stress functions for plane stress and strain problems, Uniaxial Tension, Thick-walled annular cylinder subjected to uniform boundary ure, Infinite medium with a stress free hole under far field tension loading.

- **BENDING OF PRISMATIC STRAIGHT BEAMS** **(05 hours)**
  Pure bending, bending due to uniform transverse loading and bending due to transverse sinusoidal loading of a beam, Asymmetrical bending of straight beams, Shear center, Shear stresses in thin walled open sections.

- **END TORSION OF PRISMATIC BEAMS** **(06 hours)**
  Formulation of the BVP for torsion of beams with solid cross section - warping function and Prandtl stress function approach, Torsion of circular, elliptic, rectangular and triangular cross sections, Membrane analogy, Torsion of thin walled tubes, thin rectangular sections, rolled sections and multiply connected sections

- **BENDING OF CURVED BEAMS** **(06 hours)**
  Winkler-Bach Formula, Elasticity solution for: pure bending of curved beams, curved cantilever under end loading

- **BEAM ON ELASTIC FOUNDATION** **(06 hours)**
  Derivation of the basic governing equation, Solution to beam on an elastic foundation subjected to a point load at the center, moment at the center, uniformly distributed load over some length 'a' symmetrically about the center.

(Total Lectures: 42 hours)

3. Books Recommended

1. L S Srinath, Advanced Mechanics of Solids, Tata McGraw-Hill, New Delhi, 2007.
2. A R Ragab and S E Bayoumi, Engineering Solid Mechanics: Fundamentals and Applications, CRC Press, New York, 1999.
3. M H Sadd, Elasticity: Theory, Applications and Numerics, Academic Press, London, 2006.
4. R S Khurmi, Strength of Material, S. Chand Publication, New Delhi, 2006.
5. S P Timoshenko, History of Strength of Materials, Dover Publications Inc, New York, 1983.

SEMESTER VII

CE 401 Heavy Construction and Project Management

L	T	P	C
3	1	0	4

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Apply project management fundamentals for managing heavy construction projects
CO2	Demonstrate construction planning, scheduling and controlling
CO3	Illustrate construction methods (techniques) for heavy construction
CO4	Demonstrate advanced project management tools and techniques
CO5	Assess project financial appraisals and advance management techniques

2. Syllabus

- **CONSTRUCTION PROJECTS** **(04 Hours)**
  Concept of project and its features, characteristics of construction projects, construction project management practice, organization of construction project, project categories, project planning & organization systems, heavy construction projects, project success strategies, construction industry in India

- **HEAVY CONSTRUCTION EQUIPMENTS** **(08 Hours)**
  Classification of construction equipment, types & characteristics of heavy construction equipment, equipment capacities & costs, machine power, dozers, scrapers, excavators, trucks & hauling equipment, draglines & clamshells, pile driving equipment, selection of equipment, acquisition of equipment, time value of money for heavy construction equipment

- **CONSTRUCTION OF HEAVY FOUNDATIONS** **(08 Hours)**
  Fundamentals theories of heavy foundations, deep foundation theories, design concepts of deep foundation, types of heavy foundations, pile foundation, caissons, coffer dams and raft foundation, construction techniques of heavy foundation, safety during construction of heavy foundation, resource planning for heavy foundation construction

- **PROJECT MANAGEMENT** **(14 Hours)**
  Work scope planning, project work breakdown structures, bar charts, network analysis fundamentals, network elements, network development, CPM network development and analysis, PERT, CPM vs. pert, precedence network analysis fundamentals, line of balance, network updating, resource allocation and scheduling fundamentals, leveling & smoothing, time–cost analysis, quality control methods, construction safety, disputes and resolution techniques

- **PROJECT FINANCE AND APPRAISAL** **(04 Hours)**
  Need & types of project appraisals, concepts of financial appraisal, finance source for heavy construction projects, methods of financing the heavy construction projects, major financing bodies, economic evaluation of project, Indian practice of investment appraisal, time value of money, analysis of risk, discounted and non-discounted cash flow methods

- **ADVANCED PROJECT MANAGEMENT** **(04 Hours)**
  Project management information systems, it applications in project management, project document management, cloud computing, cloud economics, project management software, web based construction project management, building information modelling (BIM) for construction project management

(Total Lectures: 42 hours, Tutorials: 14 hours)

3. Books Recommended

1. K N Jha, Construction Project Management: Theory and Practice, Pearson Education, New Delhi, 2015.
2. K K Chitkara, Construction Project Management: Planning, Scheduling & Controlling, 3rd Edition, Tata McGraw - Hill Publishing Co. Ltd., New Delhi, 2014.
3. P Chandra, Projects: Planning, Analysis, Selection, Financing, Implementation, and Review, Tata McGraw-Hill, New Delhi, 2009.
4. R L Peurifoy, Construction Planning, Equipment, and Methods, Tata McGraw-Hill, New Delhi, 2002.
5. F Harris and R McCaffer, Modern Construction Management, Seventh Edition, Blackwell Publishers, Oxford, 2013.

CE 403 Design of Concrete Structures

L	T	P	C
3	0	2	4

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Apply the fundamental concept of limit state method
CO2	Use IS code of practice for the limit state design of concrete elements
CO3	Design the beams, slabs, columns, isolated footings, and stairs
CO4	Design earthquake resistant building frame

2. Syllabus

- **INTRODUCTION** **(05 Hours)**
  Materials for reinforced cement concrete (RCC) – Design loads – Concrete structural systems – Basis of structural design – Principles of limit state design – Characteristics strength and design strength – idealized stress – Strain curve for materials – Design codes.

- **LIMIT STATE DESIGN OF BEAMS UNDER FLEXURE AND SHEAR** **(11 Hours)**
  Limit state of Collapse in Flexure – Design parameters of stress block – Analysis of singly reinforced rectangular sections – Moment of resistance – Design of singly and doubly reinforced rectangular section – Analysis and design of flanged beam sections. Behaviour of RC Beams under shear –Design shear reinforcement.

- **LIMIT STATE DESIGN OF SLABS** **(06 Hours)**
  Types of slabs – Behaviour of one way and two way slabs – Design of one way simply supported and continuous slabs – Design of two way slabs.

- **LIMIT STATE DESIGN OF COLUMNS** **(06 Hours)**
  Types of columns – Behaviour of axially loaded RC Columns-Uniaxial and Biaxial loaded column – Practical provision on Reinforcement Detailing.

- **LIMIT STATE DESIGN OF FOOTING** **(05 Hours)**
  Types of footings – General design consideration for RC Footings – Structural design of axially loaded isolated rectangular and circular footings – Analysis of footing subjected to vertical load and moments.

- **LIMIT STATE DESIGN OF RC STAIRCASE** **(03 Hours)**
  Types of staircase – Effective Span of staircases – Design of Dog-Legged staircase

- **INTRODUCTION TO EARTHQUAKE RESISTANCE DESIGN** **(06 Hours)**
  Principles for consideration of design earthquake forces – Ductility requirement and detailing – Lateral force analysis of building systems – Analysis of RC building under earthquake forces

(Total Lectures: 42 hours, Practicals: 14 hours)

3. Practicals

1. Design of rectangular, T, L beam of Singly / Doubly Reinforced types.
2. Design of one way simply supported slab.
3. Design of two-way simply supported slab.
4. Design of one-way continuous slab.
5. Design of two-way continuous slab for different boundary conditions.
6. Design of footing
7. Design of Stair case
8. Application of Structural analysis and design software.

4. Books Recommended

1. S U Pillai and D Menon, Reinforced Concrete Design, 3rd edition, Tata Mc Graw Hill Publication Ltd, New Delhi. 2009.
2. S N Sinha, Reinforced Concrete Design, 2nd edition, Tata Mc Graw Hill Publishing Co., Ltd, New Delhi, 2006.
3. H J Shah, Reinforced Concrete, Vol-I 6th Edition, Charotar Publishing House, Anand, 2007.
4. M L Gambhir, Fundamentals of Reinforced Concrete Design, Prentice Hall of India, New Delhi, 2006
5. N Subramanian, Design of Reinforced Concrete Structures, Oxford University Press, New Delhi, 2013.

CE421 Urban Infrastructure Planning and Management

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Explain urban infrastructure needs and provision techniques
CO2	Interpret urban infrastructure norms and guidelines
CO3	Analyse field situation for implementable solutions
CO4	Apply modern maintenance and management techniques
CO5	Explain different models for infrastructure provision

2. Syllabus

- **URBAN INFRASTRUCTURE PLANNING:** **(04 Hours)**
  Data required for provision & planning of urban Infrastructure, Types, significance, impact on urban form, norms and financial aspects, public private, SPV and PPP models in infrastructure provisions, infrastructure policy.

- **NETWORKS AND SERVICES SYSTEMS:** **(10 Hours)**
  Urban services overview, classification and significance, Concepts and theories for design and operation, components, interrelationship, requirements of appropriate technology, cost recovery, Gap analysis.

- **WATER SUPPLY NETWORK:** **(08 Hours)**
  City and Household Network Scenario, Norms, National water policy, Water rights: excess and underutilization of water, role of community in water provision, water harvesting, privatization of water supply and its implications.

- **SEWERAGE NETWORK:** **(04 Hours)**
  City and Household Network Scenario, Norms. Sewerage drainage, refuse collection, storage, recycling and disposal, minimum basic needs, formulation of objectives, norms and standards both for space allocation and quality control, Storm water Network.

- **SANITATION AND SOLID WASTE MANAGEMENT:** **(04 Hours)**
  Types, Generation, collection system, transfer station location, Segregation, transportation, disposal, site selection, Effect of population density, Impact of Urban land use, Bio-medical waste and disposal, Policies and programs in the provision of sanitation at various level, Low Cost Sanitation, city sanitation plan and state sanitation strategies, cost recovery in solid waste.

- **ELECTRICITY AND COMMUNICATION NETWORK:** **(04 Hours)**
  Location, transformer, station, street lighting requirements, telecommunication network requirement.

- **SOCIAL INFRASTRUCTURE:** **(08 Hours)**
  Health and Education hierarchy, norms and location. Energy distribution, fire protection: requirements, norms and standards, planning provision, milk distribution system, Recreation & Open Space planning in Social Infrastructure

(Total Lectures : 42 hours)

3. Books Recommended

1. T M V Kumar, Networks and services, ITPI Reading Manuals, 2009.
2. TCPO and Ministry of Works and Housing, Norms and Standards for Urban Water Supply and Sewerage Services, New Delhi, 2017.
3. National Institute of Urban Affairs, Status of water supply, sanitation and solid waste management in urban area, New Delhi, 2005.
4. T Yigitcanlar, Sustainable urban and regional infrastructure development: technologies, application and management, IGI Global publishing company, New York, 2010.
5. CPHEEO, CPHEEO Manuals on water supply, sewerage, drainage and solid waste management, MoH and UA, GoI, New Delhi, 2019.

CE423 Urban Land Management

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Explain significance of Urban Land Scenario in national perspective
CO2	Postulate dynamics of Urban Land market
CO3	Interpret land management techniques used in practice
CO4	Study land policies adopted at various levels
CO5	Study legal aspects for urban land development

2. Syllabus

- **LAND MARKET DYNAMICS:** **(10 Hours)**
  Concept, Scope, Principles, Land Use and Land Value, Parameters of Land dynamics market mechanism and land use pattern, Land Revenue Code, Land use restriction; compensation and acquisition, Urbanization and land price speculations.

- **LAND ECONOMICS:** **(10 Hours)**
  Economics and Principles of land use, Development of land and real properties, Land Development charges and betterment levy PPP in urban land development & case studies.

- **LAND POLICIES AND PRACTICES AND TECHNIQUES:** **(14 Hours)**
  Policy: Concept, Need, Objective, Significance, Factor influencing location decision, Analysis of location of specific land use like residential-industrial commercial and institutional in intra-regional as well as inter regional level Case studies of various land use policies and practices at national, state, district and settlement level, Land acquisition and land pooling techniques, Process of virgin agricultural land converted into fiscal Resources.

- **LEGAL ASPECTS:** **(08 Hours)**
  Provisions of Land Acquisition Act, Urban Land Ceiling Act and Conservation Act, Town planning Acts, Origin, Objectives and applications. Building Bye-laws-Formations, Provisions and implications. Impacts on real estate developments.

(Total Lectures: 42 hours)

3. Books Recommended

1. J Randolph, Environmental Land use planning and Management, Island Press, 2009.
2. P R Berke, Urban Land use Planning, University of Illinois Press, Illinois, 2009.
3. S V Lall, Urban Land Markets: Improving Land Management for Successful Urbanization, Springer, New York, 2009.

CE 425 Urban Transport System Planning

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Plan and carry out transport planning surveys in cities.
CO2	Synthesize NUTP goals with transport planning practice.
CO3	Generate travel demand patterns for a city based on the land use, transport network and socio economic data.
CO4	Estimate fleet size and capacity for suitable urban transit system.
CO5	Estimate fleet size and capacity for suitable urban transit system.

2. Syllabus

- **URBANISATION PROCESS** **(04 Hours)**
  Urban growth mechanism – Urban morphology - Urbanization & travel demand - Urban development planning policy – NUTP - Urban transport projects - Urban transport problems in India.

- **URBAN TRANSPORT PLANNING PROCESS** **(04 Hours)**
  Urban travel patterns - Study area delineation- Zoning - Planning surveys - Urban activity system- Sustainable urban transport - Systems approach.

- **TRAVEL DEMAND ESTIMATE** **(04 Hours)**
  Trip based and activity based approach - Four stage travel demand modeling - Data needs and outputs - Quick response techniques - Survey designs.

- **TRIP GENERATION** **(04 Hours)**
  Productions & Attractions - Influential factors –Trip rate analysis-Category analysis- Simple & Multiple linear regression models – FHWA method.

- **TRIP DISTRIBUTION** **(06 Hours)**
  Interchange matrix – Growth factor methods – Synthetic methods – Calibration of Gravity model.

- **MODAL SPLIT** **(06 Hours)**
  Influential factors – FHWA Procedure – Diversion curves & surfaces- Discrete choice models, Concept, Types, BL, MNL & HL models.

- **TRIP ASSIGNMENT** **(06 Hours)**
  Trip Assignment procedure – Diversion curves- BPR model - All or Nothing assignment - Multipath assignment - Capacity restraint assignment – User equilibrium and system equilibrium approach - Stochastic assignment approach.

- **LAND USE TRANSPORT SYSTEM** **(04 Hours)**
  Urban system components - Urban spatial structure – Accessibility - Location theory - Land use models - Land use transport models, Lowry & Garin – Lowry models.

- **URBAN PUBLIC TRANSPORTATION** **(04 Hours)**
  Urban growth and public transport needs - transit mode classifications - transit characteristics - fleet size and capacity estimation, goods/logistic transportation.

(Total Lectures: 42 hours)

3. Books Recommended

1. B G Hutchinson, Principles of Urban Transportation System Planning, Mc-Graw Hill, 1974.
2. J D Ortuzar and L G Willumsen, Modeling Transport, John Wiley & Sons,4th Edition, 2011.
3. M J Bruton, Introduction to Transportation Planning, Hutchinson of London, 1988.
4. P Chakroborty and N Das, Principles of Transportation Engineering, PHI, New Delhi, 2003.
5. P Sarkar, V Maitry and G J Joshi, Transportation Planning –Principles, Practices & Policies, PHI, New Delhi, 2014.

CE 427 Flood Control and River Training Works

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Evaluate morphological variation in Alluvial Rivers
CO2	Predict local scour in Alluvial Rivers
CO3	Design river embankment, guide banks, groyens and revertment for Alluvial Rivers
CO4	Apply Geo-Synthetics and other material in river training works
CO5	Compare flood control methods.

2. Syllabus

- **MORPHOLOGY AND HYDRAULICS OF ALLUVIAL RIVER** **(10 Hours)**
  Alluvial streams and their hydraulic geometry, bed level variation of alluvial streams, variation in plan form of alluvial streams, Analytical models of river morphology, Numerical models for morphological studies, flood plain analysis, morphology of some Indian rivers

- **FLOOD CONTROL AND ITS ASSESSMENT** **(12 Hours)**
  Types of Floods, Different methods of Flood control, Floods in major Indian river basins, Types and design of flood forecasting and protection systems, Comparison of levees with bypass channels and off stream storage, reservoir operation for flood control and management, flood damage estimation models.

- **RIVER TRAINING AND FLOOD PROTECTION WORK** **(20 Hours)**
  Guide lines for planning and design of river embankments (levees), planning, design, construction and maintenance of guide banks and groynes for alluvial rivers, Application of Geo-synthetics and other materials in river training works.

(Total Lectures: 42 hours)

3. Books Recommended

1. V T Chow, R M David and W Mays Larry, Applied Hydrology, McGraw-Hill Book Company, New Delhi, 1988.
2. R J Garde and K G Ranga Raju , Mechanics of sediment transportation and alluvial streams problems, New age International (P) Limited, Publishers, New Delhi, 2000.
3. R J Garde , River Morphology, New Age International Publishers, New Delhi, 2006
4. W Mays Larry, Hydraulic Design Handbook, Mc Graw Hill Companies, New Delhi, 1999.
5. BIS 10751(1994), 12094 (2000), 12926 (1995), 8408 (1994).

CE429 Advanced Hydrologic Analysis and Design

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Analyse the trends in rainfall
CO2	Estimate evapotranspiration and infiltration.
CO3	Estimate flood of gauged and ungauged catchments.
CO4	Apply flood routing models in rivers and reservoirs.
CO5	Estimate discharge and design storm water drainage system.

2. Syllabus

- **PRECIPITATION AND EVAPOTRANSPIRATION** **(10 Hours)**
  Global hydrological cycle, Atmospheric water vapour, Greenhouse effect, Computation and measurement of precipitation, missing data analysis and check on consistency of data, trend analysis, evaporation, evapotranspiration, spatio-temporal distribution of rainfall.

- **FLOW THROUGH UNSATURATED ZONE** **(10 Hours)**
  Unsaturated flow models for potential infiltration rate - Horton's equation, Philips equation and Green-Ampt model, Models for actual infiltration rate, Computation of excess rainfall hyetograph from observed flood hydrograph using ϕ-index, Green-Ampt infiltration equation and SCS method

- **FLOOD ESTIMATION METHODS- DETERMINISTIC APPROACHES** **(08 Hours)**
  Unit hydrograph theory, derivation of instantaneous unit hydrograph and synthetic unit hydrograph. Rational method, Project hydrology Design flood PMF storm transportation, PMP and PMF for project by using conceptual models.

- **FLOOD ROUTING** **(06 Hours)**
  Lumped flow routing, distributed flow routing models including kinematic, diffusion and dynamic wave routing models. Numerical solutions of distributed flow routing models.

- **HYDROLOGIC STATISTICS** **(08 Hours)**
  Hydrologic statistics, Flood forecasting and flood frequency analysis. Hydrologic Design Storm Water Drainage Design Introduction glacier lake outburst flood (GLOAF)

(Total Lectures: 42 hours)

3. Books Recommended

1. V T Chow, R M David and W Mays Larry, Applied Hydrology, McGraw-Hill Book Company, New Delhi, 1988.
2. K N Mutreja, Applied Hydrology, Tata McGraw-Hill Publishing company Ltd., New Delhi, 1990.
3. K Subramanya, Engineering Hydrolog, Third Edition - Tata McGraw-Hill Publishing company Ltd., New Delhi, 2012.
4. V P Singh., Elementary Hydrology, Prentice Hall, New Delhi, 1992.
5. C S P Ojha, P Bhunya and P Berndtsson, Engineering Hydrology, Oxford University Press, Oxford, 2008.

CE431 Advanced Fluid Mechanics

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Identify the fluid flows and accordingly application of basic laws of fluid mechanics to solve real time problems.
CO2	Analyse viscous flow and flow instability
CO3	Analyse boundary layer
CO4	Analyse turbulent flow
CO5	Evaluate unsteady flow in pipe

2. Syllabus

- **EQUATIONS GOVERNING FLUID FLOW** **(07 Hours)**
  Reynolds transport theorem, law of conservation of mass-continuity equation, law of conservation of momentum equation of motion, law of conservation of energy- energy equation.

- **POTENTIAL FLUID FLOW** **(07 Hours)**
  Standard flow pattern- uniform flow, source, irrotational vortex circulation, doublet, source and sink, vortex pair; source and vortex-spiral flow; source and uniform flow-flow past a half body; doublet and uniform flow-flow past a half body; source, sink and uniform flow- flow past a Rankine body; doublet and uniform flow-flow past cylinder, doublet; Doublet, vortex and uniform flow-flow past a cylinder with circulation; Magnus effect.

- **VISCOUS FLOW AND FLOW INSTABILITY** **(07 Hours)**
  Equation of motion – Navier-Stokes equation, Exact and approximate solutions of N-S equation, creeping motion, theory of instability of laminar flow- methods of small disturbance, stability analysis, Orr-Somerfield equation, solution of OSE equation- neutral stability curve, stages of transition from laminar to turbulent flow, factors affecting transition from laminar to turbulent flow.

- **BOUNDARY LAYER THEORY** **(08 Hours)**
  Factors affecting growth of boundary layer, momentum thickness, displacement thickness, energy thickness, order of magnitude analysis, Prandtl's boundary layer equation, exact solution of laminar boundary layer equation for flow on a flat plate, von Karman momentum integral equation and its application in computation of boundary shear stress, drag, local and average coefficients of friction for laminar and turbulent boundary layers, factors affecting separation of boundary layer and its control.

- **TURBULENT FLOW** **(07 Hours)**
  Characteristics of turbulent flow, types of turbulent flow, averaging procedure, Reynolds equation for turbulent flow from N-S equation, Prandtl's mixing length theory for two-dimensional parallel flows, Karman-Prandtl's universal velocity distribution, smooth and rough turbulent flow and their velocity distributions, Moody's diagram - friction factor and its variation with Reynolds number and relative roughness.

- **UNSTEADY FLOW IN PIPE** **(06 Hours)**
  Water hammer, Rigid and elastic water column theories, methods of analysis.

(Total Lectures: 42 hours)

3. Books Recommended

1. W R Fox and A T McDonald, Introduction to Fluid Mechanics, Wiley and Sons Inc., New York, 1998.
2. A K Jain, Fluid Mechanics, Khanna Publishers, New Delhi,2012
3. V L Streeter, K Bedford and E B Wylie, Fluid Mechanics, McGraw Hill Book Company Ltd., New York, 1998.
4. F M White, Fluid Mechanics, The McGraw Hill Companies, New Delhi, 2008.
5. V Gupta and S K Gupta, Fluid Mechanics and its Applications, New Age International Private Limited, New Delhi, 2015.

CE433 Stochastic Hydrology

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Acquire a thorough understanding of stochastic hydrology and its applications
CO2	Explain basic concepts in the probability theory
CO3	Explain various types of time series analyses
CO4	Explain various types of stochastic models
CO5	Apply various types of time series analyses and stochastic models

2. Syllabus

- **INTRODUCTION** **(02 Hours)**
  Stochastic hydrology. Applications of stochastic hydrology.

- **FUNDAMENTALS OF STATISTICS** **(09 Hours)**
  Concept of probability. Discrete and continuous variables. Probability distributions including fitting to hydrological data.

- **TIME SERIES ANALYSIS** **(08 Hours)**
  Definitions and classification of time series. Stochastic processes. Components of time series. Trend analysis. Periodicity. Auto-correlation and spectral analysis. Frequency analysis.

- **STOCHASTIC MODELS** **(12 Hours)**
  Univariate models: classification of models, univariate annual models with normal and other distributions, univariate annual models obeying Hurst's law, univariate seasonal models. Multivariate models: multisite annual models, multisite AR models for seasonal flows, MA models, ARIMA models, non-stationary processes.

- **CASE STUDIES** **(11 Hours)**
  Examples related to fitting probability distributions. Trend analysis, Spectral analysis. Stochastic models in hydrologic forecasting.

(Total Lectures: 42 hours)

3. Books Recommended

1. N T Kottegoda, Stochastic Water Resources Technology, The Macmillan Press Ltd., London, 1980.
2. V P Singh, Handbook of Applied Hydrology, Second Edition, McGraw-Hill, New York, 2016.
3. V Yevjevich, Stochastic Processes in Hydrology, Water Resources Publications, Fort Collins, Colorado, 1972.
4. C T Hann, Statistical Methods in Hydrology, First East-West Press Edition, New Delhi, 1995.
5. R T Clarke, Mathematical Models in Hydrology, Food and Agriculture Organization, Geneva, 1973.

CE435 GPS and Applications

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Describe GPS and geodesy
CO2	Explain different positioning modes
CO3	Analyze different errors
CO4	Integrate GPS with other technologies
CO5	Solve complex civil engineering applications using GPS

2. Syllabus

- **GLOBAL POSITIONING SYSTEM** **(06 Hours)**
  History - Segments of GPS system - GPS receivers and its components –GPS signals

- **DATUM, COORDIANTE SYSTEMS AND MAP PROJECTIONS** **(06 Hours)**
  Geodesy - Earth surface - Datum – Co-ordinate systems - Projection systems

- **POSITIONING MODES** **(06 Hours)**
  Absolute positioning - Relative positioning - Differential GPS –Real Time Kinematic GPS

- **ERRORS AND CORRECTIONS** **(06 Hours)**
  Types of errors - Accuracy and precision - Basic statistical concept – Satellite Geometry

- **GPS AND INFORMATION TECHNOLOGY** **(09 Hours)**
  GPS-GIS integration–Other types of integrations - GPS and Remote Sensing - Web based development - GPS software

- **APPLICATIONS OF GPS** **(09 Hours)**
  General applications - Engineering applications - Special applications - Innovative applications - 3D modelling- Case studies

(Total Lectures: 42 hours)

3. Books Recommended

1. N K Agrawal, Essentials of GPS, Spatial Network, Hydrabad, 2006.
2. A Leick, L Rapoport and D Tatarnikov, GPS Satellite Surveying, John Wiley and Sons, 2015.
3. M N Kulkarni, Proceedings of CEP Training Course on The Global Positioning System and its Applications, IIT Bombay, Mumbai, 2003.
4. A E Rabbany, Introduction to GPS, Artech House, Boston, 2002.
5. G S Rao, Global Navigation satellite Systems, Tata McGraw Hill, New Delhi, 2010.

CE437 Industrial Waste Management

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Explain industrial wastewater with its impact on environment
CO2	Analyse the quality and quantity of waste generated from by different industrial manufacturing processes
CO3	Analyse industrial pollution prevention by applying advance treatment
CO4	Analyse wastewater management by advance treatment system
CO5	Explain handling of different industrial wastewater with 3R concept

2. Syllabus

- **INTRODUCTION** **(10 Hours)**
  Sources of wastes – Industrial and domestic – Nature and characteristics of wastewater – Industrial wastewater and environmental impacts – Regulatory requirements for treatment of industrial wastewater– Quality and quantity of industrial wastes –Evaluation of pollution prevention – physical, chemical and biological process. Prevention Vs Control of Industrial Pollution – Benefits and Barriers.

- **INDUSTRIAL POLLUTION PREVENTION** **(10 Hours)**
  Waste minimization – Source reduction Techniques – waste volume reduction- Waste strength reduction – Neutralization – Removal of suspended and colloidal solids – Removal of inorganic and dissolved solids – reduction of wastewater at point source.

- **ADVANCE WASTEWATER MANAGEMENT** **(10 Hours)**
  Waste Audit -- Mass Balance - Toxicity of industrial effluents and Bioassay tests - Individual and common effluent treatment plants – Zero effluent discharge systems – Wastewater quality requirements for its reuse. Quantification and characteristics of Sludge – Thickening, conditioning, digestion, dewatering and sludge disposal.

- **CASESTUDIES** **(12 Hours)**
  Industrial manufacturing process description-- source of wastewater-Wastewater, characteristics– effect of wastewater on receiving water and sewers –waste treatment flow sheet for Textiles, Tanneries, Pulp and paper, Pharmaceuticals, Sugar.

(Total Lectures: 42 hours)

3. Books Recommended

1. P G Smith and J S Scott, Dictionary of Water and Waste Management - Heinemann, Linacre House, Oxford 2005.
2. S N Barton, Industrial Waste: Management, Assessment and Environmental Issues; Nova Science Publishers, New York, 2016.
3. A D Patwardhan, Industrial Waste Water Treatment. PHI Learning, New Delhi, 2008.
4. N L Nemerow, Industrial Waste Treatment, Elsevier Butterworth- Heinemann, USA, 2007.
5. M N Rao and A K Datta, Waste Water Treatment, Oxford & IBH Publishing, New Delhi, 2017.

CE439 Building Maintenance

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Realize significance of building maintenance in national context.
CO2	Realize the effect on buildings through different components.
CO3	Analyse special materials through case studies.
CO4	Develop skills for rehabilitation of buildings.
CO5	Acquire expertise of rehabilitation of historical buildings.

2. Syllabus

- **PRINCIPLES OF MAINTENANCE:** **(10 Hours)**
  Terminology of maintenance and repairs- Objective - Life expectancy of buildings – Property inspection and report – Maintenance budget estimate – Health and safety requirement in maintenance – Agencies Causing Deterioration - Preventive and corrective maintenance - Routine maintenance of buildings– Maintenance problem and root causes. Maintenance cost – Specifications for maintenance work

- **MAINTENANCE OF BUILDINGS** **(10 Hours)**
  Effect of environmental elements on buildings – Effect of chemical agents on buildings and building materials – Damage by biological agents like plants, trees, algae, fungus, moss, insects etc . Damp proofing of existing area – Repair of water supply and sanitary system – Type of repair materials, characteristics – Common technique of building repair – Surface preparation – Specification of Maintenance work – Termite control – Type of fire – Fire Protection and its effect on building.

- **FAILURE AND REPAIR OF BUILDINGS:** **(12 Hours)**
  Definitions of building failure – Functional, structural and aesthetical failures – Case studies – Methodology to investigate of failures in building – Diagnostic testing methods and equipment, Material test, NDT – Repair of cracks in concrete and masonry – grouting, grouting, etc. – Repair and maintenance of foundation, basement and DPC – The Efflorescence Triangle – Repair of building joints - protection - Repair and maintenance of RCC element.

- **REHABILITATION AND CONSERVATION:** **(10 Hours)**
  Analysis-Planning-Cost Estimates-Tender-Methods-construction Methods-Modern materials for repairs – Historical Building -Conservation movement – Materials and methods for conservation work – Case studies – Reliability Engineering Principle – Its application in selection if building system.

(Total Lectures: 42 hours)

3. Books Recommended

1. S M Johnson, Deterioration Maintenance & Repair of Buildings, McGraw Hill Pub, New York, 1990.
2. R N Raikar, Technology of Building Repairs, Raikar Pub., Bombay, 1994.
3. H J Eldridge, Common defects in Buildings, HMSO. Publishers, New York, 2006.
4. National Building Code, 2002.

CE441 Environmental Health and Risk Management

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Explain the significance of health and hygiene
CO2	Describe health issues related with occupational and societal factor.
CO3	Correlate epidemiology with environmental exposures and diseases.
CO4	Integrate health and sanitation approach.
CO5	Design risk management tools and program.

2. Syllabus

- **INTRODUCTION** **(12 Hours)**
  Dimensions of environmental health – Causative agents of diseases – Social factors – Urban problems – Housing and health – Economy and health – Climate and other atmospheric elements – Violence – Chronic and communicable diseases – Occupational health – Epidemiological data – Occupational health hazards – Environmental exposure and diseases – industrial toxicants – Ergonomics – Controlling stress of life.

- **ASSESSMENT OF ENVIRONMENTAL HEALTH** **(08 Hours)**
  Epidemiology – Out break Epidemiology –Disease control – disease prevention – morbidity and mortality – Foodborne and waterborne diseases outbreaks – Integrated Approach to Health and Sanitation.

- **ELEMENTS OF ENVIRONMENTAL RISK ASSESSMENT** **(10 Hours)**
  Hazard identification and accounting – Fate and Behaviour of toxics and persistent substances in the environment – Receptor exposure to Environmental Contaminants – Dose Response Evaluation – Exposure Assessment – Exposure Factors, Slope Factors – Dose Response calculations and Dose Conversion Factors – Risk Characterization and consequence determination – Vulnerability assessment – Uncertainty analysis – Event tree and fault tree modelling and analysis.

- **TOOLS FOR RISK MANAGEMENT** **(12 Hours)**
  HAZOP and FEMA methods – Risk communication and Risk Perception – comparative risks – Risk based decision making – Risk based environmental standard setting – Design of risk management programs – Case studies on risk assessment and management programme.

(Total Lectures: 42 hours)

3. Books Recommended

1. J X Kasperson and R E Kasperson, Global Environmental Risks, V N University Press, New York, 2003.
2. S L Cutter, Environmental Risks and Hazards, Prentice Hall of India, New Delhi, 1999.
3. J F Louvar and B D Louver, Health and Environmental Risk Analysis Fundamentals with applications, Prentice Hall, New Jersey, 2007.
4. A Ramaswami, A Milford and J B Small, Integrated Environmental Modelling - Pollutant Transport, Fate, and Risk in the Environment , John Wiley and Sons, New Jersey, 2005.
5. B Taylor, Effective Environmental, Health, and Safety Management Using the Team Approach, Culinary and Hospitality Industry Publications Services, New York, 2005.

CE443 Air Pollution and Control

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Understand the concepts of air pollution sources and air pollutants.
CO2	Explain standards and legislation pertaining to air and noise pollution.
CO3	Understand the fate of pollutants through meteorology.
CO4	Explain the use of different air quality models for predicting air quality
CO5	Design air pollution control devices for particulate pollutants.

2. Syllabus

- **SOURCES, MEASUREMENT AND ANALYSIS** **(05 Hours)**
  Important air pollutants, their sources, characteristics and effects. Sampling and Analysis, Ambient air sampling, stack sampling, Air quality standards.
- **AIR QUALITY AND STANDARDS** **(05 Hours)**
  Ambient air sampling, stack sampling, Air quality standards.
- **AIR POLLUTION METEOROLOGY AND DISPERSION MODELS** **(15 hours)**
  Atmospheric motion, lapse rate, atmospheric stability, inversion, atmospheric dispersion, maximum-mixing depth, diffusion models, plume rise, effective and minimum stack height.
- **AIR POLLUTION CONTROL** **(12 hours)**
  Characteristics of particulates. Filters, gravitational, centrifugal-multiple type cyclones, prediction of collection efficiency, pressure drop, Wet collectors, Electrostatic Precipitator theory-particle charging-particle collection-ESP design procedure. Control of gaseous pollutants. adsorption, absorption. Emission control in coal-fired power plants and other important industries. Condensation and incineration
- **OTHER TOPICS** **(05 hours)**
  Noise pollution and control, odour pollution and control, indoor air pollution

(Total Lectures: 42 hours)

3. Books Recommended

1. H.D Nevers, Air Pollution Control Engineering, McGraw-Hill, New York, 2000.
2. K Wark, C F Warner and W Davis, Air Pollution: Its Origin and Control, Harper and Row, New York, 1998.
3. M N Rao, Air Pollution, Tata McGraw Hill, New Delhi, 2004.
4. R D Griffin, Principles of Air Quality Management, CRC Press, Boca Raton, USA, 2006.
5. H S Peavy, D R Rowe and G Tchobanoglous, Environmental Engineering, McGraw-Hill , New Delhi,2004.

CE 445 Traffic Engineering and Management

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Identify basic characteristics of traffic stream at micro and macro level.
CO2	Conduct traffic studies and analyze traffic data for practical applications.
CO3	Characterise heterogeneous traffic stream behaviour.
CO4	Design and plan different roadway facilities and elements and capacity estimation of different facilities.
CO5	Analyse and evaluate the safety of road users at different traffic environments.

2. Syllabus

- **TRAFFICCHARACTERISTICS** **(06 Hours)**
  Introduction, Fundamental parameters of traffic and relationships; Time headways, temporal, spatial and flow patterns; Interrupted and un-interrupted traffic; Microscopic and macroscopic speed characteristics; Vehicular speed trajectories; Speed characteristics- mathematical distributions; Speed and travel time variations, Computation of AADT, Design Hourly Volume.

- **TRAFFICFLOWMEASUREMENTS** **(06 Hours)**
  Traffic study components, types of data; Volume studies; Speed studies; Travel time and delay studies; Intersection studies,Originanddestinationstudies,Pedestrianstudies;Parkingstudies, Vehicle detection methods; Advanced methods: GPS, Instrumented Vehicles, Image Processing, Bluetooth, Infrared methods.

- **TRAFFICFLOWANALYSIS** **(08 Hours)**
  Differences- heterogeneous and homogeneous traffic flows, Macroscopic, Microscopic & Mesoscopicapproach–TypesofFlow-Trafficstreamcharacteristics–Space–Timediagram– Relationship between speed, flow & Density-Highway capacity, Level of service & capacity analysis – mixed traffic flow behavior: Non-lane based movement, Heterogeneity, Applications.

- **INTERSECTIONDESIGN** **(08 Hours)**
  At-grade intersections- Principles of design – Design of Channelizing Islands and Roundabouts. Traffic signals - pre-timed and traffic actuated. Design of signal setting - phase diagrams, timing diagram – Signal co-ordination – Area traffic Control System. Grade separated interchanges their Warrants and Design Features.

- **ELEMENTS OF DESIGNANDREGULATIONS** **(10 Hours)**
  Geometric Design: Alignment-Crosssectionalelements-Stoppingandpassingsightdistance, Horizontal curves - Vertical curves. Design problems. Traffic regulation and control. - Signs and markings-Traffic System Management, Speed, vehicle, parking, enforcement regulations, Bus Stop Location and Bus Bay Design, Design of Road Lighting. – Traffic Management techniques, one-way, tidal flow, turning restrictions etc. – TSM planning &Strategies.

- **TRAFFICSAFETY** **(04 Hours)**
  Principles and Practices – Safety along links - Safety at intersections. Road Safety Audit Countermeasures, evaluation of effectiveness of counter-measures– Road safety programmes.

(Total Lectures: 42hours)

3. Books Recommended

1. L R Kadiyali, Traffic Engineering and Transport Planning, Khanna Publishers, New Delhi, 2002.
2. C J Khistyand L B Kent, Transportation Engineering-An Introduction, Prentice-Hall, New Jersey, 2005.
3. A D May, Traffic Flow Fundamentals, Prentice – Hall, Inc., New Jersey, 1990.
4. W R McShane, and R P Roess, Traffic Engineering, Prentice-Hall, New Jersey, 2010.
5. F L Mannering, and S S Washburn, Principles of Highway Engineering and Traffic Analysis, John Wiley and Sons, US, 2016.

CE447 Design of Industrial Structures

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Classify the various industrial structures considering the statutory requirements.
CO2	Establish co-relationship between the various design parameters and determine forces, analysis, and design of various components of industrial building and gable frames
CO3	Analyse and design Foot Over Bridge, towers, gantry girders and different cable roofs.
CO4	Design industrial foundation.
CO5	Determine various design parameters for design of various foundation for Industrial structure.

2. Syllabus

- **PLANNING OF INDUSTRIAL STRUCTURES** **(06 Hours)**
  Classification of industries and local regulations - Factors affecting planning - General Aspects - Civil Engineering Aspects - Light and Ventilation.

- **DESIGN OF INDUSTRIAL STRUCTURES** **(12 Hours)**
  Types of Loads - Structural configurations - Components of a typical industrial building and overview of design procedure - Analysis of industrial buildings and Gable frames - Analysis of columns supporting Crane Girders

- **LARGE SPAN STRUCTURES** **(08 Hours)**
  Cable roofs - Types of cable roofs - Analysis of a cable subjected to concentrated loads and uniformly distributed load, Complexities in the analysis of a cable roof, Overview of deep beams, Virrendel Girder, Castellated Girders - Introduction to earthquake forces

- **SILOS AND BUNKERS** **(08 Hours)**
  Concept of Angle of Repose - Pressure distribution - Dynamic loads - Stability of bunkers - Foundations.

- **TOWERS and MASTS** **(04 Hours)**
  Types of towers and masts, IS Requirement, Analysis, Design.

- **FOUNDATIONS FOR INDUSTRIAL STRUCTURES** **(04 Hours)**
  Machine foundations - General requirements - Design criteria - General analysis - Design of a block foundation for vertical compressor - Vibration Isolation - Foundations for Chimney and Microwave Towers

(Total Lectures: 42 hours)

3. Books Recommended

1. N Subramanian, Steel Structure Design Practice, Oxford Press, Oxford, 2013.
2. M R Shiyekar, Limit State Design in Structural Steel, PHI Learning Private Ltd., Delhi, 2013.
3. P Srinivasula, Handbook of Machine Foundation, First Edition, Tata McGraw Hill Publications, New Delhi, 2000.
4. Ramchandra and V Gehlot, Design of Steel Structures, Seventh Edition, Standard Book House, New Delhi, 2017.
5. M Raghupati, Design of Steel Structures, First Edition, Tata McGraw Hill Publication, New Delhi, 2003.

CE449 Ground Engineering

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Illustrate the methods of Geotechnical field investigations and interpretations
CO2	Identify the expansive soils and collapsible soils and provide solutions to rest foundations on same soil
CO3	Evaluate the soil dynamic properties and analyze the parameters for design of machine foundations
CO4	Provide solutions for treatment of weak deposits, such as soft clay, loose sand, etc, Types of dynamic load, Earthquake load.
CO5	Interpret the waves in layered media and evaluate the liquefaction susceptibility from laboratory and field-testing results

2. Syllabus

- **EXPLORATION TECHNIQUES** **(07 Hours)**
  Objectives – Methods – Suitability – Sub soil investigation – Bore log – Penetration tests – Geophysical methods – Report preparation.

- **FOUNDATION ON EXPANSIVE SOIL** **(07 Hours)**
  Properties – Problems – Identification – Classification – Remedial measures – Case studies

- **FOUNDATION ON COLLAPSIBLE SOIL** **(07 Hours)**
  Definition – Types of collapsible soil – Physical parameters for identification – Procedure for calculating collapse settlement – Case histories of stabilization of collapsible soil.

- **FOUNDATIONS FOR MACHINES** **(07 Hours)**
  Classification – General requirements – Dynamic parameters of Soil – Foundations for reciprocating and impact type machines – Vibration isolation.

- **PRELOADING AND SAND DRAIN** **(07 Hours)**
  Precompression – General considerations – Sand drains and its application – Prefabricated vertical drains.

- **EARTHQUAKE GEOTECHNIQUES** **(07 Hours)**
  Types – Seismic waves – Location of earthquake – Factors influencing ground motion – Liquefaction evaluation of liquefaction susceptibility

(Total Lectures: 42 hours)

3. Books Recommended

1. B M Das, Principles of Foundation Engineering, Cengage Learning, New Delhi, 2015.
2. S L Kramer, Geotechnical Earthquake Engineering, Pearson Education India, new Delhi, 1996.
3. S K Gulhati, M Datta, Geotechnical Engineering, Tata Mc Graw Hill Publishing Company Limited, New Delhi, 2005.
4. R W Day, Geotechnical Engineer's Portable Handbook, Columbus: McGraw Hill, 2000.
5. M R Hausmann, Engineering Principles of Ground Modification, McGraw Hill Publishing Company, New York, 1990.

CE 451 Advanced Concrete Technology

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Explain the cement hydration and its microstructure development.
CO2	Design the special concrete and its mix design procedure.
CO3	Apply the Rheometers and corrosion analyzer systems for measurement in fresh and hardened concrete properties
CO4	Analyse the various durability related problems in reinforced concrete and its mitigation.
CO5	Evaluate strength properties of hardened concrete.

2. Syllabus

- **HYDRATION AND MICRO-STRUCTURE OF CEMENT** **(09 Hours)**
  Hydration of Cements and Micro-structural development, Mineral additives, Chemical admixtures, Cracking and Volume stability, Deterioration processes, Special concretes, Advanced Characterization Techniques, Sustainability issues in concreting, Modeling properties of concrete.

- **PARTICLE PACKING AND RHEOLOGY** **(15 Hours)**
  Advanced Mixture Design, Design Philosophy - Particle Packing & Rheology - Discrete and Continuous approach, Packing density of powders and aggregates - Experimental tests and Models, Ternary Packing Diagram, Mixture Design of Self - Compacting Concrete (SCC); Fresh Concrete Properties, Empirical test for SCC – Rheology, Basics, Parameters, Models, Rheometers, Rheology of Paste and concrete – Pumping, Setting, Curing, Plastic shrinkage, Strength Development, Maturity Method; Hardened Concrete Properties, Factors influencing strength, Interfacial Transition Zone, Stress strain relationship –Localization, End effects, Loading Conditions; Dimensional Stability, Creep and Shrinkag

- **DURABILITY ASPECTS OF CONCRETE** **(10 Hours)**
  Durability, Permeability and Porosity, Chemical attack (Sulphate attack, Delayed Ettringite Formation, Chloride attack, Acid Attack, Sea Water attack, Carbonation, Freezing and Thawing, Alkali aggregate reaction, Alkali carbonate reaction Corrosion, Mode of action, failure, Tests& Protection methods.

- **REBAR CORROSION** **(08 Hours)**
  Rebar Corrosion, Factors inducing rebar corrosion, electrochemical process, role of chloride in corrosion, role of carbon-di-oxide in corrosion, onset of corrosion, corrosion propagation, and service life prediction of concrete structures.

(Total Lectures: 42 hours)

3. Books Recommended

1. P Kumar Metha and P J M Monterio, Concrete- Microstructures, Properties and Materials, Indian Edition, Indian Concrete Institute, Chennai, 1999.
2. P C Aitcin, High Performance Concrete, E&FN Spon, London, 1998.
3. A R Santhakumar, Concrete Technology, Oxford University Press, New Delhi, 2007.
4. A M Neville, and J J Brooks, Concrete Technology, Pearson Education Ltd., Singapore, 2012.
5. K Kalliopi. Aligizaki; Pore Structure of Cement-Based Materials: Testing, Interpretationand Requirements, CRC Press, 2005.

CE453 Geosynthetics and Reinforced Soil Structures

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Illustrate the principles of reinforced soil and its applications
CO2	Identify the types of Geosynthetics and their functions
CO3	Analyse the different engineering properties of Geosynthetic and recognize their applications for various civil engineering constructions
CO4	Design the mechanically stabilised earth wall as per the codal guidelines
CO5	Design the reinforced slope and footing

2. Syllabus

- **INTRODUCTION** **(03 Hours)**
  Historical background of reinforced soil, Principles of reinforced soil through Mohr circle analysis
- **DIFFERENT TYPES OF GEOSYNTHETICS** **(04 Hours)**
  Types of geosynthetics like geotextiles, geogrids, geonets, geocells, geo-composites, their manufacturing methods
- **TESTING METHODS FOR GEOSYNTHETICS** **(05 Hours)**
  Techniques for testing of different index properties, strength properties, Apparent Opening Size, In-plane and cross-plane permeability tests, assessment of construction induced damage, extrapolation of long term strength properties from short term tests.
- **REINFORCED SOIL RETAINING WALLS** **(12 Hours)**
  Different types of walls like wrap-around walls, full-height panel walls, discrete-facing panel walls, modular block walls. Design methods as per BS-8006 and FHWA methods Construction methods for reinforced soil retaining walls.
- **REINFORCED SOIL SLOPES** **(08 Hours)**
  Basal reinforcement for construction on soft clay soils, construction of steep slopes with reinforcement layers on comptenet soils, Different slope stability analysis methods like planar wedge method, bi-linear wedge method, circular slip methods. Erosion control on slopes using geosynthetics.
- **APPLICATIONS IN FOUNDATIONS** **(05 Hours)**
  Binquet and Lee's approach for analysis of foundations with reinforcement layers.
- **PAVEMENT APPLICATION:** **(05 Hours)**
  Geosynthetics for separation and reinforcement in flexible pavements, design by Giroud-Noiray approach, reflection cracking and control using geosynthetics. Use of geosynthetics for construction of heavy container yards and raiway lines.

(Total Lectures: 42 hours)

3. Books Recommended

1. R M Koerner, Designing with Geosynthetics. Prentice Hall, New Jersey, 2012.
2. S Babu, An Introduction to Soil Reinforcement & Geosynthetics, Universities Press, India, 2005.
3. J N Mandal, Geosynthetics Engineering: In Theory and Practice, Research Publishing, Singapore, 2018.
4. SK Shukla, An Introduction to Geosynthetic Engineering, CRC Press, Leiden, 2017.
5. S K Shukla, Yin JH. Fundamentals of Geosynthetic Engineering, CRC Press, Leiden, 2006.

CE455 Introduction to Finite Element Method

L	T	P	C
3	0	0	4

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Illustrate the basic concepts of finite element (FE) analysis
CO2	Identify and select the suitable element and mesh configuration to obtain converged solution
CO3	Develop the element characteristic equation and generation of global equation
CO4	Create 1D, 2D and 3D FE models of practical problems
CO5	Applying the FE analysis on actual problem to determine induced displacements, forces, stresses and strains

2. Syllabus

- **INTRODUCTION** **(06 Hours)**
  Matrix algebra, Fundamentals of continuum mechanics, Stresses displacements and strains in soils, solids and structures, Constitutive relations.

- **ONE- AND TWO-DIMENSIONAL PROBLEMS** **(08 Hours)**
  Plane stress and strain, Interpolation functions, Shape functions (Lagrangian / Natural), Isoparametric elements – 1D and 2D, Numerical integration. Infinite elements, Joint elements, Assembly and Solution techniques, Convergence requirements, Patch test, Examples.

- **AXISYMMETRIC PROBLEMS** **(06 Hours)**
  Formulation and Examples

- **THREE-DIMENSIONAL PROBLEMS, CONSTITUTIVE MODELLING** **(08 Hours)**
  Formulation and Examples, Elastic, Elastic-plastic and Advanced constitutive models.

- **FINITE ELEMENTS IN CIVIL ENGINEERING** **(08 Hours)**
  Applications: Analysis of Shells, Trusses, Beams and Frames, Thin and thick plates, Dynamic considerations, In situ earth pressure, Construction and excavation sequences, Slope stability analysis (c-φ reduction), Seepage, Consolidation, Settlement analysis, Groundwater flow.

- **SOFTWARE BASED LEARNING** **(6 Hours)**
  Pre-processing and Post processing, Tutorials/Assignments, Solving few examples using FE based software (StaadPro, SAP 2000, ABAQUS, PLAXIS, Geo Studio, etc.).

(Total Lectures: 42 hours, Tutorial: 14 hours)

3. Books Recommended

1. Zienkiewicz OC, Taylor RL and Zhu JZ, The Finite Element Method Its Basis and Fundamentals, Elsevier, Amsterdam, 2014.
2. Hutton DV, Fundamentals of Finite Element Analysis, McGraw-Hill, New Delhi, 2004.
3. Reddy JN, An Introduction to the Finite Element Method, McGraw-Hill, New Delhi, 2005.
4. Chandrupatla TR and Belegundu AD, Introduction to Finite Elements in Engineering, Pearson Education, New Jersey, 2011.
5. Logan DL, A First Course in the Finite Element Method, Cengage-Learning, New Delhi, 2007.

CE 457 Rock Mechanics

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Identify different types of rock and rockmass for its suitability and uses in civil engineering applications
CO2	Classify the rock and rockmass on the basis of different rating systems
CO3	Analyze the strength and deformation behavior of rock and rockmass
CO4	Apply the laboratory and field results to determine engineering properties of rock and rockmass
CO5	Provide the engineering solutions for weak soil and rock deposits

2. Syllabus

- **INTRODUCTION** **(04 Hours)**
  Scope of rock mechanics, Object of rock exploration, Methods of rock exploration, Rock quality designation, Geophysical prospecting, Problems related to rock mechanics

- **PHYSICAL AND ENGINEERING PROPERTIES OF ROCKS** **(08 Hours)**
  Rock materials, Physical properties, Strength behaviour in uniaxial compression, tension and triaxial state, Stress-strain relationships, Factors influencing strength, Failure mechanism, Anisotropy, Brittle – ductile transition, In-situ determination of elastic properties of rocks by dynamic method, Weathered rocks

- **DETERMINATION OF ENGINEERING PROPERTIES OF ROCKS** **(06 Hours)**
  Laboratory testing methods - Compressive strength test, Tensile strength test, Permeability, Direct shear test, Test for internal stress in rock, Indirect methods, Flexural strength of rock

- **FAILURE CRITERIA AND RHEOLOGY** **(06 Hours)**
  Coulomb, Mohr's, Griffiths and Modified Griffiths criteria and Empirical criteria, Creep and its measurement, Rheology and rheological models

- **ROCKMASS BEHAVIOUR** **(06 Hours)**
  Rock discontinuities - Joints, Faults, Folds, Strength and deformation behaviour of discontinuities, Rockmass behaviour, Shear strength of jointed rocks, Strength criteria for rockmass

- **INTACT AND ROCKMASS CLASSIFICATIONS** **(06 Hours)**
  Deere and Miller, Geological classification, ISRM, Terzaghi, RQD, RSR, RMR and Q classifications, Rating, Applications

- **FIELD TESTS** **(03 Hours)**
  Necessity, Requirements of in-situ tests, Plate load test, Pressure tunnel test, Bore hole test

- **IMPROVEMENT IN PROPERTIES OF ROCKMASS** **(03 Hours)**
  Necessity, Grouting, Rock bolting, Cable anchorage

(Total Lectures: 42 hours)

3. Books Recommended

1. Vukuturi VS, Lama RD, Saluja SS, Handbook on Mechanical Properties of Rocks, Trans. Tech., Bay Village, Ohio, 1974.
2. Goodman RE., Introduction to Rock Mechanics, Jhon Wiley, London, 1989.
3. Bieniawski ZT, Engineering Rock Mass Classifications, John Wiley and Sons, New York, 1989.
4. Jaeger JC, Cook NG, Zimmerman R, Fundamentals of Rock Mechanics, Blackwell Publishing, Oxford, 2009.
5. Zhang L, Engineering Properties of Rocks, Butterworth-Heinemann, Cambridge, 2016..

CE459 Design of Formwork

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Classify the various type of Formwork, Formwork material, Formwork properties.
CO2	Establish the various design parameters and those parameters for design of formwork.
CO3	Analyse and design formwork for special structure
CO4	Design innovation structural formwork using innovative material and failure study
CO5	Analyse the design of form structure.

2. Syllabus

- **INTRODUCTION** **(05 Hours)**
  Introduction to Formwork as a Temporary Structure, Requirements, Selection, and Classification (Types) of Formwork - Formwork Materials, Shoring Towers, and Scaffolds

- **FORMWORK DESIGN** **(15 Hours)**
  Formwork Design Concepts - Conventional and Proprietary Foundation Formwork. - Conventional and Proprietary Wall Formwork - Conventional and Proprietary Column Formwork.

- **ADVANCE FORMWORK** **(14 Hours)**
  Slab and Beam Formwork - Formwork for Special Structures such as Shells, Domes, Folded Plates, Overhead Water Tanks, Natural Draft Cooling Tower, Nuclear Reactor, Tunnel, and Lift Shaft.- Formwork for Bridge Structures, Cases in Failure of Temporary Support Structures of Bridges - Flying Formworks such as Table Forms, Tunnel Formwork System, Column Mounted Shoring System, Gang Forms - Slip form -Formwork for Precast Concrete

- **FORMWORK MANAGEMENT ISSUE AND FAILURE** **(08 Hours)**
  Pre-Award and Post –award Formwork Management Issues - Formwork Failure -Formwork Issues in Multi-Story Building Construction

(Total Lectures: 42 hours)

3. Books Recommended

1. K N Jha, Formwork for Concrete Structures, First Edition, McGraw Hill., New Delhi, 2012.
2. R L Peurifoy and G D Oberlender, Formwork for Concrete Structures, McGraw Hill, New York, 2011.
3. Robinson and J.R.,Piers, Abutments and Formwork for Bridges Crosby Lockwood & Son Ltd., New York, 1964.
4. C K Austin, Formwork to Concrete, 3rd Edition, George Godwin, 1978.
5. C E Moore, Concrete Form Construction Albany, N.Y.: Delmar Publishers, New York, 1977.

SEMESTER VIII

HU 410 Innovation, Incubation and Entrepreneurship

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Explain the concepts of Entrepreneurship
CO2	Develop skills related to various functional areas of management (Marketing Management, Financial Management, Operations Management, Personnel Management etc.)
CO3	Develop skills related to Project Planning and Business Plan development
CO4	Demonstrate the concept of Innovation, Intellectual Property Rights (IPR) and Technology Business incubation
CO5	Build knowledge about Sources of Information and Support for Entrepreneurship

2. Syllabus

- **CONCEPTS OF ENTREPRENEURSHIP** **(10 Hours)**
  Scope of Entrepreneurship, Definitions of Entrepreneurship and Entrepreneur, Characteristics of an Entrepreneur, Entrepreneurial Development models and Theories, Entrepreneurs Vs Managers Classification of Entrepreneurs; Major types of Entrepreneurship – Techno Entrepreneurship, Women Entrepreneurship, Social Entrepreneurship, Intrapreneurship (Corporate entrepreneurship), Rural Entrepreneurship, Family Business etc.; Problems for Small Scale Enterprises and Industrial Sickness; Entrepreneurial Trait Tests; Entrepreneurial Environment – Political, Legal, Technological, Natural, Economic, Socio – Cultural etc. ; Motivation; Business Opportunity Identification

- **FUNCTIONAL MANAGEMENT AREA IN ENTREPRENEURSHIP** **(12 Hours)**
  Marketing Management: Basic concepts of Marketing, Development of Marketing Strategy and Marketing plan, Online Marketing, New Product Development Strategy, Operations Management: Basic concepts of Operations management, Location problem, Development of Operations strategy and plan, Personnel Management: Main operative functions of a Personnel Manager, Development of H R strategy and plan Financial Management: Basics of Financial Management, Ratio Analysis, Capital Budgeting, Working Capital Management, Cash Flow Statement, Break Even Analysis

- **PROJECT PLANNING** **(06 Hours)**
  Product Development – Stages in Product Development; Feasibility analysis – Technical, Market, Economic, Financial etc.; Project report; Project appraisal; Setting up an Industrial unit – procedure and formalities in setting up an Industrial unit; Business Plan Development

- **PROTECTION OF INNOVATION THROUGH IPR** **(04 Hours)**
  Introduction to Intellectual Property Rights – IPR, Patents, Trademarks, Copy Rights

- **INNOVATION AND INCUBATION** **(06 Hours)**
  Innovation and Entrepreneurship, Creativity, Green Technology Innovations, Grassroots Innovations, Issues and Challenges in Commercialization of Technology Innovations, Introduction to Technology Business Incubations, Process of Technology Business Incubation

- **SOURCES OF INFORMATION AND SUPPORT FOR ENTREPRENEURSHIP** **(04 Hours)**
  State level Institutions, Central Level institutions and other agencies

(Total Lectures : 42 hours)

3. Books Recommended

1. V Desai, Dynamics of Entrepreneurial Development and Management, Himalaya Publishing House, New Delhi, 2011.
2. P M Charantimath, Entrepreneurial Development and Small Business Enterprises, Pearson Education, Singapore, 2018.
3. H David, Entrepreneurship: New Venture Creation, Pearson Education, Singapore, 2016.
4. P Chandra, Projects: Planning, Analysis, Selection, Financing, Implementation and Review, Tata McGraw Hill, New Delhi, 2019.
5. T R Banga and S C Shrama, Industrial Organisation and Engineering Economics, Khanna Publishers, New Delhi, 2015.

CE 422 Regional Planning

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Explain significance of region and planning needs.
CO2	Delineate geographical regions.
CO3	Explain basics of regional economics.
CO4	Analyze resources requirements for regional development.
CO5	Interpret regional development theories for balanced outcome.

2. Syllabus

- **REGIONAL DYNAMICS** **(06 Hours)**
  Definition of Region, Typology, classifications and Delineation of regions. Growth of Mega and Metro Regions: Scale, Complexity and its impact on national and international scenario, convergence and divergence. Regional Economy, competitiveness among regions, backward and leading regions in development; Special Regions: SEZ, Agro Regions, Ecological regions, etc.

- **REGIONS IN INDIA AND ITS PLANNING** **(08 Hours)**
  Regions in Indian Context: Resource Regions, Corridors as regions, National, subnational and State as a region, macro, meso and micro regions in India. Role of resources in regional development, utilization of resources and environmental problems Sectoral and regional development and imbalances, multilevel planning, special area development plans. Balanced developed development national and state level planning mechanism. Resource regions in India.

- **CORE AND PERIPHERY IN A REGION IN INDIAN CONTEXT** **(08 Hours)**
  Core, Fringe and Periphery in a Region and its planning; Tools and techniques available for planning regions in India; Role of 73rd and 74th Constitution Amendment Acts in regional plan Preparation and implementation. Concept of District Planning.

- **DEMOGRAPHIC AND EMPLOYMENT FORECASTING** **(04 Hours)**
  Population forecasting, Linear & Exponential models, Employment classification

- **ELEMENTS OF MICRO AND MACRO ECONOMICS** **(04 Hours)**
  Basic Economics: Demand, Supply, Elasticity, Revenue Cost, National Income, Consumption, Investment, Inflation, Capital Budgeting
  Development Economics: Economic Growth and development, Human Development Index, Economic Principles, Policies and strategies in Land use planning.

- **TECHNIQUES AND GROWTH MODELS OF REGIONAL ANALYSIS** **(12 Hours)**
  Regional Analysis: Introduction to regional analysis, regional linear programming, regional input-output analysis, factor analysis, industrial location theory, spatial diffusion theory, gravity analysis.
  Growth Models: Concept of growth pole and growth foci, core-periphery concept, role of settlements in regional development, urbanization and regional development, input – output models, central place Theory Christaller Loseh.

(Total Lectures: 42 hours)

3. **Books Recommended**

1. J Glassion, Introduction to regional planning, Hutchinson and MIT Press, Cambridge, 1996.
2. J R Chaudhuri, An Introduction to Development and Regional Planning, Orient Longman Ltd, Kolkata, 2001.
3. K V Sundaram, Urban and Regional Planning in India, Vikas Publishers, New Delhi, 1978.
4. M Chand and U K Puri, Regional Planning in India, Allied Publishers, New Delhi, 2011.
5. R P Mishra, Regional Planning, Concept Publishing Co., New Delhi, 2002.

CE 424 Real Estate Management

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Explain concept of real estate sector development
CO2	Analyse urban building industry in national perspective
CO3	Interpret urban land policy for effective implementation
CO4	Evaluate real estate management limitations and finding solutions
CO5	Explain modern concept of land value and rent

2. Syllabus

- **REAL ESTATE:** **(08 Hours)**
  Terminology: Land Documentation, Land Revenue Records, Document Registration, City Survey Record, Land Registration Process; Property Card, Index concepts and characteristics; Urban real estate market problems, factors affecting real estate property, rights and interests; Contract law and real estate; Speculation in urban land; betterment and worsening.

- **REAL ESTATE PLANNING AND MANAGEMENT** **(08 Hours)**
  Real estate planning methods, constraints, environmental factors, schemes & finance, Government policies.

- **ECONOMICS AND LOCATION MODELLING:** **(16 Hours)**
  Factors affecting different land uses such as residential, commercial, industrial, public and semi public; Land value – Concept and factors affecting; Rent and modern theory of rent; Macro and Micro approaches of Location such as trade-off model and environment preference model.

- **URBAN LAND POLICY:** **(10 Hours)**
  Contents, importance, objectives, measures, instruments for its implementation, direct Govt. action, legal and physical controls; Relationship between economic trends, land market and urban development. Modern Methods for Land Pooling; PPP method for Land Pooling; Issues and strategies for Land Management

(Total Lectures: 42 hours)

3. Books Recommended

1. B N Paul, Urban Land Economics, The McMillan Press, London, 1997.
2. B Singh, Urban Infrastructure and Real Estate Management, Surendra Publications, New Delhi, 2011.
3. W Lean, Aspects of Land use Planning, Gonthic Publications, New Jersey, 1982.

CE 426 Urban Design and Landscape Planning

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Explain sustainable urban design and landscape for quality of life
CO2	Describe functional design strategies and landscape planning.
CO3	Analyse of planning parameter for CBD, Town Centre and area based character
CO4	Explain Public Private Partnership practices for revenue generation.
CO5	Describe global practices and implications

2. Syllabus

- **SCOPE AND OBJECTIVES OF URBAN DESIGN:** **(04 Hours)**
  Its relation with architecture and urban planning, scale of various urban design projects, regional and city level, urban design survey, inventories, techniques/approaches to urban design. Concepts and theories in landscape architecture/city planning urban design in the historical perspective, origin of forms, organization of space, relationship of activity with buildings.

- **BEHAVIORAL ISSUES IN URBAN DESIGN:** **(04 Hours)**
  Principals of urban spatial organization, urban scale, urban spaces, urban massing, quality of urban enclosure. Imageability, townscape and elements of urban design (Gordon, Cullen, Kevin Lynch) Urban conservation with historic preservation and integrated approach to conservation, urban renewal, its purpose, economics and planning issues.

- **URBAN DESIGN AT MICRO LEVEL:** **(02 Hours)**
  Campus planning, city centers, transportation corridors, residential neighbourhood, water fronts. Urban landscape in relation to topography.

- **DEVELOPMENT CONTORL GUIDELINES:** **(02 Hours)**
  Zoning, Historical examples of urban design projects. Evaluation/ feasibility study of urban design projects.

- **OBJECTIVES AND SCOPE OF LANSCAPE PLANNING:** **(10 Hours)**
  Behavioral issues in landscape design, principles and aesthetic theory in landscape design, Land from design and elements of geomorphology, hydrology, pedology, drainage in landscape planning. Spatial organization of selected cities, emphasizing landscape assessment. Site and resources inventory methods, analyses and appraisal, landscape suitability analysis, Plant characteristics and planting design, environmental factors in landscape planning.

- **LANDSCAPE PLANNING:** **(10 Hours)**
  Urban and regional level open spaces, residential neighborhoods, urban roads and regional highways, coastal area landscape planning. Landscape Urbanism, sustainable landscape, streetscape Waterfronts, evolution of different landscape philosophies.

- **OPEN SPACE SYSTEM:** **(08 Hours)**
Concept for opens space and park system in urban area. Open space development in urban design context. Evolution of Public Park as a major component of urban landscape. Open space development in new towns. Park systems, water fronts. Green infrastructure. Urban ecology, urban water sheds.

- **EVALUATION PROCESS IN LANDSCAPE PLANNING:** **(02 Hours)**
Critical appraisal of historical examples of landscape plans. Relevance of Social forestry in urban and regional landscape planning.

(Total Lectures: 42 hours)

3. Books Recommended

1. B Hackett, Landscape planning: an introduction to theory and practice, Oriel, London, 1971.
2. F R Steiner, The living landscape: an ecological approach to landscape planning, McGraw-Hill, New York, 1991.
3. I L McHarg, Design with nature, Wiley, New Jersey, 1992.
4. M Carmona, Public places – Urban spaces, Architectural press, New York, 2003.
5. T Turner, Landscape planning and environmental impact design, 2nd ed, UCL Press, 1998.

CE 428 Tourism Planning and Development

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Explain fundamentals of tourism planning and development
CO2	Describe concept, technique and scheme of tourism
CO3	Analyse tourism industry and national economic development.
CO4	Apply sustainable techniques for tourism planning and development.
CO5	Interpret global and national tourism policies and case studies

2. Syllabus

- **INTRODUCTION TO TOURISM** **(10 Hours)**
  Definitions, scope, nature, classification and dimension, tourism as an industry, tourism in developed and developing world. Tourism as system, Demand and supply, Relationship between Tourism and Urban Development. Creation of Urban Space for recreation and tourism, Principles of Recreation, Leisure and Tourism. Nature and scope of a tourism plan- key issues and stages, data requirements, surveys, role of key players / stake holders in tourism policy and planning.

- **SUSTAINABLE PLANNING FOR TOURISM DEVELOPMENT:** **(16 Hours)**
  Natural resource assessment; Techniques of tourism potential analysis; Concept of Ecotourism, Environmental threats and planning precautions. Concepts and parametric analysis; Integrated wildlife, Tourism multiplier and forecasting methods: capacity building and carrying capacity planning for tourism projects, tourism and cultural and social change: Socio, Tourism infrastructure development, Tourism Project conception and preparation for project report.

- **TOURISM MANAGEMENT AND ECONOMICS:** **(12 Hours)**
  Management and Economics of tourism industry and development management. Tourism marketing - concept, techniques and strategies. GIS application in tourism development, policies and programme at National State and District level. Tourism planning case studies.

- **POLICIES AND PROGRAMMES:** **(04 Hours)**
  Tourism policies at various levels. CASE STUDIES: Indian Site, Projects for Gujarat Tourism

(Total Lectures: 42 hours)

3. Books Recommended

1. C M Hall, Tourism Planning: Policies, Process & relationship, Prentice Hall, Singapore, 2008.
2. N David, Natural area tourism Ecology impacts and management, Chainal View Publication, 2008.
3. G Clare, Tourism Planning: Basics, Concepts, cases, France & Taylor Publication, London, 2009.
4. C R Goeldner, J R R Brent, Tourism: Principles, Practices, Philosophies, John Wiley & Sons, New jersey, 2009.
5. A Satishbabu, Tourism Development in India, APH Publishing Corporation, New Delhi, 2008

CE 432 Smart Cities Planning and Management

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Explain concept and global practices.
CO2	Study framework, practice codes and national mission.
CO3	Able to design Smart Cities and draft relevant project management schemes.
CO4	Application of smart solution
CO5	Explain phases of Implementation and monitoring, Finance and Governance.

2. Syllabus

- **INTRODUCTION** **(04 Hours)**
  Concept and practice of Smart Cities across the world, Purpose and importance of Smart Cities, Role of different stake-holders

- **FRAMEWORK** **(10 Hours)**
  Human framework, Institutional framework, Energy framework, Data Management framework and technology framework, Present practice of road map for planning and benchmarking their performance for Indian context, accelerate impact, scaling up and across

- **PLANNING AND MANAGEMENT** **(16 Hours)**
  Planning and management for area-based development, PAN city solutions and retrofitting of existing area, green field development, integrated planning approach

- **SMART SOLUTIONS** **(08 Hours)**
  ICT in Smart City, Smart monitoring, Technology, Challenges, solutions and work around, replication and up-scaling, Smart Infrastructure for building, mobility, energy, water and solid waste

- **FINANCE AND GOVERNANCE** **(04 Hours)**
  E-finance, E-governance, balancing top-down and bottom-up approach

(Total Lectures: 42 hours)

3. Books Recommended

1. J Borsboom-van Beurden, Smart City Guidance Package for Integrated Planning and Management, NTNU, 2017.
2. T M V Kumar, Smart Metropolitan Regional Development: Economic and Spatial Design Strategies, Springer Nature Singapore, 2019.
3. T.M V Kumar, E-Democracy for Smart Cities, Springer Nature Singapore, 2019.
4. Ministry of Urban Development Government of India, Smart Cities: Mission Statement & Guidelines, New Delhi, 2015.

CE 434 Public Transport System Design and Operation

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Synthesize urban growth with transit system needs..
CO2	Plan and execute appropriate transit data collection scheme.
CO3	Generate transit demand patterns and design the system.
CO4	Analyse the demand and recommend suitable network size and configuration for transit.
CO5	Carry out performance evaluation of transit operations.

2. Syllabus

- **TRANSIT SYSTEMS** **(08 Hours)**
  Growth history – Urban growth & transit evolution - Types of Transit Modes - Buses - LRT, RTS - Air cushioned and Maglev System – S-Bahn Dual Mode Busses, Para Transit - Dial - a- Ride-Taxi- Jitney and Ridesharing – PRT Networks -DRTS Technological Characteristics – Resistances, acceleration & velocity Profiles – Operational characteristics speed, capacity & payloads – Route capacity – Comfort conditions - Performance relationships - Public and Private Operations - Modes for Intercity Transport.

- **ESTIMATION OF TRANSIT DEMAND** **(06 Hours)**
  Data requirements & Collection techniques, Conventional Methods - Destination Survey - Transit Stop & Ride Surveys and Analysis - Mode Split Models - Captive and Choice Riders - Attitudes of Travelers - Patronage Determination.

- **TRANSIT DESIGN** **(06 Hours)**
  Frequency & headway determination methods – Rail operation design – Bus operation design – Way capacity & Station capacity –Transit level of service.

- **TRANSIT ROUTE NETWORK PLANNING** **(06 Hours)**
  Route Systems - Route Location, Route Structure, Route Coding Techniques, Route Capacity - Planning of Transit Network - Different Types - Service Area Coverage - Evaluation - Selection of Optimal Network - Path Building Criteria - Integration with UTPS.

- **SCHEDULING** **(06 Hours)**
  Patterns of transit Services - Frequency of Services - Special Services - Single Route Bus Scheduling - Fleet Requirement, Marginal Ridership Concept - Use of Optimization Technique - Load Factor - Depot Location - Spacing of Bus Stops.

- **MASS TRANSIT CORRIDOR IDENTIFICATION AND PLANNING** **(06 Hours)**
  Corridor identification - Network Compression Method - Planning of Rapid Transit System - System Selection - Aesthetics and Noise Consideration - Cost of Construction - Station Arrangements - Platform Capacity - Fare Structure, Transit Marketing.

- **TRANSIT TERMINALS AND PERFORMANCE EVALUATION** **(04 Hours)**
  Performance Evaluation – Efficiency, Capacity, Productivity and Utilization – Performance Evaluation Techniques and Application – System Network Performance – Transit Terminal Planning and Design.

(Total Lectures: 42 hours)

3. Books Recommended

1. A Ceder, Public Transit Planning and Operation: Theory, Modelling and Practice, B-H Elsevier Ltd., Massachussets, 2007.
2. C J Khisty, L B Kent, Transportation Engineering – An Introduction, Prentice-Hall, New Jersey, 2005.
3. C S Papacostas and P D Prevedouros, Transportation Engineering & Planning, PHI, New Delhi,2002.
4. V R Vuchic, Urban Public Transportation: Systems & Technology, John –Wiley & Sons, New Jersey, 2007.
5. P Sarkar, V Maitry, G J Joshi, Transportation Planning –Principles, Practices & Policies, PHI, New Delhi, 2014.

CE 436 Transportation Safety and Environment

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Analyse the present scenario about transport safety and environment with a multidisciplinary approach.
CO2	Examine factors affecting road safety engineering and crash investigation, human factors relating to crashes/accidents, crash/accident.
CO3	Predict hazard identification related to the transport safety and environment and take management measures for improving safety and environment.
CO4	Create awareness about empathetic and improving the present practices related to the Transportation Safety Audit and Environmental Impact Assessment (EIA) for transportation projects.
CO5	Evaluate effectiveness of measures for improving traffic safety and environment.

2. Syllabus

- **INTRODUCTION** **(08 Hours)**
  Transportation Safety scenario in India and World, Accident Characteristics, Distribution among different modes. Need of Planning for Network, Land Use and Road Environment for Safety, Designing for Safety: Road Link Design, Junctions. Introduction to Road Safety Engineering and Crash Investigation, Human Factors Relating to Crashes/Accidents, Crash/Accident

- **ROAD SAFETY DIAGNOSIS** **(06 Hours)**
  Investigation & Crash Problem Diagnosing, Crash Problems into Solutions & Crash, Investigation Reporting, Crash/Accident, Costing, Economic Appraisal. Safety at Construction Site: Safety provisions for workers at construction site, Construction Zone markings, signs.

- **ROAD SAFETY AUDIT** **(06 Hours)**
  Road Safety Auditing: An Introduction, Concept and need of Road Safety Audit (RSA). Procedures in RSA, design standards, audit tasks, stages of road safety audit, Road Safety Audit Types, key legal aspects, process, audit team and requirements, Checklist, how to use Checklists Road Safety inspection.

- **TRANSPORT AND ENVIRONMENT ISSUES** **(08 Hours)**
  Introduction to transport and the environment: Context, mechanisms and sustainability; Air Pollution: Mechanisms, technology solutions, modelling and social costs; Traffic Noise: Units, sources, and impacts Climate Change: Transport contribution, potential impacts, regulatory framework and policies.

- **MEASUREMENT AND MODELLING** **(07 Hours)**
  Environmental planning and assessment practices, Measurement of environmental impacts of transport: Emissions, air quality and noise, Modelling of environmental impacts of transport: Emissions, air quality and noise, Land use transport relationships.

- **IMPACT ASSESSMENT** **(07 Hours)**
  Environmental Impact Assessment for Transportation Projects: Basic Concepts, Objectives, Transportation Related Environmental Impacts; Vehicular Impacts; Safety & Capacity Impacts; Roadway Impacts, Construction Impacts, Environmental Impact Assessment, Environmental Impact Statement, Environment Audit, Typical case studies.

(Total Lectures: 42hours)

3. Books Recommended

1. R Lamm, B Psarianos, and T Mailaender, Highway Design and Traffic Safety Engineering Handbook, McGraw Hill Publishing, New York, 1999.
2. J Glasson, R Therivel and A Chadwick, Introduction to Environmental Impact Assessment, Routledge, London, 2007.
3. L W Canter, Environmental Impact Assessment, McGraw Hill Inc. Singapore, 1996.
4. J G Rau, and D C Wooten, Environmental Impact Assessment, McGraw Hill Pub. Co., New York, 1996
5. Relevant IRC and NHAI guidelines.

CE438 Waterways Infrastructure Planning and Design

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Assess the available resources, and analyse the present and future requirement to plan and design harbour facilities
CO2	Gain detailed insights concerning the traffic demand for harbour planning
CO3	Differentiate harbour works, berthing structures and transit sheds.
CO4	Design coastal protection facilities and learning navigation aids
CO5	Assess repair facilities, port facilities and cargo handling facilities required.

2. Syllabus

- **HARBOUR PLANNING** **(08 Hours)**
  Types of water transportation, water transportation in India, requirements of ports and harbours, classification of harbours, selection of site and planning of harbours, location of harbour, traffic estimation, master plan, ship characteristics, harbour design, turning basin, harbour entrances, type of docks, its location and number, Site investigations – hydrographic survey, topographic survey, soil investigations, current observations, tidal observations.

- **HARBOUR WORKS** **(08 Hours)**
  Design and construction of breakwaters, berthing structures - jetties, fenders, piers, wharves, dolphins, trestle, moles, navigational aids, requirements of signals, fixed navigation structures, necessity of navigational aids, light houses, beacon lights, floating navigational aids, light ships, buoys, radar.

- **DOCKS AND REPAIR FACILITIES** **(08 Hours)**
  Harbor docks, use of wet docks, design of wet docks, repair docks, lift docks, dry docks, keel and bilge blocking, construction of dry docks, gates for dry docks, pumping plant, floating docks, slipways, locks, size of lock, lock gates, types of gates.

- **PORT FACILITIES** **(08 Hours)**
  Port development, port planning, port building facilities, transit sheds, warehouses, cargo handling facilities, container handling terminal facilities, shipping terminals, inland port facilities.
- **DREDGING AND COASTAL PROTECTION** **(06 Hours)**
  Classification, types of dredgers, choice of dredger, uses of dredged materials, coastal erosion and protection, sea wall, revetment, bulkhead, coastal zone and beach profile.

- **INLAND NAVIGATION** **(04 Hours)**
  Inland waterways, Inland water transportation in India, classification of waterways, economics of inland waterways transportation, national waterways.

(Total Lectures: 42hours)

3. Books Recommended

1. B Cunningham, The Dock and Harbour Engineer's Reference Book: Being a Compilation of Notes on Various Matters Connected with Maritime Engineering and Ports and Harbours, Franklin Classics Trade Press, New York, 2016.
2. C A Thoresen, Port Designer's Handbook: Recommendations and Guidelines, Thomas Telford, Tokyo, 2006.
3. G P Tsinker, Handbook of Port and Harbor Engineering: Geotechnical and Structural Aspects, Springer, New York, 2014.
4. H P Oza and G H Oza, Dock and Harbour Engineering, 8th Edition, Charotar Publishing House Pvt. Ltd., Anand, 2016.
5. S B Junnarkar and HJ Shah, Dock and Harbour Engineering, Charotar Publishing House Pvt. Limited, Anand, 2010.

CE442 Traffic Flow Theory

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Investigate traffic flow characteristics and its variation at microscopic and macroscopic levels over space and time.
CO2	Distinguish various traffic flow theories for identifying key factors affecting traffic performance.
CO3	Apply the traffic flow theories for varying roadway and traffic conditions using various design and control parameters.
CO4	Examine vehicle-following behaviour under heterogeneous traffic conditions.
CO5	Apply programming and simulation skills to interpret and analyse data pertaining to Traffic Engineering problems.

2. Syllabus

- **TRAFFIC STREAM CHARACTERISTICS** **(08 Hours)**
  Measurement of microscopic and macroscopic traffic flow characteristics; Time-space plots; Study of Traffic Stream Characteristics - Flow, Speed and Concentration; Density measurement techniques, Use of Counting, Interval and Translated Distributions for Describing Vehicle Arrivals, Headways, Speeds, Gaps and Lags; Fitting of Distributions, Goodness of Fit Tests, gap acceptance behavior.

- **TRAFFIC STREAM MODELS** **(12 Hours)**
  Fundamental Equation of Traffic Flow, Speed-Flow-Concentration Relationships, Pedestrian stream models, Normalized Relationship, Fluid Flow Analogy Approach, Gas-kinematic models, Shock Wave Theory, Car-Following Theory, Advanced Car-Following Models, Psycho-physical models, Traffic Flow Stability, Social-force models, Hysteresis based behavioral studies.

- **SHOCKWAVE ANALYSIS** **(6 Hours)**
  Shock wave equations; Types of shockwaves and propagation; Shock waves at toll gates, Signalized intersections, Shockwaves due to incidents; Shockwaves due to bottlenecks, Shockwave analysis on flow-density diagram and using simulation.

- **QUEUING ANALYSIS** **(6 Hours)**
  Fundamentals of Queuing Theory; Demand Service Characteristics, Deterministic Queuing Models, Stochastic Queuing Models, Multiple Service Channels, Models of Delay at Intersections and Pedestrian Crossings, Queuing examples and numerical analysis; Determination of number of servers, Average time and vehicles in Queuing system.

- **TRAFFIC SIMULATION** **(10 Hours)**
  Monte Carlo method; Generation of Pseudorandom Numbers; Discrete Random deviates; Simulation methods; Fundamentals of simulation; Introduction to factorial experimental designs, Fractional factorial design, Components of traffic simulations models, vehicle arrival and movement models, mixed traffic flow simulation, Simulation model development strategies; Study of large scale simulation models; Scanning

Technique; Time based and Even-based methods; Examples of Macroscopic, Mesoscopic, and Microscopic based simulation models, Calibration and Validation of Simulation Models; methodology for calibrating and validating a microscopic traffic simulation model; Case studies of application of simulation for various transportation engineering problems.

(Total Lectures: 42hours)

3. Books Recommended

1. B S Kerner, Introduction to Modern Traffic Flow Theory and Control, Springer, Berlin, Heidelberg, 2009.
2. D R Drew, Traffic Flow Theory and Control, McGraw Hill, New York, 1976.
3. A D May, Traffic Flow Fundamentals, 1st Edition, Prentice Hall, New Jersey, 1990.
4. R P E Roess, S Prassas and W R McShane, Traffic Engineering, 4th edition, Prentice Hall, New Jersey, 2010.
5. J Banks, J S Carson, B L Nelson, Discrete-Event System Simulation. 5th Edition. Prentice Hall, New Jersey, 2010.

CE444 Advanced Hydraulic Structures

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Describe different aspects of reservoirs.
CO2	Identify the methods of hydraulic structure design.
CO3	Design hydraulic structures.
CO4	Analyse weir and barrages, canal regulating structures.
CO5	Design and selection of cross drainage works and energy dissipaters.

2. Syllabus

- **PLANNING OF WATER RESOURCES ENGINEERING PROJECT** **(04 Hours)**
  Planning and investigations of reservoir and dam sites, Choice of dams, preparation and protection of foundation and abutments.

- **GRAVITY DAM** **(08 Hours)**
  Forces acting on solid gravity dam, modes of failures, stability analysis, elementary and practical profile of gravity dam, internal stresses and stress concentrations in gravity dam, joints, seals, keys in gravity dams, dam safety and hazard mitigation

- **EMBANKMENT DAM** **(08 Hours)**
  Classification of embankment dam, Homogeneous and zoned embankment dams, factors influencing design of embankment dams, criteria for safe design of embankment dam, steps in design of embankment dam, seepage analysis and its control through dam and its foundation, design considerations for rock fill dam, instrumentation

- **SPILLWAYS AND ENERGY DISSIPATERS** **(08 Hours)**
  Capacity of spillways, components and profile of different types spillways, Non-conventional type of spillways, selection and design of energy dissipaters, spillway aerator.

- **DIVERSION HEADWORK** **(07 Hours)**
  Components of diversion head works and their functions, design of weirs and barrages on permeable foundations

- **DESIGN OF CANAL AND CANAL STRUCTURE** **(07 Hours)**
  Canal regulation structures and design of cross drainage works, canal falls, operation and maintenance of canals.
  Review of codes of practice

(Total Lectures: 42 hours)

3. Books Recommended

1. USBR, Design of gravity dams, A Water Resources Technical Publication, Denver, Colorado, 1976.
2. G L Asawa, Irrigation and water resources engineering, New Age International Publishers, New Delhi, 2014.
3. W P Creager, J D Justin and J Hinds., Engineering for dams, Nemchand and Brothers, Roorkee, 1995.
4. R M Khatsuria, Hydraulics of spillways and energy dissipaters, CRC Press, Boca Raton, 2005.
5. P Novak, A Moffat, C Nalluri, and R Narayana, Hydraulic Structures, Taylor and Francis Group publishers, London, 2007.

CE 446 Hydraulics of Alluvial Rivers

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Estimate incipient motion condition of sediments.
CO2	Estimate flow resistance in alluvial rivers.
CO3	Compute transport of sediments in alluvial rivers.
CO4	Design lined and unlined stable channels.
CO5	Analyse planform and estimate bed level variations in alluvial rivers.

2. Syllabus

- **PROPERTIES AND INCIPIENT MOTION OF SEDIMENTS** **(10 Hours)**
  Nature of sediment problems, Origin and formation of sediments, individual and bulk properties of sediments, competent velocity, lift force and critical tractive stress concept on cohesion less and cohesive soils; regimes of flow; Resistance to flow in alluvial streams, resistance relations based on total resistance and division of resistance into grain and form resistance, preparation of stage discharge curves for alluvial streams, velocity distribution in alluvial channel, sediment Petrography (Sediment sampling)
- **BED LOAD TRANSPORTATION** **(11 Hours)**
  Bed load computation by empirical equations, dimensional considerations and semi theoretical equations for uniform and non-uniform sediments, saltation.
- **SUSPENDED LOAD TRANSPORTATION** **(08 Hours)**
  Mechanism of suspension, general equations of diffusion. Integration of sediment distribution equation, Differences between actual and theoretical exponents, prediction of reference concentration, Method of integrating curves of concentration and velocity. Simple relations for suspended load, Effect of temperature on suspended load, Wash load, Non-equilibrium transport of suspended load
- **STABLE CHANNEL DESIGN** **(05 Hours)**
  Design of lined and unlined channels for carrying clear and sediment laden water.
- **PLANFORM AND BED LEVEL VARIATIONS OF ALLUVIAL RIVERS** **(08 Hours)**
  Hydraulic geometry of alluvial streams, bed level variation of alluvial streams, aggradations and degradation models, reservoir sedimentation, local scours.

(Total Lectures: 42 Hours)

3. Books Recommended

1. S Dey, Fluvial hydrodynamics: Hydrodynamic and sediment transport phenomena, Springer-Verlag Berlin Heidelberg, 2014.
2. R J Garde and K G Ranga Raju, Mechanics of sediment transportation and alluvial stream problems, Third edition, New Age International (P) Limited, New Delhi, 2006.
3. R J Garde, River morphology, New Age International Publisher, New Delhi, 2006.
4. A J Raudkivi, , Loose boundary hydraulics, Pergamon Press, Oxford, 1976.
5. M S Yalin, , Mechanics of sediment transport, Pergamon Press, Oxford,1976

CE 448 Computational Hydraulics

L	T	P	C
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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Classify type of equation used for describing physical progress of fluid motion
CO2	Solve the simultaneous linear and non-linear equations
CO3	Apply the concepts of fluid motion on real world problems related to water flow.
CO4	Apply the Finite Difference Method for solution of fluid motion equations.
CO5	Solve the real world problems related to water flow

2. Syllabus

- **BASIC CONCEPTS OF FLUID MOTION** **(14 Hours)**
  Basic Concepts – Lagrangian and Eulerian methods of describing fluid motion, acceleration and deformation of fluid elements, Laws governing fluid motion, continuity, Euler's equation, Energy equation, Saint Venant equation, classification of partial differential equations.

- **NUMERICAL TECHNIQUES FOR SOLUTION OF PARTIAL DIFFERENTIAL EQUATION** **(14 Hours)**
  Review of linear algebra, solution of simultaneous linear algebraic equations-matrix inversion, solvers-direct methods, elimination methods, ill conditioned systems, Gauss-Seidel method, successive over relaxation method, Finite difference method.

- **ENGINEERING APPLICATIONS** **(14 Hours)**
  Application to water resources problems in open channel flows, Pressure Flow, ground water flows, and unsaturated flows through porous media.

(Total Lectures: 42 hours)

3. Books Recommended

1. C F Gerald and P O Wheatley, Applied Numerical Analysis, Addison Wesley Publishing Company, New York, 1994.
2. H M Choudhary, Open Channel Flows, Prentice Hall of India, New Delhi, 1994.
3. M B Abbott, Computational Hydraulics, Pitman Publishing House, London, 1979.
4. J A Cunge, F M Holly, and A Verway, Practical Aspects of Computational River Hydraulics, Pitman Publishing House, London, 1980.
5. G Pinder and W G Gray, Finite Element Simulation in Surface and Subsurface Hydrology, Academic Press, New York, 1997.

CE 452 Geospatial Techniques

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Describe fundamentals of Remote Sensing
CO2	Apply digital image processing
CO3	Explain fundamentals and processes of GIS
CO4	Apply GPS technology and different methods of measurements
CO5	Solve complex civil engineering applications using Geospatial Techniques

2. Syllabus

- **INTRODUCTION** **(01 Hours)**
  Introduction to geospatial techniques - Benefits and applications of geospatial techniques

- **REMOTE SENSING** **(08 Hours)**
  Fundamentals of remote sensing - Energy interactions - Ideal remote sensing systems, - Fundamentals of interpretation - Basic equipment used for interpretation - Elements of air photo interpretation - Interpretation keys - Different types of sensors - Platforms and remote sensing images

- **DIGITAL IMAGE PROCESSING** **(05 Hours)**
  Characteristics of a digital image –Digital Image processing techniques– Image registration – Digital image interpretation techniques

- **GEOGRAPHICAL INFORMATION SYSTEMS** **(10 Hours)**
  Introduction - Geo referenced data - Data input and output - Data quality and management - GIS analysis functions - Implementation of GIS - Principles and methods of data collection – Digital Elevation Models

- **GLOBAL POSITIONING SYSTEM** **(10 Hours)**
  Earth Surface, datum – Co-ordinate systems - Segments of GPS System - GPS receivers and its components - Different methods of observation

- **ENGINEERING APPLICATIONS** **(08 Hours)**
  Application of Remote Sensing, GIS and GPS in different areas of Civil Engineering, Software in Geospatial Techniques

(Total Lecturers: 42 hours)

3. Books Recommended

1. M Lillesand and RW Kiefer, Remote Sensing and Image Interpretation, John Willey, New York, 2015.
2. A M Chandra and S K Ghosh, Remote Sensing and Geographical Information System, Narosa Publishing, New Delhi, 2006.
3. G S Srivastava, An Introduction to Geoinformatics, Mc Graw Hill, New Delhi, 2014.
4. N K Agrawal, Essentials of GPS, Spatial Network, Hyderabad, 2004.
5. C P Lo and A K W Yeung, Concept and Techniques of Geographical Information Systems, PHI Learning, New Delhi, 2008.

CE 454 Advanced Water and Wastewater Treatment

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Analysis the quality and quantity of water and wastewater.
CO2	Describe primary and secondary water and wastewater treatment processes.
CO3	Explain basic theory for designing different units of water and wastewater treatment plants.
CO4	Describe advance water treatment process, including natural processes.
CO5	Apply reclamation, recycling and reuse of wastewater.

2. Syllabus

- **INTRODUCTION** **(10 Hours)**
  Objectives of water and waste-water treatment - classification of treatments, parameters commonly employed to indicate pollution strength – standards for water quality and wastewater disposal – Self-purification of water bodies – Simple Mathematical models. Introduction to process selection and analysis - Measurement of wastewater flow - Variation in wastewater flow. Theory and design of sedimentation, coagulation, filtration, aeration units.

- **WATER AND WASTEWATER TREATMENT PROCESSES** **(10 Hours)**
  Types of sedimentation-Plat settlers, Diffusion double layer theory for colloids, Mechanisms of destabilization of colloids, Jar tests , Perikinetic and Orthokinetic Flocculation, Velocity Gradient, Clari-flocculator, Mechanisms of filtration, mono media and multimedia filters kinetics of disinfection, types of aerators , Film coefficients and equilibrium relationship for aeration.

- **ADVANCE WATER AND WASTEWATER TREATMENT PROCESSES** **(10 hours)**
  Equalization – Neutralization - Secondary treatment units and their design concepts- Trickling filter, Activated sludge process, stabilization ponds, lagoons – oxidation ditch. Wastewater disinfection. Aquatic Plant Systems, Constructed Wetlands and Vermi-culture.

- **RECLAMATION AND REUSE OF WASTEWATER** **(12 hours)**
  Tertiary treatment for removal of residual organics, removal of nutrients, recycling and reuse of wastewater. Membrane Filtration Technology. Advanced Oxidation Technology. Working principle, application and maintenance of Ion-exchange, reverse osmosis, adsorption, ultra-filtration, electro-dialysis. Desalination. Adsorption – Isotherms – Advance Oxidation Process

(Total Lectures : 42 hours)

3. Books Recommended

1. R L Droste and R L Gehr, Theory and Practice of Water and Wastewater Treatment, Wiley Publication, New Delhi, 2018.
2. Metcalf and Eddy, Wastewater Engineering: Treatment and Reuse, Tata McGraw-Hill, New Delhi, 2003.
3. D G Rao, R Senthilkumar, J A Byrne, and S Feroz, Wastewater Treatment Advanced Processes and Technologies, CRC Press, New York, 2012.
4. M L Davis, Water and Wastewater Engineering, McGraw-Hill, New Delhi, 2010.
5. Manual on Water Supply & Treatment 3rd Ed. Central Public Health and Environmental Engineering Organization, Ministry of Urban Development, Govt. of India, New Delhi, 1999.

CE 456 Solid and Hazardous Waste Management

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Explain solid and hazardous waste management issues and its legal aspects.
CO2	Characterize and quantify solid and hazardous waste.
CO3	Analyse collection, transportation and processing of waste management system.
CO4	Design disposal and treatment facility for solid and Hazardous waste
CO5	Develop waste management facility for bio medical, plastic, E-waste etc.

2. Syllabus

- **INTRODUCTION** **(04 Hours)**
  Solid waste sources – Nature and characteristics – Quantities and Qualities – Generation rates – Potential of disease – Nuisance and other problems.

- **COLLECTION AND STORAGE** **(10 Hours)**
  Solid waste management – Functional elements of solid waste–on–site storage –Collection and separation – Containers and its location – Collection systems and its example – physical , chemical and microbiological characteristics of waste – Vehicle routing – Route balance – Transfer station – Processing – Recovery and reuse.

- **PROCESSING OF MUNICIPAL SOLID WASTE** **(10 Hours)**
  Conveying and compacting waste – Shredding – Types of shredders – Shredders Design–Material separation – Types – Devices for material separation – Thermal processing of municipal solid waste – incinerator and pyrolysis – Refuse Drived fuel – Biological process like composting , vermi composting and biomethanation

- **DISPOSAL** **(08 Hours)**
  Disposal methods – Sanitary land filling – Planning – Site selection – Design – Landfill Process – Monitoring Closure – Post closure monitoring – Other methods like incineration, pyrolysis, and composting, biological digestion.

- **HAZARDOUS WASTE MANAGEMENT** **(10 Hours)**
  Introduction to hazardous waste – Definition – Characterization and composition – TCLP test – Storage and transportation of hazardous waste – Labeling of hazardous waste – Physical, Chemical and Biological treatment of hazardous waste – Bioremediation of hazardous waste – Treatment of Bio medical – Nuclear waste and Radio – Active waste – Fly ash management and E-waste management

(Total Lectures: 42 hours)

3. Books Recommended

1. G Tchobanoglous and F Kreith, Handbook of Solid Waste Management, McGraw-Hill, New York, 2002.
2. H S Peavy and G Tchobanoglous, Environmental Engineering, McGraw Hill, New Delhi, 2004.
3. CPHEEO, Manual on Municipal Solid waste management, Central Public Health and Environmental Engineering Organisation, Government of India, New Delhi, 2016.
4. R J Watts, Hazardous Wastes - Sources, Pathways, Receptors, John Wiley and Sons, New York, 2008.
5. J Pichtel, Waste Management Practices, CRC Press, New York, 2005.

CE 458 Metro Construction Technology

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Analyze needs of metro construction project
CO2	Prepare construction schedules and manage metro construction projects
CO3	Illustrate underground construction and tunnel boring technology
CO4	Design precast concrete and understand fundamentals of metro rail
CO5	Demonstrate railway technology for metro projects

2. Syllabus

- **METRO PROJECT FUNDAMENTALS** **(4 Hours)**
  Concept of rapid transit systems, requirements of rapid transit systems. types of rapid transit systems, concept of metro rail transit system, terminology of metro construction, advantages and disadvantages of metro, metro construction projects in India

- **UNDERGROUND CONSTRUCTION** **(12 Hours)**
  Need for underground construction, fundamentals of underground constructions, planning for underground construction, site preparations, characteristics of soil and basics of geotechnical engineering, methods of underground construction, top-down constriction method, bottom-up construction method, safety during underground construction, workers health and safety provisions, regulations of underground construction

- **TUNNEL CONSTRUCTION** **(12 Hours)**
  Fundamentals theories of tunnel construction, types of tunnels, different cross-sections of underground tunnels, methods of tunnel boring, tunnel boring machine (TBM), parts of TBM, working procedure of TBM, procedure of tunnel construction using TBM, stations construction during tunnels, removal and dumping of excavated materials

- **PRECAST CONCTERE TECHNOLOGY** **(8 Hours)**
  Fundamentals of pre-cast concrete technology, Requirements of precast concrete elements in metro construction, Theories of formwork for precast concrete, curing of precast concrete, Admixtures and ingredients of precast concrete, Transportation off precast segments, Precast segments of tunnel, Precast bridge segments, Fundamentals of precast concrete bridge construction

- **METRO RAIL** **(6 Hours)**
  Fundamentals of railway construction, terminology of railway and its components, Railway systems, Railway track construction, Components of railway track, Rail signaling, Introduction to electric supply for metro rail

(Total Lectures: 42 hours)

3. Books Recommended

1. M Ramachandran, Metro Rail Projects in India: a Study in Project Planning, Oxford University Press, New Delhi, 2011.
2. R K Goel, B Singh and J Zhao, Underground Infrastructures: Planning, Design and Construction, Butterworth-Heinemann, Oxford, 2012.
3. S Chandra, Railway Engineering, Oxford University Press, New Delhi, 2008.
4. K S Elliott, Precast Concrete Structures, CRC Press, Boca Raton, 2016.
5. K N Jha, Construction Project Management: Theory and Practice, Pearson Education, New Delhi, 2015.

CE462 Environmental Impact Assessment

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Introduce EIA and EIA methodologies.
CO2	Analyze prediction and evaluation of environmental impacts of new projects.
CO3	Describe socio-economic assessment and public participation.
CO4	Apply legal provisions and statutory requirement for environmental protection.
CO5	Evaluate public participation and public hearing in EIA.

2. Syllabus

- **IMPACT ASSESSMENT – TYPES AND SIGNIFICANCE** **(06 Hours)**
  Types of impacts – Significant impacts – Various impact assessments viz. Health impact assessment, Social Impact Assessment, Disaster Impact Assessment, Environment Impact Assessment Rules-1994, EIA Notification-2006.

- **EIA: INTRODUCTION** **(06 Hours)**
  Evolution of EIA – EIA at project, regional and policy levels – Environmental clearance procedures in India – EIA Rules 1994 and amendments.

- **EIA: PLANNING** **(09 Hours)**
  Screening - Baseline data collection – Terms of Reference – Scoping – Identification of impacts - Rapid and Comprehensive EIA – Monitoring, analysis and report preparation in EIA.

- **EIA: METHODOLOGIES AND STRATEGIES** **(15 Hours)**
  Prediction of impacts of physical, biological and socio–economic environment – Impact prediction tools / techniques such as Adhoc method, checklist method etc – Development of environment management plan – Post project monitoring – EIA report and EIS – Review process – EIA case studies / histories.

- **PUBLIC PARTICIPATION** **(06 Hours)**
  Project Affected Persons - Significance of public participation in EIA – Methods of public consultation – Public Notice and Public Hearing - Resettlement and rehabilitation issues.

(Total Lectures : 42 hours)

3. Books Recommended

1. LW Canter, Environmental Impact Assessment, Tata McGraw Hill Co, Singapore, 1996.
2. R E Munn, Environmental Impact Assessment, John Wiley and Sons, Toronto, 1979.
3. S KDhameja, Environmental Engineering and Management, S. K. Kataria and Sons, Delhi. 2004.
4. Relevant MoEF Notifications and CPCB / GPCB Acts and Rules, New Delhi.
5. R Hillary, Environmental Management Systems and Cleaner Production, Wiley Publishers, New York, 1997.

CE 464 Construction Laws

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Assess legal and commercial framework of construction contracts
CO2	Analyze claims for losses as per the Indian laws
CO3	Demonstrate roles of the various Indian Acts in construction
CO4	Analyze international contracts
CO5	Apply different techniques of dispute resolution in projects

2. Syllabus

- **LEGAL AND COMMERCIAL FRAMEWORK** **(3 Hours)**
  Introduction, the power of governments, agency regulation, statute law, application of law, contractor, subcontractor, consultant, supplier, government, funder, etc.

- **CONSTRUCTION CONTRACTS AND MANAGEMENT** **(6 Hours)**
  Contract specification, types of contract documents used for construction, selection of a contractor, standard of work, use of construction management contracts, allocation of risk in construction management, contents of construction management contracts

- **CONTRACTORS CLAIMS FOR LOSS AND EXPENSES** **(6 Hours)**
  Contract claims and damages, grounds for claims, claims procedures, quantification of procedure, insurance, bonds and guarantees

- **THE INDIAN CONTRACT ACT, 1871** **(6 Hours)**
  Definition of a contract and its essentials, formation of a valid contract - offer and acceptance, consideration, capacity to contract, free consent, legality of object, discharge of a contract by performance, impossibility and frustration, breach, damages for breach of a contract, quasi contracts, special contracts contract of indemnity and guarantee, contract of bailment and pledge, contract of agency

- **THE COMPANIES ACT, 1956** **(6 Hours)**
  Nature and definition of a company, registration and incorporation, memorandum of association, articles of association, employee welfare, strategic human resource development; employment legislation, labour legislations: industrial dispute act, factories act, payment of wages act, workmen's compensation act. Important provisions of employees' state insurance act, payment of gratuity act, employees provident fund act

- **THE BUILDING AND OTHER CONSTRUCTION ACT, 1996** **(3 Hours)**
  Registration of establishment, registration of building workers, building and other construction workers welfare boards, conditions of service of building workers, safety and health measures, special provisions, penalties and provisions

- **REAL ESTATE (REGULATION AND DEVELOPMENT ACT, 2016)** **(4 Hours)**
  Objectives and techniques of site investigation, decision process for choosing foundation, general failures, classifications introduction, registration of real estate project, functions and duties of promoter, rights and duties of allotted, the real estate appellate tribunals, role of company secretaries, offences and penalties, agreement for sale between promoter and allottee

- **DISPUTE RESOLUTION** **(4 Hours)**
  Background of dispute, the nature of construction dispute, the role of contractor, method of dispute resolution, arbitration, litigation, adjudication, alternative dispute resolution procedure

- **INTERNATIONAL CONTRACTS** **(4 Hours)**
  Introduction to FIDIC, the necessity of FIDIC contract, contract administration and claims, risk, insurance and securities, remedies and dispute resolution

(Total Lectures: 42 hours)

3. Books Recommended

1. J Coggins, T Davie, T Ears and P Evans, Understanding Construction Law, LexisNexis Butterworths, Chatswood, 2016.
2. E Baker, B Mellors, S Chalmers and A Lavers, FIDIC Contracts Law and Practices, Routledge, Taylor & Francis Group, London, 2009.
3. J Bailey, Construction Law, Taylor and Francis Group, Oxford, 2011.
4. G Kelley, Construction Law: An Introduction for Engineers, Architects, and Contractors, John Wiley & Sons, New Jersey, 2012.
5. V Bhatt and P Vyas, Laws for Engineers (Contract, Arbitration, Evidence, Limitations), Second Edition, ProCare, New Delhi, 2015.

CE466 Professional Practice

L	T	P	C
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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Prepare tender and contract documents following Acts and byelaws.
CO2	Prepare valuation report for Civil engineering projects.
CO3	Solve the disputes in construction industries through Arbitration.
CO4	Apply for registration of IP rights like patent, design, trademark, etc.
CO5	Act as team member / leader in all type of organizations with its legal responsibilities as per prevailing Acts.

2. Syllabus

- **OFFICE PRACTICE** **(04 Hours)**
  Organisational set up, working of professional firms, office procedures, construction contracts, legal aspects, professional charges, the role of architect, developer, builder and contractor.

- **TENDERING AND CONTRACTING** **(10 Hours)**
  Tender and tendering process, types of tenders, Dynamics of contracting, contract documents, condition of contract, Indian contract act, improper work and defect liability period, liquidated damages, contract breach, certificates and payments, duties and liabilities.

- **ARBITRATION AND EASEMENT** **(08 Hour)**
  The purpose of arbitration, the powers and duties of arbitrator, arbitration and building contract. Types of arbitration, fire insurance, easement characteristics types.

- **VALUATION** **(12 Hours)**
  Definition, market value, freehold and leasehold, sinking fund, depreciation methods of valuation, a rental method of valuation, land and building based development method of valuation.

- **P.W.D. ACCOUNTS AND PROCEDURE OF WORKS** **(04 Hours)**
  Organisation set up, classification of work, execution of work, bookkeeping, measurement book, store procedure, mode of payments, public works accounting system.

- **ENTREPRENEURSHIP DEVELOPMENT** **(02 Hours)**
  Concept need and scope of entrepreneurship, characteristic of entrepreneurship, forms of business organization.

- **IPR AND PATENT ACT** **(02 Hours)**
  Importance and scope, forms of IPR, patents, copy rights, trademarks, relevant acts.

(Total Lectures: 42 Hours)

3. Books Recommended

1. B S Patil, Civil Engineering Contracts and Estimates, 4th Edition, Orient BlackSwan Pvt. Ltd., Hyderabad, 2015.
2. B N Dutta, Estimating and Costing in Civil Engineering (Theory and Practice), 28th Revised Edition, UBS Publishers' Distributors Pvt. Ltd., New Delhi, 2016.
3. R H Namavati, Professional Practice, 1st Edition, Lakhani Book Depot, Mumbai, 2016.
4. S K Guha Thakurta and K R Shah, Manual of Construction Project Management, 1st Edition, Multi-tech Publishing Co., Mumbai, 2003.
5. P C Tulsian, Business Organization and Management, 1st Edition, Pearson Education, New Delhi, 2002.

CE 468 Advanced Construction Technology

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Apply special and modern construction technologies
CO2	Illustrate modern construction and building materials
CO3	Execute prefab, underground and offshore construction
CO4	Employ automation techniques in construction
CO5	Apply virtual technologies in construction

2. Syllabus

- **SPECIAL CONSTRUCTION** **(06 Hours)**
  Special concrete like high performance, self-compacting etc., construction procedure of modern construction techniques of box pushing technology, advanced types of retaining walls, modern piling technology, pile driving machineries, sheet piling, well and caisson, diaphragm walls, dewatering techniques and design of dewatering system, surface finishing materials techniques and advanced curing technologies

- **MODERN TECHNOLOGIES** **(08 Hours)**
  Formwork systems, different materials for formwork like wood, steel, aluminum, plastic, fiber glass, laminated veneer lumber, new joineries and fixtures of forms, modern scaffolding technologies, doors and windows modern materials and fixtures, Building cladding system with aluminum composite sheets. advanced paints of buildings and infrastructures like weather proof coating paint, anti-fungal paint etc.

- **MODERN BUILDING MATERIALS** **(08 Hours)**
  Artificial manufactured sand and its application areas, different fly ash and its applications, different slag like steel slag and blast furnace slag and its applications, geosynthetics like geogrid, geofoam, geomembrane, geojute and geotextiles. geopolymers and its applications, fibers in concrete like steel fiber, polypropylene fibers and glass fibers

- **PREFAB CONSTRUCTION TECHNOLOGIES** **(08 Hours)**
  Reinforced concrete based technologies- precast concrete technology, monolithic concrete structure with aluminum formwork. structural steel based technologies- pre-engineered building (PEB) technology, light gauge steel frame structure (LGSF) technology. expanded polystyrene (EPS) technology, other technologies – glass fiber reinforced gypsum (GFRG) technology, wood house technology, polypropylene honeycomb panels technology, polyurethane foam (PUF) panel technology

- **UNDERGROUND AND OFFSHORE CONSTRUCTION** **(06 Hours)**
  Site investigation and geological studies, top down and bottom up underground construction, pneumatic breakers, advanced drilling methods, blasting and explosives. Different tunneling technologies like mechanized, shield, micro etc. offshore: barges, cranes, derrick barges, drilling vessels, different stages of offshore construction, offshore facilities and fabrication methods, safety in underground and offshore construction

- **AUTOMATION IN CONSTRUCTION** **(6 Hours)**
  Advance computer technology in construction, internet of things (IoT) in construction, RFID technology, building information modelling, virtual design and construction technologies, augmented and virtual reality (AR & VR) in construction, artificial intelligence (AI) in construction

(Total Lectures: 42 hours)

3. Books Recommended

1. R Chudley and R Greeno, Advanced Construction Technology, Pearson Education, Harlow, 2006.
2. R E Smith, Prefab Architecture: A Guide to Modular Design and Construction, John Wiley and Sons, Hoboken, 2010.
3. G Beer, Technology Innovation in Underground Construction, CRC Press, London, 2009.
4. L H Forbes and S M Ahmed, Modern Construction: Lean Project Delivery and Integrated Practices, CRC Press, New York, 2010.
5. G Shen, P Brandon and A Baldwin, Collaborative Construction Information Management, Routledge, Oxford, 2009.

CE 472 Operation and Maintenance Management of Pavements

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Prepare Model Concession Agreement for various types of PPP models of project implementation for operation and maintenance of highways.
CO2	Assign the priorities of maintenance by identifying significant factors influencing the project.
CO3	Evaluate the functional and structural condition of existing pavement.
CO4	Identify the pavement distresses and suggest suitable maintenance strategies.
CO5	Design the overlays for the existing pavement using various approaches using BBD and FWD .

2. Syllabus

- **INTRODUCTION** **(06 Hours)**
  Operation and maintenance (O&M) of the Project Highway - Model Concession Agreement (MCA) for various types of PPP projects -Management and Organization - Project Cycle -Levels of Management - Administration and Logistics - Site Management Road Maintenance – Approach – Organization - Management Activities.

- **OPERATIONAL MANAGEMENT ACTIVITIES** **(06 Hours)**
  Road Inventory - Assessment of Maintenance Requirements – Drainage – Running Surface – Structures - Setting Priorities - Planning Maintenance Works – Implementation Work Activities and Task Rates - Tools for Maintenance Works - Reporting and Monitoring.

- **PAVEMENT EVALUATION** **(06 Hours)**
  General concept of pavement evaluation - Evaluation of pavement performance - Structural capacity – Distress – Safety.

- **PAVEMENT DISTRESS** **(08 Hours)**
  Structural and functional – serviceability - fatigue cracking - pavement deformation and low temperature shrinkage cracking - factors affecting performance - relation between performance and distress - Methods of performance surveys - Methods of measuring defects - Pavement – Life studies.

- **DISTRESS MEASURING EQUIPMENTS** **(08 Hours)**
  Functional and structural evaluation - Functions parameters such as roughness - Distress, rutting - Skid resistance etc. - structural parameters such as structural capacity - Benkelman beam - bump integrator - demonstration of equipment's for dynamic testing of pavements (LWD) - pavement skid resistance measuring equipment's - fatigue testing equipment.

- **DESIGN OF OVERLAYS** **(08 Hours)**

  Types of Overlays - Design Methodologies - Flexible overlays - Rigid overlays – design of overlay by Benkelman beam and falling weight Deflectometer - Asphalt Institute Method - Portland Cement Association Method, -AASHTO Method.

(Total Lectures: 42hours)

3. Books Recommended

1. R Hass, W R Hudson and J Zaniewski, Modern Pavement Management, Krieger Publishing Company, Melbourne, 1994.
2. Y H Huang, Design of Functional Pavements, Pearson Prentice Hall, Singapore, 2004.
3. E J Yoder, and M W Witczak, Principles of Pavement Design, John Wiley and sons, New Jersey, 1975.
4. L R Kadiyali, Principles & Practice of Highway Engineering, Khanna Publishers, New Delhi, 2003.
5. Relevant IRC code & Infrastructure development form Planning commission of India Publication, MoRTH Publications.

CE474 Advanced Design of Concrete Structures

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Analyse and design of combined footing
CO2	Design underground and ground supported RC water tank
CO3	Predict behaviour and do structural design of RC Retaining walls
CO4	Design RC shear wall.

2. Syllabus

- **DESIGN OF COMBINE FOOTING** **(10 Hours)**
  Introduction – Types of combine footings– Rectangular pad footing – Rectangular strap footing – Strip footing–Trapezoidal Footing.

- **LIMIT STATE DESIGN OF WATER TANK** **(10 Hours)**
  Classification of water tank –Codal provisions –Design of circular and rectangular ground supported water tanks. – Design of circular and rectangular underground water tanks.

- **DESIGN OF RETAINING WALL** **(12 Hours)**
  Introduction – Types of Retaining wall – behavior and application of retaining wall– Loads on retaining wall – stability criteria – design of cantilever retaining wall – design of counter fort retaining wall.

- **DESIGN OF RC SHEAR WALL** **(10 Hours)**
  Introduction – Types of shear wall – Behavior of shear wall – Design procedure of shear wall – Detailing of shear wall

(Total Lectures: 42 hours)

3. Books Recommended

1. S U Pillai and D Menon, Reinforced Concrete Design, 3rd edition, Tata Mc Graw Hill Publication Ltd, New Delhi. 2009.
2. H J Shah, Reinforced Concrete, Vol. I and II, Charotar Publishing House, Anand, 2007.
3. A V Varghese, Advanced Reinforced Concrete, Varghese, Prentice Hall of India. New Delhi, 2005.
4. M L Gambhir, Fundamentals of Reinforced Concrete Design, Prentice Hall of India, New Delhi, 2006.
5. N Subramanian, Design of Reinforced Concrete Structures, Oxford University Press, New Delhi, 2013.

CE476 Design of Prestressed Concrete Structure

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Explain the pre stressing system and its various losses
CO2	Design the flexural strength of pre stress concrete members
CO3	Understand the transfer of pre stress in pre-tensioning and post-tensioning
CO4	Design various pre stressed concrete structures
CO5	Evaluate parameters for design for various structures

2. Syllabus

- **INTRODUCTION** **(07 Hours)**
  Introduction – concept of Pre stressing – Advantages of Pre stressing – Materials for pre stressed concrete

- **PRESTRESSING SYSTEMS** **(05 Hours)**
  Different Pre stressing System – Analysis of pre stress and bending stresses various losses of pre stress – Deflection of pre stressed concrete member

- **TRANSFER OF PRESTRESS IN PRE-TENSIONED MEMBERS** **(06 Hours)**
  Flexural strength of pre stressed concrete members- Transfer of pre stress in pre-tensioned members

  TRANSFER OF PRESTRESS IN POST-TENSIONED MEMBERS **(06 Hours)**
  Anchorage zone stresses in post-tensioned members- Limit state design criteria for Pre stressed concrete members

- **DESIGN OF VARIOUS SECTIONS** **(06 Hours)**
  Design of pre stressed concrete sections – Design of pretension and post tensioned Flexural member statically indeterminate Pre stressed Structures

- **DESIGN OF PIPE AND TANKS AND OTHER STRUCUTRES** **(12 Hours)**
  Pre stressed concrete pipes and tanks- Pre stressed concrete slabs and grid floors –Pre stressed concrete poles, pipes, sleepers, pressure vessels and pavements.

(Total Lectures: 42 hours)

3. Books Recommended

1. K Raju, Pre stressed concrete, Tata Mc Graw Hil, New Delhi, 2006.
2. P Dayaratnam, Pre stressed concrete Structures, Oxford & IBH Publication, New Delhi, 2005.
3. L Y Lin, Design of pre stressed concrete Structural, Asia Public House, New Delhi, 2000.
4. F.Leonhardt, Pre stressed concrete – Design & construction, Welhelm Ernst and sohn -- Munich, 2000.
5. Y Guyon, Pre stressed concrete, Asia Publication, Pune, 2003.

CE 478 Design of Bridge Structures

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Categorize types of bridges, its components and types of loads
CO2	Design RCC TEE beam, deck slab bridge and pre-stressed concrete bridges .
CO3	Design steel bridges and its components.
CO4	Explain features and components of cable stayed bridges
CO5	Analyse the bridge structures by various methods.

2. Syllabus

- **INTRODUCTION** **(08 Hours)**
  Different types of bridges – Impact factor – Indian Road Congress Loads – Wind Load – Centrifugal forces – Economic span length – Foundation for bridges – Abutments.

- **TEE BEAM AND DECK SLAB BRIDGES** **(06 Hours)**
  General features – Courbon's Method – Guyon – Massonet Method – Hendry Jaegar Method – Eccentric and Multiple concentric loads.

- **PRESTRESSED CONCRETE BRIDGES** **(08 Hours)**
  Drive equilibrium equations in Cartesian and cylindrical polar coordinates

- **BALANCED CANTILEVER BRIDGES** **(08 Hours)**
  Segmental construction – Cast in place and precast balanced cantilever – Box section – Hinged or continuous beam system – Deck cabling arrangement

- **STEEL BRIDGES** **(06 Hours)**
  Plate girder bridge – Steel Trussed bridges – Composite bridges, Design of foundation, caissons and piles

- **CABLE STAYED BRIDGES** **(06 Hours)**
  Features – Components – Pylons configurations – Cable stays – Design principles –Advantages.

(Total Lecturers: 42 hours)

3. Books Recommended

1. K Raju, Design of Bridges, Oxford IBH Publication House, New Delhi, 2017.
2. T R Jagadeesh, Jayaram M A., Design of Bridge Structures, PHI Learning Pvt Ltd, New Delhi, 2016.
3. S Ponnuswarmy, Bridge Engineering, Tata McGraw Hill, New Delhi, 2018.
4. V K Raina, Concrete Bridge Practice-Analysis, Design and Economics, Tata McGraw-Hill, New Delhi, 2018.
5. N Subramanian, Design of Steel Structures, Oxford Publications, New Delhi, 2008.

CE 482 Design of Tall Structures

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Classify tall structure according to geometrical and structural configuration.
CO2	Compute basic governing forces and dynamic forces (i.e. wind force and earthquake force) in the analysis of high tension transmission line tower, T.V. and microwave towers.
CO3	Analyze all structures like multi-storeyed building, tall chimney foundation and guyed chimney.
CO4	Design latest building using Indian Standard codes.
CO5	Evaluate parameters for design of Multi-storeyed building.

2. Syllabus

- **HIGH TENSION TRANSMISSION LINE TOWER** **(10 Hours)**
  Various forces acting on tower, classification of tower – Various type of span – Effect of ice coated cable – Sag tension calculation – Type of Bracing patterns – Foundation – Different condition for design – Joint's in tower. I.S. Code provisions.

- **T.V. / MICROWAVE TOWER** **(08 Hours)**
  Self- supporting–Guyedtower–Conceptofsolidarityratio–Stabilityandfoundationdesign–Limitingcriteriafortall/shorttower–Conceptofdynamicanalysis–ApproximatedynamicanalysisStack(Shaft)supportedtower–Conceptofmodeshapes–Towermountedonbuilding,it'sI.S.code provision – Concept of multipurpose tower – Trestles and Masts – Concept of multipurpose tower – wind turbine tower.

- **TALL CHIMNEY** **(08 Hours)**
  Types of chimney – Free standing, Guyed with fixed base, Pin base – Stability of chimney, Concrete and steel – Foundation design – Conceptual design – Concept of Earthquake force – Multipurpose chimney – Forces acting on chimney – Concept of vortex induced vibration – It's remedial measures - Cooling tower.

- **MULTISTORIED BUILDING** **(16 Hours)**
  Planning of tall structure, Different between multistoried building and Ultra High Rise building– Forces acting on normal multistoried building and additional forces acting on Ultra high rise building - Earthquake forces calculation for building– Wind force calculation for building –gust factor for building- Structural configuration required for tall building- with field example – Some provision of I.S. : 1893-2016 (Earthquake code) for building & I.S. 16700-2016 (design criteria for tall buildings)-Types of Foundation used for building. Concept of podium/ plaza type building and basement -Buildings on slopping ground - Shear wall/ core application– Application of self-compacting concrete & high strength material like epoxy, FRC (fiber reinforced concrete) etc.

(Total Lectures: 42 hours)

3. Books Recommended

1. Taranath, Structural Analysis and Design of Tall Building, McGraw-Hill, New Delhi, 2005.
2. A Pankaj and S Manish, Earthquake Engineering, Prentice Hall of India Pvt Ltd, New York, 2004.
3. S N Manhar, Tall Chimneys Design and Calculations, Tata McGraw-Hill, New Delhi, 1985.
4. K Raju, Advanced Reinforced Concrete, 2nd Edition, CBS Publishers, Oxford Pergamon Press, New Delhi, 1988.
5. U H Varyani, Structural Design of Multi-Storeyed Buildings, Standard Publishers Distributors, New Delhi, 2014.

CE 484 Computer Aided Design of Structures

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Apply software such as MATLAB, EXCEL / VBA applicable to engineering problems.
CO2	Explain structural design process and advantages of computer aided design
CO3	Apply stiffness method for analysis of Truss, Beams, and Frames with special constructional aspects.
CO4	Apply numerical methods for solving structural engineering problems
CO5	Apply Computer Assisted structural analysis and design.

2. Syllabus

- **COMPUTER BASED STRUCTURAL ANALYSIS AND DESIGN : AN OVERVIEW (02 Hours)**
  Concept of Structural design process – Role of Computers in Structural Design process – Advantages of Computer Aided Design (CAD)

- **COMPUTER PROGRAMMING FOR STRUCTURAL ENGINEERS (10 Hours)**
  Introduction to MATLAB for engineers – Development of Computer Program for the Analysis of Beams – Design of slab, beam, column etc.

- **STIFFNESS METHOD FOR LINEAR ELASIC ANALYSIS (10 Hours)**
  Analysis of Trusses and Beams with emphasis on support settlement, skewness of support, internal hinge, temperature variation etc. using stiffness approach - Analysis of frames using stiffness approach .

- **INTRODUCTION TO COMPUTATIONAL TOOLS FOR STRUCUTRAL ENGINEERS (10 Hours)**
  Spreadsheet tool for engineers – Programming with Excel / VBA – Developing Spreadsheets for the design of structural elements - Developing spreadsheet tool for finding solution of linear simultaneous equations – Roots of Non-linear equations.

- **COMPUTER ASSISTED STRUCTURAL ANALYSIS AND DESIGN (10 Hours)**
  Modeling of Structural elements like truss – beam – frame and grid using structural design software – Introduction to integrated analysis and design process using structural design software packages – Integrated analysis and design of building structures for gravity and lateral loads.

(Total Lectures: 42 hours)

3. Books Recommended

1. J A D Balfour, Computer Analysis of Structural Frameworks, 2nd Edition, Blackwell Scientific Publication, Oxford, London, 1992.
2. V L Shah, Computer Aided Design in Reinforced Concrete, 3rd Edition, Structures Publishers, Pune, 1998.
3. S R Davies, Spreadsheets in Structural Design, Longman Scientific and Technical, London, 1995.
4. B V Liengme, A Guide to Microsoft excel for scientist and engineers, 2nd edition, Butterworth Heinemann, New York, 2000.
5. G Amos, MATLAB: An Introduction with Applications, 4th Edition, John Wiley, New Jersey, 2012.

CE 488 Introduction to Geotechnical Earthquake Engineering

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Identify the basic concepts in assessing seismic hazard and in characterising earthquake actions
CO2	Identify and select various seismic terminology, measurements and geotechnical aspects of earthquake engineering
CO3	Determine the dynamic soil properties using basis of the wave propagation theory
CO4	Evaluate various design methods for different geotechnical structures and predict the behaviour of the foundation subjected to earthquake loading
CO5	Evaluate various design methods for different geotechnical structures and predict the behaviour of the foundation subjected to earthquake loading

2. Syllabus

- **INTRODUCTION TO GEOTECHNICAL EARTHQUAKE ENGINEERING (01 Hour)**
  Scope and objective, Nature and types of earthquake loading, Importance of Geotechnical Earthquake Engineering

- **SEISMOLOGY AND EARTHQUAKES (04 Hours)**
  Engineering Seismology Basic Seismology, Earthquake, List of major earthquakes, Causes of earthquakes, Sources of earthquake data, Faults, Plate tectonics, Seismograph and Seismogram, Prediction of Earthquakes, Protection against earthquake damage, Origin of Universe, Layers of Earth, Theory of Continental Drift, Hazards due to Earthquakes

- **STRONG GROUND MOTION (PARAMETERS AND ESTIMATION (06 Hours)**
  Strong Ground Motion Size of Earthquake, Magnitude and Intensity of Earthquake, Modified Mercalli Intensity Scale, Measuring of Earthquake, Earthquake Magnitude Local (Richter) magnitude, surface wave magnitude, Moment magnitude, Seismic energy, Correlations. Spectral Parameters: Peak Acceleration, Peak Velocity, Peak Displacement, Frequency Content and duration

- **SEISMIC HAZARD ANALYSIS (05 Hours)**
  Identification of seismic sources, Deterministic and Probabilistic Analyses

- **WAVE PROPAGATION (1D AND 3D) (05 Hours)**
  Elastic response of continua, one dimensional Waves in layered media, Mohorovicic discontinuity and Gutenberg Discontinuity, Seismic Travel Time Curve, Three Circle Method for locating an Earthquake's Epicentre

- **DYNAMIC SOIL PROPERTIES (06 Hours)**
  Laboratory and Field Determination, Correlations of different soil parameters, Liquefaction (basics, evaluation and effects), Liquefaction hazard map, Lateral Spreading.

- **GROUND RESPONSE ANALYSIS, LOCAL SITE EFFECTS AND DESIGN GROUND MOTIONS (05 Hours)**

- **CASE STUDIES IN EARTHQUAKE GEOTECHNICS (10 Hours)**
  Seismic Analysis and Design of Various Geotechnical Structures, Pseudo-static method, Pseudo dynamic method, other dynamic methods, Seismic slope stability analysis, Behaviour of reinforced soil under seismic conditions, seismic design of shallow foundations, seismic design of pile foundations, seismic uplift capacity of ground anchors, Codal provisions/guidelines for seismic design of geotechnical structures.

(Total Lectures: 42 hours)

3. Books Recommended

1. B A Bolt, Earthquakes, Centennial Update, W. H. Freeman, New York, 2005.
2. S L Kramer, Geotechnical Earthquake Engineering, Prentice Hall, New Jersey, 1996.
3. I Towhata, Geotechnical Earthquake Engineering, Springer, Berlin, 2008.
4. M Srbulov, Geotechnical Earthquake Engineering Simplified Analyses with Case Studies and Examples, Springer, Dordrecht, 2008.
5. D Day, Geotechnical Earthquake Engineering Handbook, McGraw-Hill, New York, 2012.

CE 492 Introduction to Wind Engineering

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Illustrate different characteristics of wind.
CO2	Determine dynamic effects of wind load on structures
CO3	Describe about wind tunnels and various available wind flow measuring techniques.
CO4	Design a structure for different types of wind induced loadings.
CO5	Estimate wind induced load according to IS – 875 code.

2. Syllabus

- **WIND CHARACTERISTICS** **(10 hours)**
  Variation of wind velocity, atmospheric circulations – pressure gradient force, coriolis force, frictionless wind balance, geo strophic flow, boundary layer. Extra ordinary winds – Foehn, Bora, Cyclones and Tornadoes etc.

- **DYNAMIC WIND EFFECTS** **(16 hours)**
  Wind induced vibrations, flow around bluff bodies, along wind and across wind response, flutter, galloping, vortex shedding, locking, ovalling; analysis of dynamic wind loads, codal provisions – gust factor, dynamic response factor; wind load calculations as per IS 875 (part III); vibration control and structural monitoring; exposure to perturbation method, averaging techniques

- **WIND TUNNEL TESTING** **(10 hours)**
  Open circuit and closed circuit wind tunnels, rigid and aero elastic models, wind tunnel measurements and instruments along with site visit.

- **CASE STUDIES** **(06 hours)**
  Low rise buildings, parking sheds, workshop building, multi-storey building, water tanks, towers, chimneys, bridges.

(Total Lectures: 42 hours)

3. Books Recommended

1. E Simiu and D H Yeo, Wind Effects on Structures: Modern Structural Design for Wind, John Wiley & Sons, New York, 2019.
2. E Simiu and R H Scanlan, Wind Effects on Structures – An Introduction to Wind Engineering, John Wiley & Sons, New York, 1986.
3. C Scruton, An Introduction to Wind Effects on Structures, Oxford University Press, Oxford, 1981.
4. P Sachs, Wind Forces in Engineering, Pergamon Press, Oxford, 1978.
5. T V Lawson, Wind Effects on Buildings, Applied Science Publishers, London, 1980.

CE 494 Tunnelling Engineering

L	T	P	C
3	0	0	3

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Describe the different types of underground structures and their applications
CO2	Identify the excavation methods for construction of underground structures in different. In – situ conditions
CO3	Analyze the underground structures in rock and soil using elastic and elastoplastic stress-strain behavior of rock and soil
CO4	Design the underground structure using empirical, analytical and numerical approaches
CO5	Solve underground problems by using codes and standards

2. Syllabus

- **INTRODUCTION** **(04 ours)**
  Types and classification of underground openings, Factors affecting design, Design methodology, Functional aspects - Size and shapes, Support systems, Codal provisions

- **EXCAVATION METHODS** **(08 Hours)**
  Principles of rock breakage, Excavation methods, Blasting - types of explosives, blast hole design, Drilling methods and machines, Blast hole timing, TBM tunneling, Factors influencing and evaluation, Excavation mechanics, Geological considerations, Safety provisions

- **CASE STUDIES** **(04 Hours)**
  Tunnels, Energy storage caverns, Nuclear waste disposal repositories, Metros, Underground chambers and defence installations

- **ANALYSIS** **(12 Hours)**
  Stresses and deformations around openings, Stresses and deformations around tunnels and galleries with composite lining due to internal pressure, Closed form solutions

- **DESIGN** **(14 Hours)**
  Design based on analytical methods, Empirical methods based on RSR, RMR, Q systems, Design based on Rock support interaction analysis, Observational method- NATM, Stability of excavation face and Tunnel portals. Use of appropriate software package

(Total Lectures : 42 hours)

3. Books Recommended

1. E T Brown and E Hoek, Underground Excavations in Rock, CRC Press, Boca Raton, 1980.
2. L Obert and W I Duvall, Rock Mechanics and the Design of Structures in Rock, John Wiley, New York, 1967.
3. H G Poulos and E H Davis, Elastic solutions for Soil and Rock Mechanics, John Wiley, New York, 1974.
4. Z T Bieniawski, Rock Mechanics Design in Mining and Tunnelling, AA Balkema, Rotterdam, 1984.
5. N R Barton, TBM tunnelling in Jointed and Faulted Rock, AA Balkema, Rotterdam, 2000.

CE 496 Ground Improvement Techniques

L	T	P	C
3	0	0	3

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Illustrate the principle of ground improvement and identification of weak deposit
CO2	Identify the Geosynthetics and its application in Civil Engineering Project
CO3	Execute the ground improvement using stabilization and grouting technique
CO4	Design the ground improvement system for given soil situation based on codal guidelines
CO5	Design of stone column and sand drain/PVD as per codal guidelines

2. Syllabus

- **INTRODUCTION** **(05 Hours)**
  Role of ground improvement in foundation engineering, Weak deposite, Classification of Ground Improvement Techniques, Principle of Ground Improvement, Factors affecting selection of Ground improvement Techniques,

- **HYDAULIC MODIFICATION** **(08 Hours)**
  Methods of Dewatering, Design steps of Dewatering systems, Precompression and Vertical drain, Pre loading with sand drains. Radial consolidation, combined vertical and radial consolidation.

- **IN-SITU DESIFICATION OF SOIL** **(08 Hours)**
  Dynamic compaction, Design of dynamic compaction by FHWA guidelines, Vibrotory compaction in sands, Vibroflotation, Blasting, Vibro compaction piles, Stone Columns, Methods of Installation of stone column, Design of stone column as per IS:15284.

- **EARTH REINFORCEMENT** **(12 Hours)**
  Geo-synthetics,Geo-synthetics applications of reinforced earth. Different types of walls like wrap-around walls, full-height panel walls, discrete-facing panel walls, modular block walls. Design methods as per ASD method, construction of steep slopes with reinforcement layers on competent soils,

- **GROUTING AND STABILIZATION** **(09 Hours)**
  Grouting principle and design, Suitability of methods of stabilization and Grouting, Suspension and solution grout, Injection methods, electrochemical stabilization, Stabilization with cement, lime and chemicals, stabilization of expansive clays.

(Total Lectures: 42 hours)

3. Books Recommended

1. J Han, Principles and Practice of Ground Improvement, John Wiley & Sons, New Jersey, 2015.
2. M R Hausmann, Engineering Principles of Ground Modification, McGraw Hill Publishing Company, New York, 1990.
3. K Kirsch, A Bell, Ground Improvement, CRC Press, Boca Raton, 2012.
4. S K Gulhati and M Datta, Geotechnical Engineering, Tata McGraw-Hill Education, New Delhi, 2017.
5. S Mittal, An Introduction to Ground Improvement Engineering, Medtech, Dellhi, 2013.

Bachelor of Technology
Computer Science and Engineering

B.Tech. CSE
Curriculum

21|7|2020

Teaching Scheme of B.Tech.-I (Semester I & II)
Division –A, B, C, D, E & F

Semester I

Sr. No.	Course	Code	Credits	Teaching Scheme			Examination Scheme			Total
				L	T	P	L	T	P	
1	Mathematics-I	MA101S1	4	3	1	0	100	25	0	125
2	Electrical Networks **Branch Specific Course-I**	CSEE102S1	4	3	0	2	100	0	50	150
3	Mechanics, Lasers and Fiber Optics	PH103S1	4	3	0	2	100	0	50	150
4	Applied Chemistry	CY104S1	4	3	0	2	100	0	50	150
5	Engineering Drawing	CIME105S1	4	2	0	4	50	0	100	150
6	Energy & Environmental Engineering	CIME106S1	4	3	1	0	100	25	0	125
7	Holistic Empowerment & Human Values*	HU107S1	0	3	0	0	0	0	0	0
	Total		**24**	**20**	**1**	**12**	**550**	**50**	**250**	**850**
	Total Contact Hours per week			**33**						

*Audit Course

Semester II

Sr. No.	Course	Code	Credits	Teaching Scheme			Examination Scheme			Total
				L	T	P	L	T	P	
1	Engineering Mechanics	AM108S2	4	3	0	2	100	0	50	150
2	Fundamentals of Computer & Programming	CS109S2	4	3	0	2	100	0	50	150
3	English & Professional Communication	HU110S2	3	3	0	0	100	0	0	100
4	Workshop Practice	ME111S2	2	0	0	4	0	0	100	100
5	Physics of Materials and Nuclei	PH112S2	4	4	0	0	100	0	0	100
6	Web Programming **Branch Specific Course-II**	CSCS113S2	4	3	0	2	100	0	50	150
7	Mathematics-II	MA114S2	4	3	1	0	100	25	0	125
	Total		**25**	**18**	**2**	**10**	**600**	**25**	**250**	**875**
	Total Contact Hours per week			**30**						

S1 = Semester-1, S2 = Semester-2, AM = Applied Mechanics, CH = Chemical, CE = Civil, CS = Computer, ME = Mechanical, EE = Electrical, EC = Electronics, PH = Physics, CY = Chemistry, MA = Mathematics, HU = Humanities. Branch Specific Course: First two letters indicate branch for which the course is offered and the last two letters indicate the department which is offering the course.

21|7|2020

Teaching Scheme of B.Tech-I (Semester I & II)
Division – G, H, I, J, K & L

Semester-I

Sr. No.	Course	Code	Credits	Teaching Scheme			Examination Scheme			Total
				L	T	P	L	T	P	
1	Mathematics-I	MA101S1	4	3	1	0	100	25	0	125
2	Electrical Networks **Branch Specific Course-I**	CSEE102S1	4	3	0	2	100	0	50	150
3	Engineering Mechanics	AM108S1	4	3	0	2	100	0	50	150
4	Fundamentals of Computer & Programming	CS109S1	4	3	0	2	100	0	50	150
5	English & Professional Communication	HU110S1	3	3	0	0	100	0	0	100
6	Workshop Practice	ME111S1	2	0	0	4	0	0	100	100
7	Physics of Materials and Nuclei	PH112S1	4	3	0	2	100	0	50	150
	Total		**25**	**18**	**1**	**12**	**600**	**25**	**300**	**925**
	Total Contact Hours per week			**31**						

Semester-II

Sr. No.	Course	Code	Credits	Teaching Scheme			Examination Scheme			Total
				L	T	P	L	T	P	
1	Mechanics, Lasers and Fiber Optics	PH103S2	4	4	0	0	100	0	0	100
2	Applied Chemistry	CY104S2	4	3	0	2	100	0	50	150
3	Engineering Drawing	CEME105S2	4	2	0	4	50	0	100	150
4	Energy & Environmental Engineering	CEME106S2	4	3	1	0	100	25	0	125
5	Holistic Empowerment & Human Values*	HU107S2	0	3	0	0	100	0	0	100
6	Web Programming **Branch Specific Course-II**	CSCS113S2	4	3	0	2	100	0	50	150
7	Mathematics-II	MA112S2	4	3	1	0	100	25	0	125
	Total		**24**	**21**	**3**	**8**	**650**	**50**	**200**	**900**
	Total Contact Hours per week			**32**						

*Audit Course

21/7/2020

Teaching Scheme of B.Tech.-II (CSE) (Semester III)

Sr. No.	Course	Code	Credits	Teaching Scheme			Examination Scheme			Total
				L	T	P	L	T	P	
1	Discrete Mathematics (Mathematics – III)	MA221	4	3	1	0	100	25	0	125
2	Data Structures (Core-1)	CS210	5	3	1	2	100	25	50	175
3	Computer Organization (Core-2)	CS201	5	3	1	2	100	25	50	175
4	Digital Electronics & Logic Design (Core-3/Interdisciplinary Subject)	EC207	5	3	1	2	100	25	50	175
5	Digital Communication (Core-4/Interdisciplinary Subject)	EC209	4	3	0	2	100	0	50	150
	Total		**23**	**15**	**4**	**8**	**500**	**100**	**200**	**800**
	Total Contact Hours per week			**27**						

Practical Examination Scheme (Continuous Evaluation 50% and End-Semester Evaluation 50%)

Teaching Scheme of B.Tech.-II (CSE) (Semester IV)

Sr. No.	Course	Code	Credits	Teaching Scheme			Examination Scheme			Total
				L	T	P	L	T	P	
1	Linear Algebra and Statistical Analysis (Mathematic – IV)	MA212	4	3	1	0	100	25	0	125
2	Microprocessor and Interfacing Techniques (Core-5)	CS202	5	3	1	2	100	25	50	175
3	Database Management System (Core-6)	CS204	5	3	1	2	100	25	50	175
4	Design and Analysis of Algorithms (Core-7)	CS206	5	3	1	2	100	25	50	175
5	Automata and Formal Languages (Core-8)	CS208	4	3	1	0	100	25	0	125
	Total		**23**	**15**	**5**	**6**	**500**	**125**	**150**	**775**
	Total Contact Hours per week			**26**						

Practical Examination Scheme (Continuous Evaluation 50% and End-Semester Evaluation 50%)

21/7/2020

Teaching Scheme of B.Tech.-III (CSE) (Semester V)

Sr. No.	Course	Code	Credits	Teaching Scheme			Examination Scheme			Total
				L	**T**	**P**	**L**	**T**	**P**	
1	Operating Systems (Core-9)	CS301	5	3	1	2	100	25	50	175
2	Computer Networks (Core-10)	CS303	5	3	1	2	100	25	50	175
3	Professional Ethics, Economics and Business Management	HU303	4	4	0	0	125	0	0	125
4	Institute Elective-1	-	3	3	0	0	100	0	0	100
5	Core Elective-1	CS3AA	3	3	0	0	100	0	0	100
6	Seminar	CS305	1	0	0	2	0	0	50	50
	Total		**21**	**16**	**2**	**6**	**525**	**50**	**150**	**725**
	Total Contact Hours per week			**24**						

Practical Examination Scheme (Continuous Evaluation 50% and End-Semester Evaluation 50%)

Institute Elective-1 (CS3XX):

1	Soft Computing (CS361)	4	Signals & Systems (CS367)
2	Information Security (CS363)	5	Logic and Functional Programming (CS369)
3	Machine Learning (CS365)		

Core Elective-1 (CS3AA):

1	Data Science (CS321)	4	Information Theory & Coding (CS327)
2	Advanced Microprocessor (CS323)	5	Object Oriented Technology (CS329)
3	Parallel Processing and Architecture (CS325)		

21/7/2020

Teaching Scheme of B.Tech.-III (CSE) (Semester VI)

Sr. No.	Course	Code	Credits	Teaching Scheme			Examination Scheme			Total
				L	T	P	L	T	P	
1	Principles of Programming Languages (Core-11)	CS302	5	3	1	2	100	25	50	175
2	Distributed Systems (Core-12)	CS304	5	3	1	2	100	25	50	175
3	System Software (Core-13)	CS306	5	3	1	2	100	25	50	175
4	Artificial Intelligence (Core-14)	CS308	4	3	0	2	100	0	50	150
5	Institute Elective-2	-	3	3	0	0	100	0	0	100
6	Core Elective-2	CS3BB	3	3	0	0	100	0	0	100
	Total		**25**	**18**	**3**	**8**	**600**	**75**	**200**	**875**
	Total Contact Hours per week			**29**						

Practical Examination Scheme (Continuous Evaluation 50% and End-Semester Evaluation 50%)

Institute Elective-2 (CS3YY):

1	Cryptography (CS362)	4	Image Processing (CS368)
2	Digital Forensics (CS364)	5	Adaptive Signal Processing (CS372)
3	Embedded Systems (CS366)		

Core Elective-2 (CS3BB):

1	Data Visualization (CS322)	4	Wireless Networks (CS328)
2	Natural Language Processing (CS324)	5	Optimization Methods (CS332)
3	Cloud Computing (CS326)		

21/7/2020

Teaching Scheme of B.Tech.-IV (CSE) (Semester VII)

Sr. No.	Course	Code	Credits	Teaching Scheme			Examination Scheme			Total
				L	T	P	L	T	P	
1	Software Engineering (Core-15)	CS401	5	3	1	2	100	25	50	175
2	Innovation, Incubation and Entrepreneurship	HU410	3	3	0	0	100	0	0	100
3	Core Elective-3	CS4AA	3	3	0	0	100	0	0	100
4	Core Elective-4	CS4BB	3	3	0	0	100	0	0	100
5	Summer Training*	CS403	2	0	0	0	0	0	50	50
6	Project Preliminaries	CS405	3	0	0	6	0	0	150	150
	Total		**19**	**12**	**1**	**8**	**400**	**25**	**250**	**675**
	Total Contact Hours per week			**21**						

*Summer training is to be organized in the summer vacation after 6th Semester.
Practical Examination Scheme (Continuous Evaluation 50% and End-Semester Evaluation 50%)

Core Elective-3 (CS4AA):

1	Computer Graphics (CS421)	4	Video Codec Standards and Design (CS427)
2	Blockchain Technology (CS423)	5	Computational Geometry (CS429)
3	Smartphone Computing and Applications (CS425)		

Core Elective-4 (CS4BB):

1	Data Warehousing and Mining (CS441)	4	Audio and Speech Signal Processing (CS447)
2	High Performance Computing (CS443)	5	Service Oriented System (CS449)
3	Security in Resource Constrained Environment (CS445)		

21/7/2020

Teaching Scheme of B.Tech.–IV (CSE) (Semester VIII)

Sr. No.	Course	Code	Credits	Teaching Scheme			Examination Scheme			Total
				L	T	P	L	T	P	
1	Core Elective-5	CS4XX	3	3	0	0	100	0	0	100
2	Core Elective-6	CS4YY	3	3	0	0	100	0	0	100
3	Core Elective-7	CS4ZZ	3	3	0	0	100	0	0	100
4	Cyber Law and Forensics (Core-16)	CS402	4	3	0	2	100	0	50	150
5	Project	CS404	6	0	0	12	0	0	300	300
	Total		**19**	**12**	**0**	**14**	**400**	**0**	**350**	**750**
	Total Contact Hours per week			**26**						

Practical Examination Scheme (Continuous Evaluation 50% and End-Semester Evaluation 50%)

Core Elective-5 (CS4XX):

1	Social Network Analysis (CS422)	4	Cellular Network and Mobile Computing (CS428)
2	Network and System Security (CS424)	5	System Analysis and Simulation (CS432)
3	Advanced Computer Architecture (CS426)		

Core Elective-6 (CS4YY):

1	Big Data Analytics (CS434)	4	Advanced Database Management System (CS442)
2	Deep Learning (CS436)	5	Web Engineering (CS444)
3	Advanced Compiler Design (CS438)		

Core Elective-7 (CS4ZZ):

1	Foundations of Automatic Verification (CS446)	4	Research Methodology (CS454)
2	Secure Software Engineering (CS448)	5	Ethical Hacking (CS456)
3	Animation & Rendering (CS452)		

21/7/2020

ELECTRICAL NETWORKS
CSEE102S1
(BRANCH SPECIFIC COURSE-I)

	L	T	P	Credit
Scheme	3	0	2	04

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1. Course Outcomes (COs):
At the end of the course, the students will be able to

CO1	acquire knowledge about AC circuits, electrical network basics, transforms, wave form representation.
CO2	apply the fundamentals of electrical network basics to analyse different networks.
CO3	analyse electrical network using different theorems and different wave forms.
CO4	evaluate network performance using different parameters.
CO5	design and analyse different types of systems using network principles and network theorems.

2. Syllabus

- **AC FUNDAMENTALS AND CIRCUITS** **(07 Hours)**

  Alternating Voltages and Currents through Purely Resistive Inductive and Capacitive Circuits, R-L, R-C, R-L-C Series Circuits, Impedance and Admittance, Circuits in Parallel, Series and Parallel Resonance, Complex Algebra and its Application to Circuit Analysis, Circuit Transient, Initial and Final Value Theorem, DC and Induction Machines, Electrical Measurements, Power System.

- **POLYPHASE CIRCUITS AND TRANSFORMES** **(04 Hours)**

  Balanced Three Phase Systems, Star and Mesh Connections, Relation between Line and Phase Quantities, Measurement of Power, Principle of Transformer, Construction, Transformer on no-load and with load, Phasor Diagram for Transformer under No-Load and Loaded Condition (with unity, lagging power factor load) Equivalent Circuit, Open Circuit and Short Circuit Test, Efficiency, Voltage Regulation.

- **NETWORK CONCEPTS** **(04 Hours)**

  Network Element Symbols and Conventions, Active Element Conventions, Current and Voltage Conventions, Loops and Meshes, Nodes, Coupled circuits and Dot Conventions.

- **MESH CURRENT AND NODE VOLTAGE NETWORK ANALYSIS** **(07 Hours)**

  Kirchhoff's Voltage Law, Kirchhoff's Current Law, Definitions of Mesh Current and Nodal Voltage, Choice of Mesh Currents or Nodal Voltages for Network Analysis, Self and Mutual Inductances, Mesh Equation in the Impedance Matrix Form by Inspection, Solution of Linear Mesh Equations,

21/7/2020

Nodal Voltage Analysis Nodal Equations in the Form of Admittance Matrices by Inspection, Solution of Linear Nodal Equations.

- **NETWORK THEOREMS AND GRAPH** **(07 Hours)**

  Linearity and Superposition, Independent and Dependent Source and their Transformations, Thevenin, Norton, Reciprocity and Maximum Power Transfer Theorems, Use of these Theorems in Circuit Analysis, Duality and Dual of a Planner Network, Fundamental Concepts, Definition of Graph and Various Related Terms, Paths and Circuits Connections, Tree of a Graph, Cut Sets and Tie Sets, Non-separable Planner and Dual Graphs, Matrices of Oriented Graphs, Properties and Inter-Relationship of Incidence, Tie Set and Cut Set Matrices, Complete Analysis Using Tie Set and Cut Set Matrices.

- **WAVE FORM ANALYSIS BY FOURIER SERIES** **(06 Hours)**

  Trigonometric and Complex Exponential Forms, Frequency Spectra of Periodic Wave Forms, Fourier Integral and Continuous Frequency Spectra, Fourier Transform and their Relationship with Laplace Transform.

- **NETWORK FUNCTIONS AND TWO PORT PARAMETERS** **(07 Hours)**

  Poles and Zeros of a Function, Physical and Analytical Concepts, Terminal and Terminal Pairs, Driving Point Immitances, Transfer Functions, Definitions, Calculations and Interrelationship of Impedance, and Admittance, Hybrid and Transmission Line Parameters for four Terminal Networks. Image Impedance and its Calculations for Symmetrical and Unsymmetrical π, T and Ladder Networks.

(Total Contact Time: 42 Hours)

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3. Practicals:

1. To study Ammeter and Voltmeter for current and voltage measurement in circuit.
2. To study Energy meter.
3. To study Power measurement method for three phase circuits using watt meter method.
4. Verification of superposition theorem for electric circuit.
5. Verification of Thevenin's theorem of electric circuit.
6. Calculation and verification Norton's theorem.
7. Open circuit and short circuit test for the transformers for efficiency calculation.
8. Verification of Kirchhoff's current law and Kirchhoff's voltage law for electric circuit.
9. Capacitance measurement of parallel plates.
10. Calculation of efficiency of auto transformer.

21|4|2022

4. Books Recommended:

1. W. H. Hyat, J. E. Kemmerly and S. M. Durbin, Engineering Circuit Analysis, 6th Edition, TMH, 2006.
2. Van Valkenburg, Network Analysis, 3rd Edition, PHI, 2002.
3. Samarjit Ghosh, Network Theory, Analysis & Synthesis,3rd Edition, PHI, 2005.
4. C. L. Wadhwa, Network Analysis & Synthesis, Revised 3rd Edition, New Age International Publishers, 2007.
5. Kothari and Nagrath, Basic Electrical Engineering, 2nd edition, Tata McGraw-Hill Education, 2007.

ADDITIONAL REFERENCE BOOKS

1. V. N. Mittle & Arvind Mittal, Basic Electrical Engineering, 2nd edition, Tata McGraw-Hill Education, 2005.

21/7/22

FUNDAMENTALS OF COMPUTER & PROGRAMMING
CS109S1
CS109S2

	L	T	P	Credit
Scheme	3	0	2	04

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1. Course Outcomes (COs): **At the end of the course, the students will be able to**	
CO1	acquire knowledge about computer architecture, network and software development.
CO2	install an operating system and configure the network along with programming skills to solve the given problem.
CO3	debug network and operating system related issues and analyse the given problem.
CO4	evaluate programming solutions with different aspects.
CO5	design and develop solution for given problems.

2. Syllabus

- **INTRODUCTION TO COMPUTER AND ITS ARCHITECTURE** **(02 Hours)**

  Introduction and Characteristics, Computer Architecture, Generations, Classifications, Applications, Central Processing Unit and Memory, Communication between various Units, Processor Speed, Multiprocessor System, Peripheral Buses, Motherboard Demonstration.

- **MEMORY AND VARIOUS INPUT AND OUTPUT DEVICES** **(02 Hours)**

  Introduction to Memory, Input and Output Devices, Memory Hierarchy, Primary Memory and its Types, Secondary Memory, Classification of Secondary Memory, Various Secondary Storage Devices and their Functioning.

- **NUMBER SYSTEMS** **(01 Hours)**

  Introduction and type of Number System, Conversion between Number System, Arithmetic Operations in different Number System, Signed and Unsigned Number System.

- **INTRODUCTION TO SYSTEM SOFTWARES AND PROGRAMMING LANGUAGES** **(04 Hours)**

  Classification of Computer Languages, Introduction of Operating System, Evolution, Type and Function of OS, Unix Commands, Evolution and Classification of programming Language, Feature and Selection of good Programming Language, Development of Program, Algorithm and Flowchart, Program Testing and Debugging, Program Documentation and Paradigms, Characteristics of good Program.

- **WINDOWS OPERATING SYSTEM AND ITS ENVIRONMENT** **(02 Hours)**

Introduction to GUI based OS, Configuration, Setup, Services, Network Configuration.

- **LINUX OPERATING SYSTEM AND ITS ENVIRONMENT** **(02 Hours)**

Introduction to Unix based OS, Configuration, Setup, Services, Scripting, Network Configuration.

- **DEBUGGING TOOLS AND COMPILER OPTION** **(04 Hours)**

Different Debugging tools, Commands, Memory dump, Register and Variable Tracking, Instruction and Function level debugging, Compiler Options, Profile Generation.

- **DATA COMMUNICATION, COMPUTER NETWORK AND INTERNET BASICS** **(02 Hours)**

Data Communication and Transmission media, Multiplexing and Switching, Computer Network and Network Topology, Communication Protocols and Network Devices, Evolution and Basic Internet Term, Getting Connected to Internet and Internet Application, Email and its working, Searching the Web, Languages of Internet, Internet and Viruses.

- **PROGRAMMING USING 'C' LANGUAGE – INTRODUCTION** **(06 Hours)**

Characteristics of C Language, Identifiers and Keywords, Data Types Constants and Variables, Declarations and Statements, Representation of Expressions, Classification of Operators and Library Functions for Data Input and Output Statements, Formatted Input and Output Statements.

- **PROGRAMMING USING 'C' LANGUAGE – CONTROL STATEMENT, DATA STRUCTURES, POINTERS** **(06 Hours)**

Conditional Control Statements, Loop Control Statements, One Dimensional Array of Numbers and Characters, Two-Dimensional Array, Introduction and Development of User Defined Functions, Different Types of Variables and Parameters, Structure and Union, Introduction to Pointers, Pointer Arithmetic, Array of Pointers, Pointers and Functions, Pointers and structures, File Handling Operations.

- **PROGRAMMING USING 'C' LANGUAGE – FUNCTIONS** **(06 Hours)**

Functions, Passing the arguments, Return values from functions, Recursion, Header Files Design, File handling operations, Read and Write to Secondary Devices, Read and Write to Input and Output Ports.

- **PROGRAMMING USING 'C' LANGUAGE – GRAPHICS, DEBUGGING** **(05 Hours)**

Include Graphics Library, Debugging, Linking, Compilation Option for Optimization, Make file.

Practicals will be based on the coverage of the above topics. **(28 Hours)**

(Total Contact Time 42 Hours + 28 Hours = 70 Hours)

21/7/2020

3. Practicals:

1 Basic commands of Windows and Linux
2 Installing and configuring using Windows and Linux
3 Flow chart drawing and writing pseudo steps or algorithms steps
4 Programming using different data structures
5 Solving complex problems

4. Books Recommended:

1. Introduction to Computer Science, Fourth Impression, Pearson Education, ITL Education Solutions Limited, 2009.
2. B. S. Gottfried, Programming with C Schaum's outline Series, Outline Series, 2/E, Tata McGraw-Hill, 2006.
3. Brian W. Kernighan, Dennis M. Ritchie, The C Programming language, 2/E, Prentice Hall PTR publication, 1988.
4. E. Balagurusamy, Programming in ANSI C , 6/E, Tata Mc-Graw Hill, 2012.
5. Pradip Dey, Programming in C , 2/E, Oxford University Press, 2012.

21/7/2020

WEB PROGRAMMING
CSCS113S2
(BRANCH SPECIFIC COURSE-II)

	L	T	P	Credit
Scheme	3	0	2	04

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1. Course Outcomes (COs): **At the end of the course, the students will be able to**	
CO1	acquire knowledge about the basics of web pages, need of web server, configuration, client and server side scripting, style of web pages.
CO2	install and configure the web server and apply the knowledge of programming to develop web application pages using html, style sheets, client and server side scripts.
CO3	analyse given problem for the requirement of html, style sheets, client side or server side script.
CO4	evaluate web application programming solutions with different aspects like the presentation and working of the web application.
CO5	utilize the standard tools for design and development of web project solution for given problems by integrating html, client and server pages with style.

2. Syllabus

- **INTRODUCTION** **(04 Hours)**

  Basics of Internet, World Wide Web, HTTP Protocol, Universal Resource Locator, Web Server, Different Types of Web Servers, Domain Name Server, Web Server Configuration, Internet Browser, Web Document and Mark-Up Language, Hypertext Mark-Up Language, Hypermedia, Web Site Organization, Content Organization, Web Server on Different Operating System Platforms, Web Applications, Web Interface, Web Standards & Accessible Design.

- **WEB DESIGNING: STATIC WEB PAGES** **(08 Hours)**

  Web Page, Static Web Page, Hypertext Mark-Up Tags, Handling Font Style, Types, Size, Colour Etc., Handling Table, List, Images, Graphics, Menu Etc.

- **WEB DESIGING: DYNAMIC WEB PAGES** **(08 Hours)**

  Forms, Input Text Box, Drop Down Menu, Name Variable, Cookie Management, Session Management, Animation, Structure Web Pages, Image Mapping, Link Setup In Image, Frames, Structuring Web Pages Using Frames, Multimedia Handling, Linking To Pages.

- **DYNAMIC WEB PAGES AND SCRIPTING** **(08 Hours)**

21/7/2020

Scripting Language, Dynamic Pages and Forms Validation, Validation of Input Text Box, Dynamic Drop Down Menu, Validation and Accessing Name Variable-Value Pair, Cookie Management Through Scripting, Session Management through Scripting, Animation through Scripting, Dynamic Image Mapping Through Scripting, Link Handling through Scripting, Multimedia Handling through Scripting.

- **WEB PAGE STYLE SHEET** **(04 Hours)**

  Web Page Designing using Style Sheet, Different Types of Style Sheet, Defining Different Styles, Export and Importing Style Sheet, Cascade Style Sheet.

- **PYTHON PROGRAMMING** **(08Hours)**

  Basics of Python Programming: Variables, Controlling Statements, Functions, Introduction to Module Packages, Web Designing with Python.

- **WEB HOSTING AND PUBLISHING** **(02 Hours)**

  Different Steps of Web Hosting and Publishing, Documents Interchange Standards, Website Evaluation, Components of Web Publishing, Document Management, Search Engines, and Registration of a Web Site on Search Engines, Publishing Tools.

Practicals will be based on the coverage of the above topics. **(28 Hours)**

(Total Contact Time 42 Hours + 28 Hours = 70 Hours)

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3. Practicals:

1 To prepare the web page using hypertext mark-up language
2 To study and setup the web server for implementation
3 To learn client side scripting
4 To learn server side scripting
5 To apply style to the web pages

4. Books Recommended:

1. Martin C. Brown, Python: The Complete Reference, Osborne / McGraw-Hill, 2018.
2. Thomas Powell and Fritz Schneider, JavaScript: The Complete Reference, McGraw-Hill, 2017.
3. J. Sklar, Principles of Web Design , 7/E, Cengage Learning, 2017.
4. H. Deitel, A. Deitel, Internet and World Wide Web How to Program , 5/E, Pearson, 2012.
5. Jon Duckett, HTML & CSS Design and Build Websites , John Wiley & Sons, Inc., 2011.

21/9/2020

ADDITIONAL REFERENCE BOOKS

1. M.L. Young, The Complete reference of Internet , Tata Mc Graw Hill, 2002.
2. W.G. Lehnert, Internet 101, 1/E, Person Education, 2001.
3. B. Underdahle and K. Underdahle, Internet and Web Page/ Website design , 2/E, IDG Books India (P) Ltd., 2001.
4. D. Comer, The Internet Books, 2/E, Prentice Hall of India, 2001.

2/7/2020

B.Tech. II (CSE) Semester – III
DISCRETE MATHEMATICS
MA221
(MATHEMATICS - III)

	L	T	P	Credit
Scheme	3	1	0	04

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1. **Course Outcomes (COs):**

At the end of the course, the students will be able to

CO1	acquire knowledge of sets, group and functions, graphs.
CO2	apply group theory, relations and lattice.
CO3	analyse functions, counting and based on mathematical logic.
CO4	evaluate formal verification of computer programmes.
CO5	design solutions for various types of problems in different disciplines like information security, optimization, mathematical analysis.

2. **Syllabus**

- **INTRODUCTION** **(04 Hours)**

  Set Definition, Finite and Infinite Sets, Equality of Sets, Disjoint Sets, Family of Sets, Types of Sets, Operations on Sets, Algebra of Sets, Cardinality of a Set, Venn Diagrams, Multisets, Cartesian Product, Principle Inclusion and Exclusion, Functions as a Set, Domain and Co-domain, Image, Range, Types of Functions, Equal and Identity Functions, Invertible Functions, Composition of Functions, Application of Functions in Computer Science Areas.

- **GROUP THEORY** **(08 Hours)**

  Basic Properties of Group, Groupoid, Semigroup & Monoid, Abelian Group, Subgroup, Cosets, Normal Subgroup, Lagrange's Theorem, Cyclic Group, Permutation Group, Homomorphism & Isomorphism of Groups, Basic Properties, Error Correction & Detection Code.

- **RELATION & LATTICES** **(05 Hours)**

  Definition & Basic Properties, Graphs Of Relation, Matrices Of Relation, Equivalence Relation, Equivalence Classes, Partition, Partial Ordered Relation, Posets, Hasse Diagram, Upper Bounds, Lower Bound, GLB & LUB Of Sets, Definition & Properties Of Lattice, Sub Lattice, Distributive & Modular Lattices, Complemented & Bounded Lattices, Complete Lattices & Boolean Algebra.

- **MATHEMATICAL LOGIC AND PROGRAM VERIFICATION** **(05 Hours)**

  Induction, Propositions, Combination Of Propositions, Logical Operators & Propositional Algebra, Equivalence, Predicates & Quantifiers, Interaction of Quantifiers with Logical Operators, Logical

21/9/2020

Interference & Proof Techniques, Formal Verification of Computer Programs (Elements of Hoare Logic).

- **COUNTING AND RECURRENCE RELATION** **(05 Hours)**

  First Counting Principle, Second Counting Principle, Permutation, Circular Permutations, Combination, Pigeonhole Principle, Recurrence Relations, Linear Recurrence Relations, Inclusion And Exclusion, Generating Functions.

- **BASICS OF GRAPHS** **(05 Hours)**

  Graph Definition, Graph Representation, Basic Concepts Of Finite & Infinite Graph, Incidence & Degree, Isomorphism, Subgraph, Walk, Path & Circuits, Cliques, Cycles and Loops, Operations On Graphs, Connected Graph, Disconnected Graph & Components, Complete Graph, Regular Graph, Bipartite Graph, Planar Graphs, Weighted Graphs, Directed & Undirected Graphs, Connectivity Of Graphs.

- **GRAPHS ALGORITHMS** **(10 Hours)**

  Flows, Combinatorics, Euler's Graph, Hamiltonian Paths & Circuits, Activity Planning and Critical Path, Planar Graphs: Properties, Graph Coloring, Vertex Coloring, Chromatic Polynomials, Edge Coloring, Planar Graph Coloring, Matching and Factorizations: Maximum Matching In Bipartite Graphs, Maximum Matching In General Graphs, Hall's Marriage Theorem, Factorization; Networks: Max-Flow Min-Cut Theorem, Menger's Theorem, Graph and Matrices.

Tutorials will be based on the coverage of the above topics separately **(14 Hours)**

(Total Contact Time: 42 Hours + 14 Hours = 56 Hours)

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3. Tutorials:

1 Examples using different set operations

2 Examples of defining groups and studying properties

3 Examples on formal verification and applying different functions

4 Examples of mathematical logics and relations

5 Examples of recurrence and counting

4. Books Recommended:

1. Rosen K.H., Discrete Mathematics and Its Applications , 6/E, MGH, 2006.
2. Liu C.L., Elements of Discrete Mathematics , MGH, 2000.
3. Deo Narsingh., Graph theory with applications to Engineering & Computer Science , PHI, 2000.

21/9/2020

4. J A Bondy and USR Murty, Graph Theory , Springer, 2008.
5. V. K. Balakrishnan, Theory and Problems of Graph Theory , Tata McGraw-Hill, 2007.

ADDITIONAL REFERENCE BOOKS

1. Kolman B., Busby R.C. & Ross S., Discrete Mathematical Structure , 5/E, PHI, 2003.
2. Tremblay J. P. & Manohar R., Discrete Mathematical structure with applications to computer science , MGH, 1999.
3. Liu C.L., Elements of Discrete Mathematics , MGH, 2000.
4. D B West, Introduction to Graph Theory , 2nd Edition, PHI 2002.
5. G Chatrand and O.R. Ollermann, Applied and Algorithmic Graph Theory ,McGraw Hill, 1993.

B.Tech. II (CSE) Semester – III
DATA STRUCTURES (CORE-1)
CS210

	L	T	P	Credit
Scheme	3	1	2	05

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1. Course Outcomes (COs): **At the end of the course, the students will be able to**	
CO1	recognize the need of different data structures and describe its characteristics.
CO2	apply different data structures for given problems.
CO3	design and analyse different data structures, sorting and searching techniques.
CO4	evaluate data structure operations theoretically and experimentally.
CO5	design solutions for complex engineering problems.

2. Syllabus

- **INTRODUCTION TO DATA STRUCTURES** **(02 Hours)**

  Review of Concepts: Information and Meaning, Abstract Data Types, Internal Representation of Primitive Data Structures, Arrays, Strings, Structures, Pointers.

- **LINEAR LISTS** **(06 Hours)**

  Sequential and Linked Representations of Linear Lists, Comparison of Insertion, Deletion and Search Operations for Sequential and Linked Lists, Doubly Linked Lists, Circular Lists, Lists in Standard Template Library (STL), Applications Of Lists.

- **STACKS** **(06 Hours)**

  Sequential and Linked Implementations, Representative Applications such as Recursion, Expression Evaluation Viz., Infix, Prefix and Postfix, Parenthesis Matching, Towers of Hanoi, Wire Routing in a Circuit, Finding Path in a Maze.

- **QUEUES** **(06 Hours)**

  Operations of Queues, Circular Queue, Priority Queue, Dequeue, Applications of Queues, Simulation of Time Sharing Operating Systems, Continuous Network Monitoring System Etc.

- **SORTING AND SEARCHING** **(04 Hours)**

Sorting Methods, Bubble Sort, Selection Sort, Quick Sort, Radix Sort, Bucket Sort, Dictionaries, Hashing, Analysis of Collision Resolution Techniques, Searching Methods, Linear Search, Binary Search, Character Strings and Different String Operations.

- **TREES** **(08 Hours)**

  Binary Trees and Their Properties, Terminology, Sequential and Linked Implementations, Tree Traversal Methods and Algorithms, Complete Binary Trees, General Trees, AVL Trees, Threaded Trees, Arithmetic Expression Evaluation, Infix-Prefix-Postfix Notation Conversion, Heaps as Priority Queues, Heap Implementation, Insertion and Deletion Operations, Heapsort, Heaps in Huffman Coding, Tournament Trees, Bin Packing.

- **MULTIWAY TREES** **(04 Hours)**

  Issues in Large Dictionaries, M-Way Search Trees, B Trees, Search, Insert and Delete Operations, Height of B-Tree, 2-3 Trees, Sets and Multisets in STL.

- **GRAPHS** **(06 Hours)**

  Definition, Terminology, Directed and Undirected Graphs, Properties, Connectivity in Graphs, Applications, Adjacency Matrix and Linked Adjacency Chains, Graph Traversal, Breadth First and Depth First Traversal, Spanning Trees, Shortest Path and Transitive Closure, Activity Networks, Topological Sort and Critical Paths.

Tutorials will be based on the coverage of the above topics separately **(14 Hours)**

Practicals will be based on the coverage of the above topics separately **(28 Hours)**

(Total Contact Time: 42 Hours + 14 Hours + 28 Hours = 84 Hours)

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3. Tutorials:

1 Problems on Array

2 Problems on Stack and Queue

3 Problems on Linked List

4 Problems on Trees

5 Problems on Graph

4. Practicals:

1 Implementation of Array and its applications

2 Implementation of Stack and its applications

21/7/2020

3 Implementation of Queue and its applications

4 Implementation of Link List and its applications

5 Implementation of Trees and its applications

6 Implementation of Graph and its applications

7 Implementation of Hashing functions and collision resolution techniques

8 Mini Project (Implementation using above Data Structure)

5. Books Recommended:

1. Trembley and Sorenson, An Introduction to Data Structures with Applications, 2nd Edition, TMH, 1991.
2. Tanenbaum and Augenstein, Data Structures using C and C++, 2nd Edition, Pearson, 2007.
3. Horowitz and Sahani, Fundamentals of Data Structures in C, 2nd Edition, Silicon Press, 2007.
4. T. H. Cormen, C. E. Leiserson and R. L. Rivest, Introduction to Algorithms, 3rd Edition, MIT Press, 2009.
5. Robert L. Kruse, C. L. Tondo and Brence Leung, Data Structures and Program Design in C, 2nd Edition, Pearson Education, 2001.

21/7/2020

B.Tech. II (CSE) Semester – III
COMPUTER ORGANIZATION (CORE-2)
CS201

	L	T	P	Credit
Scheme	3	1	2	05

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1. Course Outcomes (COs): **At the end of the course, the students will be able to**	
CO1	acquire knowledge of basics of computer architecture, its components with peripheral devices, instruction set architecture, instruction execution using data path and control unit interface.
CO2	apply knowledge of combinational and sequential logic circuits to mimic simple computer architecture to solve the given problem.
CO3	analyze performance of various instruction set architecture, control unit, memories, various processor architectures.
CO4	evaluate programming solutions to implement fast methods of ALU, FP unit implementations, processor architectures and instruction set architectures.
CO5	implement fast methods of ALU, FP unit implementations and to design and develop hardware solution for given instruction coding scheme of an Instruction Set Architecture or vice versa using available technology tools.

2. Syllabus

- **PROCESSOR BASICS** **(05 Hours)**

  Basics CPU Organization - Functional Units, Data Paths, Registers, Stored Program Concept, Data Representation - Basic Formats, Fixed and Floating Point Representation, Instruction Sets, Instruction Types, Instruction Formats, Addressing Modes, Designing of an Instruction Set, Data path Design, Concepts of Machine Level Programming, Assembly Level Programming and High Level Programming.

- **ARITHMETIC AND LOGIC UNIT** **(08 Hours)**

  Arithmetic and Logical Operation and Hardware Implementation, Implementation of some Complex Operation: Fixed-Point Arithmetic Multiplication Algorithms-Hardware Algorithm, Booth Multiplication Algorithm, Division Algorithm, Divide Overflow Algorithm, Combinational ALU and Sequential ALU, Floating Point Arithmetic Operations.

- **CONTROL UNIT** **(07 Hours)**

  Basic Concepts, Instruction Interpretation and Execution, Hardwired Control, Microprogrammed Control, CPU Control Unit Design, Performance.

21/7/2020

- **SUBROUTINE MANAGEMENT** **(03 Hours)**

  Concepts of Subroutine, Subroutine Call and Return.

- **MEMORY ORGANIZATION** **(06 Hours)**

  Concepts of Semiconductor Memory, Cpu-Memory Interaction, Organization of Memory Modules, Cache Memory and Related Mapping and Replacement Policies, Virtual Memory.

- **SYSTEM ORGANIZATION** **(05 Hours)**

  Introduction to Input And Output Processing, Working with Video Display Unit and Keyboard and Routine to Control them, Programmed Controlled I/O Transfer, Interrupt Controlled I/O Transfer, DMA Controller, Secondary Storage and Type Of Storage Devices, Introduction to Buses and Connecting I/O Devices to CPU and Memory.

- **PIPELINE CONTROL AND PARALLEL PROCESSING** **(08 Hours)**

  Instruction Pipelines, Pipeline Hazards, Pipeline Performance, Superscalar Processing, Introduction to Parallel Processing, Processor-Level Parallelism, Multiprocessor.

Tutorials will be based on the coverage of the above topics separately. **(14 Hours)**

Practicals will be based on the coverage of the above topics separately. **(28 Hours)**

(Total Contact Time: 42 Hours + 14 Hours + 28 Hours = 84 Hours)

3. Tutorials:

1 Problems on data conversion in various formats and floating-point representation
2 Solving computations involving complex arithmetic operations and hardware implementation of the same
3 Interpretation of basic instruction execution and various addressing modes possible
4 Learning instruction set architecture level instructions for the high level language programming
5 Problems on memory management, mapping and replacement policies

4. Practicals:

1 Implementation of arithmetic operations on various number systems
2 Implementation of basic combinatorial logic circuits in Logisim
3 Implementation of complex combinatorial logic circuits in Logisim
4 Design storage components as per the given specifications
5 Design of arithmetic logic unit and its associated control unit

6 Design of control unit of set of instructions

7 Implementation of control unit and memory modules

8 Implementation of basic components of computers and integration of them in Logisim

5. Books Recommended:

1. John L. Hannessy and David A. Patterson, Computer Organization and Design, 3rd Edition, Morgan Kaufmaan, 2003.
2. Andrew S. Tanenbaum, Structured Computer Organization, 6th Edition, PHI, 1995.
3. William Stallings, Computer Organization and Architecture: Designing For Performance, 6th Edition, PHI, 2002.
4. Carl Hamacher, Zvonko Vranesic and Safwat Zaky, Computer Organization, 5th Edition, McGraw-Hill, 2002.
5. Morris Mano, Computer Systems Architecture, 3rd Edition, PHI, reprint 1997.

B.Tech. II (CSE) Semester – III
DIGITAL ELECTRONICS & LOGIC DESIGN (CORE-3)
(Interdisciplinary Subject)
EC207

	L	T	P	Credit
Scheme	3	1	2	05

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1. Course Outcomes (COs): **At the end of the course, the students will be able to**	
CO1	acquire knowledge about different types of diodes and circuits.
CO2	apply the knowledge of gates, Boolean algebra and operational amplifier in designing logical and integrated circuits.
CO3	analyse the logical, integrated, and operational amplifier based circuits.
CO4	evaluate the different circuits and compare their performance.
CO5	design ALU and control unit.

2. Syllabus

- **PN DIODE AND TRANSITOR** **(04 Hours)**

  PN Diode Theory, PN Characteristic and Breakdown Region, PN Diode Application as Rectifier, Zener Diode Theory, Zener Voltage Regulator, Diode as Clamper and Clipper, Photodiode Theory, LED Theory, 7 Segment LED Circuit Diagram and Multi Colour LED, LASER Diode Theory and Applications, Bipolar Junction Transistor Theory, Transistor Symbols And Terminals, Common Collector, Emitter and Base Configurations, Different Biasing Techniques, Concept of Transistor Amplifier, Introduction to FET Transistor And Its Feature.

- **WAVESHAPING CIRCUITS AND OPERATIONAL AMPLIFIER** **(06 Hours)**

  Linear Wave Shaping Circuits, RC High Pass and Low Pass Circuits, RC Integrator and Differentiator Circuits, Nonlinear Wave Shaping Circuits, Two Level Diode Clipper Circuits, Clamping Circuits, Operational Amplifier OP-AMP with Block Diagram, Schematic Symbol of OP-AMP, The 741 Package Style and Pinouts, Specifications of Op-Amp, Inverting and Non-Inverting Amplifier, Voltage Follower Circuit, Multistage OP-AMP Circuit, OP-AMP Averaging Amplifier, OP-AMP Subtractor.

- **BOOLEAN ALGEBRA AND SWITCHING FUNCTIONS** **(04 Hours)**

  Basic Logic Operation and Logic Gates, Truth Table, Basic Postulates and Fundamental Theorems of Boolean Algebra, Standard Representations of Logic Functions- SOP and POS Forms, Simplification of Switching Functions-K-Map and Quine-Mccluskey Tabular Methods, Synthesis of Combinational Logic Circuits.

- **COMBINATIONAL LOGIC CIRCUIT USING MSI INTEGRATED CIRCUITS** **(07 Hours)**

21/7/2020

Binary Parallel Adder; BCD Adder; Encoder, Priority Encoder, Decoder; Multiplexer and Demultiplexer Circuits; Implementation of Boolean Functions Using Decoder and Multiplexer; Arithmetic and Logic Unit; BCD to 7-Segment Decoder; Common Anode and Common Cathode 7-Segment Displays; Random Access Memory, Read Only Memory And Erasable Programmable ROMS; Programmable Logic Array (PLA) and Programmable Array Logic (PAL).

- **INTRODUCTION TO SEQUENTIAL LOGIC CIRCUITS** **(04 Hours)**

  Basic Concepts of Sequential Circuits; Cross Coupled SR Flip-Flop Using NAND or NOR Gates; JK Flip-Flop Rise Condition; Clocked Flip-Flop; D-Type and Toggle Flip-Flops; Truth Tables and Excitation Tables for Flip-Flops; Master Slave Configuration; Edge Triggered and Level Triggered Flip-Flops; Elimination of Switch Bounce using Flip-Flops; Flip-Flops with Preset and Clear.

- **SEQUENTIAL LOGIC CIRCUIT DESIGN** **(06 Hours)**

  Basic Concepts of Counters and Registers; Binary Counters; BCD Counters; Up Down Counter; Johnson Counter, Module-N Counter; Design of Counter Using State Diagrams and Table; Sequence Generators; Shift Left and Right Register; Registers With Parallel Load; Serial-In-Parallel-Out (SIPO) And Parallel-In-Serial-Out(PISO); Register using Different Type of Flip-Flop.

- **REGISTER TRANSFER LOGIC** **(04 Hours)**

  Arithmetic, Logic and Shift Micro-Operation; Conditional Control Statements; Fixed-Point and Floating-Point Data; Arithmetic Shifts; Instruction Code and Design Of Simple Computer.

- **PROCESSOR LOGIC DESIGN** **(03 Hours)**

  Processor Organization; Design of Arithmetic Logic Unit; Design of Accumulator.

- **CONTROL LOGIC DESIGN** **(04 Hours)**

  Control Organization; Hard-Wired Control; Micro Program Control; Control Of Processor Unit; PLA Control.

(Total Contact Time: 42 Hours + 14 Hours + 28 Hours = 84 Hours)

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3. **Tutorials:**

1 Problems on different diode based circuits and wave shaping circuit design
2 Problems on logic gates and application of operational amplifiers
3 Problems on boolean algebra and logical circuit design
4 Problems on designing sequential circuits using digital logic gates and integrated circuits
5 Problems on designing ALU and CPU

21/9/22

4. Practicals:

1. Study of BJT Characteristics
2. Study of CE Amplifier
3. Study of RC Coupled / Tuned Amplifier
4. Study of FET Characteristics
5. Study of Diode Clipper Circuits
6. Study of Diode Clamper Circuits
7. Study and Implement RC Low Pass and High Pass Filter Circuits
8. Study and Implement RC Integrator Circuits
9. Study and Implement RC Differentiator Circuits
10. Full and Half-Adder/ Half-subtarctor Circuits using a serial Input
11. 4-Bit Gray to Binary/ Binary to Gray Code convertor using Select input
12. Logic expression with the Help of MUX IC 74153
13. Flip-flops using NAND/ NOR Gate
14. Modulo-7 Ripple Counter
15. 4-Bit Shift Left/Right Register
16. Sequence Generator

5. Books Recommended:

1. Donald L. Schilling and E. Belove, Electronics Circuits- Discrete and Integrated, 3rd Edition, McGraw-Hill, 1989, Reprint 2008.
2. Millman Jacob, Halkias Christos and C. Parikh, Integrated Electronics, 2nd Edition, McGraw-Hill, 2009.
3. H. Taub, Mothibi Suryaprakash and Millman J., Pulse, Digital and Switching Waveforms, 2nd Edition, McGraw-Hill, 2007.
4. Mano Morris, Digital Logic and Computer Design, 5th Edition, Pearson Education, 2005.
5. Lee **Samual**, Digital Circuits and Logic Design, 1st Edition, PHI, 1998.

ADDITIONAL REFERENCE BOOKS

1. Malvin Albert and David J. Bates, Electronic Principles, 7th Edition, Tata McGraw Hill, 2007.
2. De Debashis, Basic of Electronics, 1st Edition, Pearson Education, 2008.
3. Floyd and Jain, Digital Fundamentals, Pearson Education, 2006.

B.Tech. II (CSE) Semester – III
DIGITAL COMMUNICATION (CORE-4)
(Interdisciplinary Subject)
EC209

	L	T	P	Credit
Scheme	3	0	2	04

1. Course Outcomes (COs): **At the end of the course, the students will be able to**	
CO1	acquire knowledge about the basics of communication theory.
CO2	apply different modulations schemes for designing the communication network.
CO3	analyse different modulations schemes to design better schemes for different types of channels.
CO4	evaluate and compare different communication topology, modulations schemes and their performance over various types of channels.
CO5	design robust communication network based of advanced modulations scheme.

2. Syllabus

- **INTRODUCTION** **(05 Hours)**

  History, Concept of Transmitter, Receiver, Channel, Noise, Modulation, Types of Modulation, Different communication systems based on Input and Output. Classification Of Signals, Unit Impulse Signals, Correlation Of Signals, Orthogonal Signal Set, Exponential Fourier Series, Types of Noises, Internal: Shot, Thermal, Agitation, Transit Time Noise and External: Atmospheric, Extra-Terrestrial, Industrial Noise, White Noise and Filtered Noise, AWGN Properties, Signal To Noise Ratio.

- **AMPLITUDE MODULATION (AM)** **(06 Hours)**

  AM, AM Index, Frequency spectrum, Average Power for Sinusoidal AM, Effective Voltage and Current, Non sinusoidal Modulation, DSBFC & DSBSC Modulation, Amplitude modulator and Demodulator Circuits, AM Transmitters.

- **SINGLE-SIDEBAND (SSB) MODULATION** **(06 Hours)**

  SSB Principles, Balanced Modulators, SSB Generation and Reception.

- **ANGLE MODULATION** **(06 Hours)**

21/7/2020

Frequency Modulation (FM), Frequency spectra, Average power, Deviation Ratio, Measurement of Modulation Index, Phase Modulations (PM), Sinusoidal PM, Digital PM, Angle Modulator Circuits, FM Transmitters, Angle Modulations Detectors.

- **PULSE MODULATION** **(07 Hours)**

  Pulse Amplitude Modulation, Pulse Code Modulation, Delta Modulation, Pulse Frequency Modulation, Pulse Time Modulation, Pulse Position modulation and Pulse Width Modulation.

- **DIGITAL CARRIER SYSTEM** **(06 Hours)**

  Introduction and representation of Digital Modulated Signal, ASK, PSK, FSK, QAM with Mathematics and Constellation Diagram, Spectral Characteristics of Digitally Modulated Signals. M-Ary Digital Carrier Modulation.

- **FIBER-OPTIC COMMUNICATIONS** **(06 Hours)**

  Principles of Light Transmission in Fiber Losses in Fibers, Dispersion, Light Sources and Detectors for Fiber Optics.

(Total Contact Time: 42 Hours + 28 Hours = 70 Hours)

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3. Practicals:

1. Study of The Spectrum Analyzer.
2. Study of Various Signals and its Spectrum Using MATLAB.
3. DSB-SC and DSB-C AM Transmitter and Receiver with Tone and Voice Input.
4. FM Transmission and Reception Techniques.
5. Frequency Division Multiplexing Techniques.
6. AM and FM Simulation On MATLAB with AWGN Channel and Concept of SNR.
7. Study of Sampling Theorem Pulse Code Modulation and Demodulation.
8. Study of PAM/PWM/PPM Modulation.
9. Study of Delta Modulation and Demodulation.
10. ASK, FSK, PSK, QAM With Performance Analysis Under Channel Effects And BER

4. Books Recommended:

1. Dennis Roddy and John Coolen, Electronic Communications, PHI, 4th Edition, 1995.

2/7/18

2. George Kennedy, Electronic Communication Systems, 3rd Edition, McGraw Hill Book Co., 1993.
3. Simon Haykin, Communication Systems, 2nd Edition, Wiley Eastern Ltd, 1994.
4. Taub and Schilling, Principles of Communication Systems, 3rd Edition, Mc Graw Hill Publication, 1992.
5. B. P. Lathi, Modern Digital and Analog Communication Systems, 4th Edition, Holt Sounders Publication, 1998.

ADDITIONAL REFERENCE BOOKS

1. Lathi B. P. and Ding Zhi, Modern Digital and Analog Communication Systems, Oxford University Press, 4th Edition, 2010.
2. Proakis J. and Salehi M., Fundamental Of Communication Systems, PHI/Pearson Education-LPE, 2nd Edition, 2006.

21|7|2020

B.Tech. II (CSE) Semester – IV
LINEAR ALGEBRA AND STATISTICAL ANALYSIS
MA212
(MATHEMATIC – IV)

	L	T	P	Credit
Scheme	3	1	0	04

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1. Course Outcomes (COs): **At the end of the course, the students will be able to**	
CO1	acquire knowledge about different terminology of graphs and statistics.
CO2	apply graph-theoretic models to solve problems of connectivity and constraint satisfaction for different problems.
CO3	analyze the problems for developing the solution, its correctness and performance using graphs and statistics methods learned.
CO4	evaluate the solution built using different graph based modelling.
CO5	design an efficient solution using statistical methods and variety of graphs for real problems.

2. Syllabus

- **LINEAR ALGEBRA** **(08 Hours)**

  Vectors, Matrices, Determinants, Linear equations, Vector spaces, Subspace, Field, Ring, Norm and distance, Linear Mapping, Orthogonality, Eigenvectors and Eigenvalues, Least square, Least square data fitting, Constrained least square applications.

- **NUMBER THEORY** **(08 Hours)**

  Divisibility, Prime numbers, Greatest common divisor, Fermat and Mersenne primes, Congruences, Chinese remainder theorem, Fermat's Little theorem, Probabilistic primality test, Elliptic Curves.

- **PROBABILITY THEORY AND RANDM PROCESS** **(08 Hours)**

  Fundamentals of Probability Theory: - views of probability, Random variables and Joint distributions, Marginal distribution, Conditional probability, Conditional independence, Expectation and variance, Probability distributions Central limit theorem, Functions of random variable, Sum of independent random variable, Correlation and regression, Random process, Stationary random process, Autocorrelation and cross correlation, Ergodic process, Markov process, Birth and death process, Poisson process, Markov chain, Chapman Kolmogorov theory, Spectral analysis of random processes, power spectral density.

- **ESTIMATION AND STATISTICS** **(08 Hours)**

21/7/2020

Sampling theory, Population and sample, Statistical interference, Sampling distribution, Sample mean, Bias estimation, Unbiased estimator, Confidence interval, Point estimation and interval estimates, Statistical decision, Hypothesis testing, Statistical hypotheses, Null hypotheses, Significance test, Type I and types II errors, Level of significance, One tail and two tailed test, Chi square test, Maximum likelihood estimate, Least square estimate, MAP estimate, Minimum mean square estimate.

- **PROBABILISTIC GRAPHICAL MODELS** **(06 Hours)**

  Graphical models, Directed models: Bayesian network, Undirected model: Markov Random Fields, Dynamic model: Hidden Markov Model, Learning in Graphical models: Parameter estimation, Expectation Maximization, Factor Graph, Bayes Ball theorem and D-separation, Hammersley-Clifford theorem, Inference in graphical models, Belief propagation, Viterbi algorithm.

- **SCIENTIFIC ASPECTS OF PROGRAMME DEVELOPMENT** **(04 Hours)**

  Development of Programmes, Developing Invariants, Ballon Theory, Bound Functions, Iterations and Recursion, Efficiency considerations in a program, Restricting nondeterminism, Case studies of developing efficient programs.

Tutorials will be based on the coverage of the above topics separately. **(14 Hours)**

(Total Contact Time: 42 Hours + 14 Hours = 56 Hours)

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3. Tutorials:

1 Preliminary exercises based on different terminology learned of various Graphs and statistics
2 Use different types of graph and its algorithm for solving basic problems
3 Use probability and estimation methods for solving different problems in core subjects
4 Use different graphical models to build different network models for high end applications

4. Books Recommended:

1. Gilbert Strang, Introduction to Linear Algebra, Wellesley Cambridge Press, 4th Edition, 2009.
2. Kenneth Hoffman and Ray Kunze, Linear Algebra, 2nd Edition, Prentice Hall India, 2013.
3. David C. Lay, Linear Algebra and Its Applications, 3rd Edition, Pearson, 2006.
4. A. Papoulis and S. U. Pillai, Probability, Random Variables and Stochastic Processes, 4th Edition, Mc-Graw Hill, 2002.
5. Murray R. Spiegel, John J. Schiller and R. Alu Srinivasan, Theory and Problems of Probability and Statistics, 2nd Edition, Tata McGraw-Hill, 2007.

ADDITIONAL REFERENCE BOOKS

1. Gilbert Strang, Linear Algebra and its Applications, Cengage Learning, 4th Edition, 2006.
2. Cheney and Kincaid, Linear Algebra , 2nd Edition, Jones and Bartlett learning, 2014.
3. D. Koller and N. Friedman, Probabilistic Graphical Models: Principles and Techniques, MIT Press, 2009.
4. F. V. Jensen and T. D. Nielsen, Bayesian Networks and Decision Graphs, Information Science and Statistics , Springer, 2nd Edition, 2002.

21/7/2020

B.Tech. II (CSE) Semester – IV
MICROPROCESSOR AND INTERFACING TECHNIQUES (CORE-5)
CS202

	L	T	P	Credit
Scheme	3	1	2	05

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1. Course Outcomes (COs):

At the end of the course, the students will be able to

CO1	acquire knowledge of different architectures, addressing modes and instructions of 8085/86.
CO2	interface memory, I/O devices and interrupt controller with 8085/86 microprocessors.
CO3	analyse and compare the features of microprocessors and microcontrollers.
CO4	describe the internal architecture and different modes of operations of a typical peripheral device.
CO5	design and develop assembly language programs using 8085/86 instructions, software interrupts, subroutines, macros.

2. Syllabus

- **INTRODUCTION TO MICROPROCESSORS EVOLUTION** **(02 Hours)**

  Introduction to Microprocessor and Development and its Operation.

- **ARCHITECTURE FEATURES OF 8085** **(03 Hours)**

  8085 Architecture and Pin out diagram, 8085 Operations.

- **INSTRUCTION SET AND PROGRAMMING OF 8085** **(06Hours)**

  Data Transfer instructions, Arithmetic instructions and its examples, Logical Instructions and its examples, Branch, Stack, and I/O related instructions, How to write, assemble and execute assembly language programmes, Assembly language programming Practice Based on above instructions for 8085, Design Counters in 8085, Design Time delays in 8085, Stack & Subroutines: Restart, Conditional and Unconditional Call and Return Instructions, Advanced Subroutine Concepts, Code Conversion, 16-bit Data Operation.

- **PERIPHERAL & MEMORY INTERFACING WITH 8085** **(08 Hours)**

  Basic I/O Interfacing Concepts: Interfacing Display devices, Interfacing Input devices, Memory Interfacing: Absolute decoding, Partial Decoding, Shadow Memory, Interfacing Peripherals: 8255A Programmable Peripheral Interface, Examples of Interfacing Keyboard and seven-segment Display, Examples of Bidirectional Data transfer Between Two Microcomputer, The 8254 (8253) Programmable Interval Timer, The 8259A Programmable Interrupt Controller, Direct Memory

21|12|2022

Access and 8237 DMA Controller, The 8279 Programmable Keyboard/Display Interface, Interfacing Scanned Multiplexed Displays and Liquid Crystal Displays, Interfacing a Matrix Keyboard, Serial I/O and Data Communication: Basic concepts in Serial I/O, Software-Controlled Asynchronous Serial I/O, The 8085-Serial I/O lines: SOD and SID, Hardware Controlled Serial I/O Using Programmable Chips.

- **8085 INTERRUPT MANAGEMENT** **(04 Hours)**

  Interrupts and its Types in 8085, Interrupt Vector Table, Priority of Interrupts, Programming using Interrupts.

- **8086 ARCHITECTURE** **(03 Hours)**

  8086 Architecture, Pin Out Diagram and its Features, Registers of 8086.

- **INSTRUCTION SET OF 8086** **(06 Hours)**

  Data Transfer Instructions and Examples based on it, Arithmetic Instructions and Examples based on it, Logical Instructions, Comparison Instructions, Jump Instructions, Examples based on Logical, Comparison, Jump Instructions, Various 8086 Assembler Directives, Examples based on Various Assembler Directives, What are Procedures in 8086?, Procedure based Examples in 8086, What are Macros in 8086?, Macros based Examples in 8086.

- **PERIPHERAL & MEMORY INTERFACING WITH 8086** **(04 Hours)**

  Interfacing Peripherals:- 8255A: Examples of Interfacing Keyboard and Seven-segment Display, Interfacing with Alphanumeric Displays, Examples of Bidirectional Data Transfer Between Two Microcomputer, 8254, 8259A, and 8279 Interfacing with 8086.

- **8086 INTERRUPTS MANAGEMENT AND APPLICATIONS** **(03 Hours)**

  8086 Interrupts and Interrupts Responses, Interrupt Pointer Table, Hardware Interrupt, Software Interrupts, Interrupt Applications.

- **RECENT TRENDS IN MICROPROCESSORS** **(03 Hours)**

Tutorials will be based on the coverage of the above topics separately **(14 Hours)**

Practicals will be based on the coverage of the above topics separately **(28 Hours)**

(Total Contact Time: 42 Hours + 14 Hours + 28 Hours= 84 Hours)

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3. **Practicals:**

1 Introduction of 8085 kit and Installation Of 8085 simulator

2 Assembly Language Programming based on Data transfer and Arithmetic and Logic instructions

21/12/2020

3 Assembly Language Programming based on Branch operations
4 Assembly Language Programming based on stack and subroutines
5 Assembly Language Programming based on Code conversions
6. Assembly Language Programming based on counter and time delays
7. Introduction of 8086 Microprocessor and Installation of TASM,TLINK, TD, and DEBUG
8. Assembly Language Programming based on 8086 instruction and assembler directives
9. Practical based on 8085 interfacing

4. Books Recommended:

1. Sentilkumar N, Saravanan M and Jeevananthan S, Microprocessors and Microcontrollers, 2nd Edition, Oxford University Press, 2018.
2. Ramesh S. Gaonkar, Microprocessor Architecture: Programming and Applications with 8085, 6th Edition, Penram International Publishing (India) Pvt. Ltd., 2013.
3. Douglas V Hall, Microprocessors and Interfacing: Programming and Hardware, 3rd Edition, TMH, 2013.
4. Brey, The Intel Microprocessors, 8th Edition, Pearson Education, 2009.
5. A. K. Ray and K. M. Bhurchandi, Advanced Microprocessors and Peripherals: Architecture Programming and Interfacing, 2nd Edition, TMH, 2006.

ADDITIONAL REFERENCE BOOKS

1. Abel Peter and Nizamuddin, IBM PC Assembly Language and Programming , 5th Edition, Pearson Education, 2001.

21/9/2020

B.Tech. II (CSE) Semester – IV
DATABASE MANAGEMENT SYSTEMS (CORE-6)
CS204

	L	T	P	Credit
Scheme	3	1	2	05

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1. Course Outcomes (COs): **At the end of the course, the students will be able to**	
CO1	have knowledge of different database models and query languages to manage the data for given real life application scenario.
CO2	apply the concept of lock management to handle transactions and concurrent user access.
CO3	analyse and evaluate the database design to produce efficient and optimum solution.
CO4	analyse and evaluate the query performance and design the optimum query solution.
CO5	design, populate, and document a normalized database that meets business requirements using industry standards for the given problem.

2. Syllabus

- **INTRODUCTORY CONCEPTS OF DBMS** **(02 Hours)**

  Introduction, Applications of DBMS, Purpose of Database, Data Independence, Database System Architecture, Data Abstraction, Database users and DBA.

- **ENTITY RELATIONSHIP MODEL** **(06 Hours)**

  Basic Concepts, Design Process, Constraints, Keys, Design Issues, E-R Diagrams, Attribute Types, Mapping Cardinality, Types of Relationship, Weak/Strong Entity Sets, Extended E-R Features – Generalization, Specialization, Aggregation.

- **RELATIONAL MODELS** **(04 Hours)**

  Structure of Relational Databases, Domains, Relations, Mapping of ER Model to Relational Model, Relational Algebra – Fundamentals, Operators and Syntax, Relational Algebra Queries, Tuple Relational Calculus.

- **RELATIONAL DATABASE DESIGN** **(08 Hours)**

  Functional Dependency – Definition, Trivial and Non-trivial FD, Closure of FD Set, Closure of Attributes, Irreducible Set of FD, Normalization – 1Nf, 2NF, 3NF, Decomposition using FD-Dependency Preservation, BCNF, Multi- Valued Dependency, 4NF, Join Dependency and 5NF.

- **QUERY PROCESSING AND OPTIMIZATION** **(04 Hours)**

21/7/2020

Overview of Query Processing, Measures of Query Cost, Select Operation, Sorting, Join Operation, Other Operations, Evaluation of Expressions, Overview of Query Optimization, Transformation of Relational, Expressions, Estimating Statistics of Expression Results, Choice of Evaluation Plans, Materialized Views, Advanced Topics in Query Optimization.

- **TRANSACTION MANAGEMENT** **(06 Hours)**

  Transaction Concepts, Properties of Transactions, Serializability of Transactions, Testing for Serializability, System Recovery, Two- Phase Commit Protocol, Recovery and Atomicity, Log-based Recovery, Concurrent Executions of Transactions and Related Problems, Locking Mechanism, Solution to Concurrency Related Problems, Deadlock, Two-phase Locking Protocol, Isolation, Intent Locking.

- **SQL CONCEPT** **(04 Hours)**

  Basics of SQL, DDL,DML,DCL, Structure – Creation/Alteration, Defining Constraints – Primary Key, Foreign Key, Unique, Not Null, Check, IN Operator.

- **PL-SQL CONCEPT** **(04 Hours)**

  Cursors, Stored Procedures, Stored Function, Database Triggers.

- **ADVANCED TOPICS** **(04 Hours)**

  Data security : Introduction, Discretionary Access Control, Mandatory Access Control, Data Encryption, Semi Structured Data and XML, Object Oriented and Object Relational DBMS, Distributed DBMS, NOSQL DBMS.

Tutorials will be based on the coverage of the above topics separately **(14 Hours)**

Practicals will be based on the coverage of the above topics separately **(28 Hours)**

(Total Contact Time: 42 Hours + 14 Hours + 28 Hours = 84 Hours)

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3. Tutorials:

1 Introduction and application of DBMS

2 Designing Relational Models, ER Models and Relational databases

3 Query solving using SQL and PL/SQL

4 Optimum query designing

5 Managing Locks for the management of Transactions and concurrent access of the database

21/7/2020

4. Practicals:

1 Implementation for Physical data storage (Sequential, Index Sequential..)

2 Practicing DDL and DML Queries for database creation and managing the data

3 Develop a Database system for the real life application scenario by managing the storage constrains

4 Practicing PL/SQL with the designed databases

5 Design considering Transaction management and concurrency control

6 Design of ER model based example

7 Design of Relational model based example

8 Design of Normalized form of database

5. Books Recommended:

1. A. Silberschatz, H. F. Korth, and S. Sudarshan, Database System Concepts, 6th Edition, TMH, 2010.
2. McFadden, F. Hoffer and M. B. Prescott, Modern Database Management, 8th Edition, Benjamin/Cummings Inc, 2006.
3. C. J. Date, An Introduction to Database Systems, 8th Edition, Addison Wesley, 2003.
4. Raghu Ramakrishnan and Gehrke, Database Management System, 3rd Edition, WCB/McGraw-Hill, 2003.
5. Margaret H. Dunham, Data Mining: Introductory and Advanced Topics, Pearson Education, 2003.

21/7/2022

B.Tech. II (CSE) Semester – IV
DESIGN AND ANALYSIS OF ALGORITHMS (CORE-7)
CS206

	L	T	P	Credit
Scheme	3	1	2	05

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1. Course Outcomes (COs): **At the end of course, students will be able to**	
CO1	acquire knowledge about the application of mathematical formula and technique to solve the problem and computational complexity analysis.
CO2	apply the different algorithm design techniques for designing a solution of different applications.
CO3	analyse the performance of algorithms using different algorithmic design techniques based on asymptotic or amortized or probabilistic methods.
CO4	evaluate the correctness and implementation of algorithms using different methods of performance evaluation.
CO5	design and innovate efficient algorithms in the field of computer science & engineering and industry related applications using the different algorithm design techniques.

2. Syllabus

- **INTRODUCTION** **(04 Hours)**

  Introduction to Algorithms, Analysis and Design Techniques, Analysis Techniques: Mathematical, Empirical and Asymptotic Analysis. Recurrence Relations and Solving Recurrences, Mathematical Proof Techniques, Amortized Analysis, Probabilistic Analysis.

- **DIVIDE AND CONQUER APPROACH** **(06 Hours)**

  Sorting & Order Statistics, Divide and Conquer Technique, Various Comparison based Sorts, Analysis of the Worst-Case and the Best-Cases, Randomized Sorting Algorithms, Lower Bound on Sorting, Non-comparison based Sorts, Medians and Order Statistics, Min-Max Problem, Polynomial Multiplication, Fast Fourier Transform.

- **GREEDY DESIGN TECHNIQUES** **(08 Hours)**

  Basic Greedy Control Abstraction, Motivation, Thirsty Baby Problem, Formalization, Activity Selection and its Variants, Huffman Coding, Horn Formulas, Tape Storage Problem, Container Loading Problem, Knapsack Problem, Graph Algorithms, Graph algorithms: All-pairs Shortest Paths, Topological Ordering of DAG, DFS in Directed Graphs, Strongly Connected Components, Minimum Spanning Trees, Single Source Shortest Paths, Maximum Bipartite Cover Problem, Network Flows: Ford Fulkerson Algorithm, Max-flow Min-cut Theorem, Polynomial Time Algorithms for Max-flow.

- **DYNAMIC PROGRAMMING** **(08 Hours)**

21/1/23

Motivation, Matrix Multiplication Problem, Assembly Line Problem, Coin Changing Problem, Longest Common Subsequence, 0/1 Knapsack problem, All-pairs Shortest Path Problems, Dynamic Programming Control Abstraction, Optimal Binary Search Tree.

- **SEARCHING ALGORITHMS** **(04 Hours)**

  Backtracking, N-Queens Problem, Sum of Subset Problem, Complexity Analysis, Branch & Bound, Least Cost Branch & Bound (LCBB), LCBB Complexity Analysis, 15-Puzzle Problem, Traveling Sales Person Problem.

- **NUMBER THEORETIC ALGORITHMS** **(06 Hours)**

  Number Theoretic Notions, GCD, Modular Arithmetic, Chinese Remainder Theorem, Generators, Cyclic Groups, Galois Fields, Applications in Cryptography, Primality Testing.

- **NP-COMPLETE PROBLEMS** **(06 Hours)**

  Polynomial Time, Verification, NP-completeness, Search Problems, Reductions, Dealing with NP-Completeness, Approximation Algorithms, Local Search Heuristics.

Tutorials will be based on the coverage of the above topics. **(14 Hours)**

Practicals will be based on the coverage of the above topics. **(28 Hours)**

(Total Contact Time: 42 Hours + 14 Hours + 28 Hours = 84 Hours)

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3. Practicals:

1 Practical based on time analysis of sorting algorithms.
2 Practical based on divide and conquer technique.
3 Practical based on greedy design technique.
4 Practical based on dynamic programming.
5 Practical based on searching algorithms.
6 Practical based on back tracking technique.
7 Practical based on Graph based algorithms.
8 Practical based on branch and bound technique.

4. Books Recommended:

1. Cormen, Leiserson, Rivest and Stein, Introduction to Algorithms, 3rd Edition, MIT Press, 2009.
2. J. Kleinberg and E. Tardos, Algorithm Design, 1st Edition, Pearson Education, Reprint 2006.

21/9/2024

3. Sartaj Sahni, Data Structures: Algorithms and Applications in C++, 2nd Edition, Universities Press/Orient Longman, 2005.
4. Sara Baase and Allen van Gelder, Computer Algorithms: Introduction to Design and Analysis, 3rd Edition, Pearson Education, 2000.
5. Donald E. Knuth, The Art of Computer Programming, Vol I & III, 3rd Edition, Pearson Education, 1997.

21/9/23

B.Tech. II (CSE) Semester – IV
AUTOMATA AND FORMAL LANGUAGES (CORE-8)
CS208

	L	T	P	Credit
Scheme	3	1	0	04

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1. **Course Outcomes (COs):** **At the end of the course, the students will be able to**	
CO1	acquire knowledge of the basis of theory of computation, different computational problems and the importance of automata as a modelling tool of computational problems.
CO2	to apply rigorously formal mathematical methods to prove properties of languages, grammars and automata.
CO3	analyse the solutions for different problems and argue formally about correctness on different restricted machine models of computation.
CO4	evaluate and Identify limitations of computational models and possible methods of proving them.
CO5	design the solution in the forms of different types of machine with correctness proof and able to develop different system software.

2. Syllabus

- **INTRODUCTION** **(05 Hours)**

  Basic Mathematical Objects: Sets, Logic, Functions, Relations, Strings, Alphabets, Languages; Mathematical Induction: Inductive Proofs, Principles, Recursive Definitions, Set Notation.

- **FINITE AUTOMATA AND REGULAR EXPRESSIONS** **(12 Hours)**

  Finite State Systems, Deterministic Finite Automata; Nondeterministic Finite Automata, Nondeterministic Finite Automata with Epsilon, Applications, Kleene' Theorem; Two-way Finite Automata, Finite Automata with Output, Regular Languages & Regular Expressions, Properties of Regular Sets: The Pumping Lemma for Regular Sets, Closure Properties, Decision Properties of Regular Languages, Equivalence and Minimization of Automata, Moore and Mealy Machines.

- **CONTEXT FREE GRAMMARS** **(14 Hours)**

  Definition, Derivation Trees & Ambiguity, Inherent Ambiguity, Parse Tree, Application of CFG, Simplification of CFG, Normal Form of CFG, Chomsky Normal Form and Chomsky Hierarchy, Unrestricted Grammars, Context-Sensitive Languages, Relations between Classes of Languages, Properties of Context Free Languages: The Pumping Lemma, Closure Properties, Decision Properties of CFL.

- **PUSHDOWN AUTOMATA** **(05 Hours)**

  Definitions, Languages of PDA, Equivalence of PDA and CFG , Deterministic PDA.

21/7/2020

- **TURING MACHINES** **(06 Hours)**

  Turing Machine Model, Language of a Turing Machine (TM), Programming Techniques of the TM, Variations of TM, Multiple TM, One-Tape and Multi-Tape TM, Deterministic and Non deterministic TM, Universal TM, Churche Thesis, Recursively Enumerable Languages, Decidability, Reducibility, Intractable Problem Classes of Problems NP Hard, NP Complete.

  Tutorials will be based on the coverage of the above topics. **(14 Hours)**

(Total Contact Time: 42 Hours + 14 Hours = 56 Hours)

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3. Tutorials:

1 Problem statements based on Regular Language and Finite Automata.

2 Questions based on Context Free Grammar.

3 Problems regarding Push Down Automata.

4 Solving Problems for Turing Machine.

5 Decidable and Undecidable Problems.

4. Books Recommended:

1. Michael Sipser, Introduction to the Theory of Computation, 3rd Edition, Cengage Learning, 2013.
2. John C. Martin, Introduction to Languages and the Theory of Computation, 3rd Edition, Tata McGraw-Hill, 2011.
3. John E. Hopcroft, Rajeev Motwani and Jeffrey Ullman, Introduction to Automata Theory, Languages Computation, 3rd Edition, Pearson India, 2008.
4. Daniel I. A. Cohen, Introduction to Computer Theory, 2nd Edition, John Wiley, Reprint 2008.
5. Andrew Ilachinski, Cellular Automata, 1st Edition, World Scientific, 2001.

ADDITIONAL REFERENCE BOOKS

1. Sushil Kumar Azad, Theory of Computation, An introduction to Automata, Formal Languages And Computability, Dhanpat Ray & Co., New Delhi, 2005.
2. A. M. Natarajan and A. Tamilarasi, Theory of Computation, 1st Edition, New Age Publication, 2003.

21|9|2020

B.Tech. III (CSE) Semester – V
OPERATING SYSTEMS (CORE-9)
CS301

	L	T	P	Credit
Scheme	3	1	2	05

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1. Course Outcomes (COs): **At the end of course, students will be able to**	
CO1	explain the significance of operating system in computing devices, exemplify the communication between application programs and hardware devices through system calls.
CO2	compare and illustrate various process scheduling algorithms.
CO3	apply appropriate memory and file management schemes.
CO4	illustrate various disk scheduling algorithms.
CO5	design access control and protection based modules for an operating system.

2. Syllabus

- **OPERATING SYSTEM OVERVIEW** **(03 Hours)**

  Operating System(OS) Objectives, Evolution, Types, Major Achievements, Modern Operating Systems, Virtual Machines, OS Design Considerations for Multiprocessor and Multicore.

- **PROCESSES AND THREADS** **(05 Hours)**

  Process Concept, Process States, Process Description, Process Control Block, PCB as a Data Structure in Contemporary Operating Systems, Process Hierarchy, Processes vs Threads, Types of Threads, Multicore and Multithreading, Case Study: Linux & Windows Process and Thread Management and its Related System Calls.

- **CONCURRENCY: MUTUAL EXCLUSION AND SYNCHRONIZATION** **(04 Hours)**

  Principles of Concurrency, Mutual Exclusion, Semaphores, Monitors, Message Passing, Readers/Writers Problem.

- **CONCURRENCY: DEADLOCK AND STARVATION** **(04 Hours)**

  Principles of Deadlock, Deadlock Prevention, Deadlock Avoidance, Deadlock Detection, Dining Philosopher's Problem, Case Study: Linux & Windows Concurrency Mechanism.

- **SCHEDULING** **(08 Hours)**

  Uniprocessor Scheduling: Long Term Scheduling, Medium Term Scheduling, Short Term Scheduling, Scheduling Algorithms: Short Term Scheduling Criteria, Use of Priorities, Alternative Scheduling Policies, Performance Comparison, Fair-Share Scheduling. Multiprocessor Scheduling:

21/7/2020

Granularity, Design Issue, Process Scheduling, Thread Scheduling, Real-Time Scheduling: Characteristics of RTOS, Real-Time Scheduling, Deadline Scheduling, Rate Monotonic Scheduling, Priority Inversion. Case Study: Linux & Windows Scheduling.

- **MEMORY MANAGEMENT** **(05 Hours)**

  Memory Hierarchy, Static and Dynamic Memory Allocation, Overview of Swapping, Multiple Partitions, Contiguous and Non-Contiguous Memory Allocation, Concepts of Simple Paging, Simple Segmentation.

- **VIRTUAL MEMORY** **(05 Hours)**

  Virtual Memory Concepts, Paging and Segmentation using Virtual Memory, Protection and Sharing, Fetch Policy, Placement Policy, Replacement Policy, Resident Set Management, Cleaning Policy, Load Control, Case Study: Linux & Windows Memory Management.

- **I/O MANAGEMENT AND DISK SCHEDULING** **(04 Hours)**

  I/O Device, Organisation of the I/O Function, Operating System Design Issue, I/O Buffering, Disk Scheduling, RAID, Disk Cache, Case Study: Linux & Windows I/O.

- **FILE MANAGEMENT** **(04 Hours)**

  Overview of : Files & File Systems, File Structure, File Management Systems, File Organisation and Access, B-tree, File Directories, File Sharing, Record Blocking, Secondary Storage Management, File System Security, Case Study: Linux & Windows File System.

Tutorials will be based on the coverage of the above topics separately. **(14 Hours)**

Practicals will be based on the coverage of the above topics separately **(28 Hours)**

(Total Contact Time: 42 Hours + 14 Hours + 28 Hours= 84 Hours)

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3. Tutorials:

1 Assignment based on Process scheduling algorithm.

2 Questions based on Page replacement algorithm.

3 Assignment based on Banker's algorithm.

4 Assignment based on Semaphores and monitors.

5. Practicals:

1 Introduction to Basic and Advance commands of Linux.

2 Introduction to Shell Script and programs based on it.

3 Practical based on different Memory management scheme.

21/7/22

4 Practical based on different Process scheduling algorithm.

5 Practical based on different Disk scheduling algorithm.

6 Process synchronization and deadlock.

7 Practical based on file management system.

8 Practical based on input output device management.

6. Books Recommended:

1. Silberschatz, Galvin and Gagne, Operating System Concepts, 10th Edition, John Wiley & Sons, 2018.
2. W. Stallings, Operating Systems: Internals and Design Principles, 9th Edition, Pearson Pub., 2017.
3. W. Richard Stevens and Stephen A. Rago, Advanced Programming in the UNIX Environment, 3rd Edition, Addison Wesley Professional, 2013.
4. Kernighan and Pike, UNIX Programming Environment, 2nd Edition, PHI, 2001.
5. A. Tanenbaum and A. Woodhull, Operating Systems - Design and Implementation, 3rd Edition, PHI EEE, 2006.

ADDITIONAL REFERENCE BOOKS

1. Crawley, Operating Systems - A Design Oriented Approach, 1st Edition, McGraw Hill, 1998.

B.Tech. III (CSE) Semester – V
COMPUTER NETWORKS (CORE - 10)
CS303

	L	T	P	Credit
Scheme	3	1	2	05

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1. Course Outcomes (COs): **At the end of the course, the students will be able to**	
CO1	describe computer network models and services offered at different layers of network protocol stack.
CO2	apply knowledge of data communication, data transmission techniques using various transmission media to deliver error free data and communicate with multiple nodes.
CO3	analyse various routing methods to identify effective routing protocols.
CO4	evaluate network performance by means of transport and flow control protocols, Congestion Control protocols and Quality of services.
CO5	create a computer network application using modern network tools and simulation softwares.

2. Syllabus

- **INTRODUCTION** **(06 Hours)**

  Overview of Computer Networks and Data Communication, Computer Networking Protocols and Standards, Types of Computer Networks, Network Topology, Protocol Hierarchies and Design Issues, Interfaces and Services, Networking Devices, OSI and TCP/IP Reference Models.

- **PHYSICAL LAYER** **(06 Hours)**

  Physical Layer Design Issues, Data Transmission Techniques, Multiplexing, Transmission Media, Asynchronous Communication, Wireless Transmission, ISDN, ATM, Cellular Radio, Switching Techniques and Issues.

- **LOGICAL LINK CONTROL LAYER** **(06 Hours)**

  LLC Design Issues, Framing, Error and Flow Control, Framing Techniques, Error Control Methods, Flow Control Methods, PPP and HDLC.

- **MEDIUM ACCESS CONTROL LAYER** **(06 Hours)**

  MAC Layer Design Issues, Channel Allocation Methods, Multiple Access Protocols - ALOHA, CSMA, CSMA/CD Protocols, Collision Free Protocols, Limited Contention Protocols, LAN Architectures, IEEE

-802 Standards, Ethernet(CSMA/CD), Token Bus, Token Ring, DQDB, FDDI, Bridges and Recent Developments.

- **NETWORK LAYER** **(06 Hours)**

  Network Layer Design Issues, Routing Algorithms and Protocols, Congestion Control Algorithms and QoS, Internetworking, Addressing, N/W Layer Protocols and Recent Developments.

- **TRANSPORT LAYER** **(06 Hours)**

  Transport Layer Design Issues, Transport Services, Sockets, Addressing, Connection Establishment, Connection Release, Flow Control and Buffering, Multiplexing, Transport Layer Protocols, Real Time Transport Protocol (RTP), Stream Control Transmission Protocol (SCTP), Congestion Control, QoS and Recent Developments, Virtualization, Network Functions Virtualization(NFV), Software Defined Networks.

- **APPLICATION LAYER** **(06 Hours)**

  Client Server Model, Domain Name System (DNS), Hyper Text Transfer Protocol (HTTP), Email: SMTP, MIME, POP3, Webmail, FTP, TELNET, Dynamic Host Control Protocol (DHCP), Simple Network Management Protocol (SNMP) and Recent Developments.

Tutorials will be based on the coverage of the above topics separately **(14 Hours)**

Practicals will be based on the coverage of the above topics separately **(28 Hours)**

(Total Contact Time: 42 Hours + 14 Hours + 28 Hours= 84 Hours)

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3. Practicals:

1 Study network configuration commands and computer network setup.
2 Implementation of different Data Link and MAC Layer protocols.
3 Implementation of different Network Layer protocols.
4 Implementation of different Transport and Application Layer protocols.
5 Design and configure a network systems using modern network simulator softwares.
6 Implementation of Secured Socket Layer protocol.
7 Implementation of ICMP based message transmission over network.
8 Implementation of SMTP protocol for mail transfer.

4. Tutorials:

1 Problem solving on basics of data communication and networking.

21/12/2020

2 Problem solving on framing, error control and flow control of Data link layer.
3 Problem solving on various LAN standards.
4 Problem solving on logical address, sub net masking and routing protocols of Network Layer.
5 Problem solving on congestion control, flow control and error control of transport layer.
6 Problem solving on various services provided by application layer.

5. Books Recommended:

1. William Stalling, Data and Computer Communication, 10th Edition, Pearson India, 2017.
2. B. Forouzan, Data Communication and Networking, 5th Edition, McGraw Hill, 2017.
3. Douglas E. Comer, Internetworking with TCP/IP Volume – I, 6th Edition, Pearson India, 2015.
4. Andrew S. Tanenbaum, Computer Network, 5th Edition, Pearson India, 2013.
5. W. Richard Stevens, TCP/IP Illustrated Volume - I, 2nd Edition, Addison Wesley, 2011.

21/7/2020

B.Tech. III (CSE) Semester – V
PROFESSIONAL ETHICS, ECONOMICS AND BUSINESS MANAGEMENT
HU303

	L	T	P	Credit
Scheme	4	0	0	04

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1. Course Outcomes (COs): **At the end of the course, the students will be able to**	
CO1	identify application of ethics in society and development of understanding regarding Professional ethical issues related to Computer Science and Engineering.
CO2	develop managerial skills to become future engineering managers.
CO3	develop skills related to various functional areas of management (Marketing Management, Financial Management, Operations Management, Personnel Management etc.)
CO4	build knowledge about modern management concepts (ERP, SCM, e-CRM, etc.)
CO5	develop experiential learning through Management games, Case study discussion, Group discussion etc.
CO6	apply knowledge of Economics and Business management aspects in Computer Science and Engineering.

2. Syllabus

- **PROFESSIONAL ETHICS** **(14 Hours)**

  Introduction, Approaches to Ethics, Meaning of Ethics, Major attributes of Ethics, Business Ethics, Factors influencing Ethics, Importance of Ethics, Ethics in Management, Organizational Ethics, Ethical aspects in Marketing, Mass communication and Ethics - Television, Whistle blowing, Education – Ethics and New Professional, Intellectual Properties and Ethics, Introduction to Professional Ethics, Engineering Ethics, Ethical issues related to Computer Science and Engineering.

- **ECONOMICS** **(08 Hours)**

  Introduction to Economics, Micro & Macro Economics, Applications & Scopes Of Economics, Demand Analysis, Demand Forecasting, Factors Of Production, Types Of Cost, Market Structures, Break Even Analysis

- **MANAGEMENT** **(12 Hours)**

  Introduction to Management, Features Of Management, Nature Of Management, Development of Management Thoughts – Scientific Management By Taylor & Contribution of Henry Fayol, Coordination & Functions Of Management, Centralization & Decentralization, Decision Making; Fundamentals of Planning; Objectives & MBO; Types of Business Organizations: Private Sector,

21/7/22

Public Sector & Joint Sector; Organizational Behaviour: Theories of Motivation, Individual & Group Behaviour, Perception, Value, Attitude, Leadership.

- **FUNCTIONAL MANAGEMENT** **(18 Hours)**

  Marketing Management: Core Concepts Of Marketing, Marketing Mix (4p), Segmentation – Targeting – Positioning, Marketing Research, Marketing Information System, Concept of International Marketing, Difference Between Domestic Marketing & International Marketing; Operations Management: Introduction to Operations Management, Types of Operation Systems, Types of Layouts, Material Handling, Purchasing & Store System, Inventory Management; Personnel Management: Roles & Functions of Personnel Manager, Recruitment, Selection, Training, Industrial Dispute, Collective Bargaining; Financial Management: Goal of Financial Management, Key Activities In Financial Management, Organization of Financial Management, Financial Institutions, Financial Instruments, Sources of Finance.

- **MODERN MANAGEMENT ASPECTS** **(04 Hours)**

  Introduction To ERP, e – CRM, SCM, RE – Engineering, WTO, IPR Etc.

(Total Contact Time: 56 Hours)

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3. Books Recommended:

1. V. Balachandran and Chandrasekaran, Corporate Governance, Ethics and Social Responsibility, 2nd Edition, PHI, 2011.
2. L. M. Prasad, Principles & Practice of Management, 8th Edition, Sultan Chand & Sons, 2015.
3. T. R. Banga and S. C. Shrama, Industrial Organisation & Engineering Economics, 25th Edition, Khanna Publishers, 2015.
4. Everett E. Adam and Ronald J. Ebert, Production and Operations Management, 5th Edition, Prentice Hall of India, 2012.
5. P. Kotler, K. L. Keller, A. Koshi and M. Jha, Marketing Management – A South Asian Perspective, 14th Edition, Pearson, 2014.

ADDITIONAL REFERENCE BOOKS

1. P. C. Tripathi, Personnel Management & Industrial Relations, 21st Edition, Sultan Chand & sons, 2013.
2. P. Chandra, Financial Management, 9th Edition, Tata McGraw Hill, 2015.
3. A. Crane and D. Matten, Business Ethics: Managing Corporate Citizenship and Sustainability in the Age of Globalisation, Oxford University, 2010.
4. D. J. Fritzsche, Business Ethics: a Global and Managerial Perspectives, McGraw Hill Irwin, Singapore, 2004.
5. S. K. Mandal, Ethics in Business and Corporate Governance, Tata McGraw Hill, 2011.

11/7/2020

B.Tech. III (CSE) Semester – V
SOFT COMPUTING (INSTITUE ELECTIVE-1)
CS361

	L	T	P	Credit
Scheme	**3**	**0**	**0**	**03**

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1. <u>Course Outcomes (COs):</u>
At the end of the course, the students will be able to

CO1	acquire knowledge about the human intelligence, artificial Intelligence and the knowledge about the soft computing approaches.
CO2	apply different soft computing techniques like fuzzy logic, genetic algorithm, neural network and bio-inspired techniques, Evolutionary approaches for problem solving.
CO3	analyse the learning methods for optimizing the solution.
CO4	evaluate performance of different soft computing techniques.
CO5	design and innovate solution for real life example using bio-inspired techniques which mimic human brain abilities.

2. Syllabus

- **INTRODUCTION** **(06 Hours)**

  Concepts of Artificial Intelligence, Need of Machine Learning, Learning Methods, Soft Computing Approach, Fuzzy Computing, Neural Computing, Genetic Algorithms, Associative Memory, Adaptive Resonance Theory, Applications.

- **NEURAL NETWORK** **(12 Hours)**

  Model of Artificial Neuron, Neural Network Architectures, Weights, Activation Functions, Learning Models, Learning Rate, Bias, McCulloch Pitts Neuron, Single Layer Neural Network, Multi Layers Neural Networks, Training Algorithms, Back Propagation Method, Supervised Learning, Unsupervised Learning, Radial Basis Functions, Auto-associative Memory, Bi-directional Hetero-associative Memory, Hopfiled Network, Kohonen Self-organizing Network, Learning Vector Quantization, Simulated Annealing Network, Boltzmann Machine, Applications.

- **FUZZY SET THEORY** **(08 Hours)**

  Fuzzy Sets, Membership, Fuzzy Operations, Properties, Fuzzy Relation, Fuzzy Systems, Fuzzy Logic, Fuzzification, Fuzzy Inference, Decision Making, Fuzzy Rule based System, De-fuzzification, Applications.

- **GENETIC ALGORITHMS** **(08 Hours)**

21/7/2023

Fundamentals of Genetic Algorithms, Chromosomes, Encoding, Selection Operator, Mutation Probability, Mutation Operator, Crossover Probability, Crossover Operator, Fitness Function, Different Variants of Genetic Algorithms, Applications.

- **NATURE INSPIRED TECHNIQUES AND HYBRID SYSTEM** **(08 Hours)**

Ant Colony, Particle Swarm Optimization, Integrating Neural Networks, Fuzzy Logic, and Genetic Algorithms, GA based Back Propagation Networks, Fuzzy Back Propagation Networks, Applications.

(Total Contact Time: 42 Hours)

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3. Books Recommended:

1. Timothy J. Ross, Fuzzy Logic with Engineering Applications, 3rd Edition, Willey, 2010.
2. B. Yagnanarayana, Artificial Neural Networks, 1st Edition, PHI, 2009.
3. Simon O. Haykin, Neural Networks and Learning Machines, 3rd Edition, Prentice Hall, 2009.
4. S. Rajasekaran and G. A. VijayalakshmiPai, Neural Networks, Fuzzy Logic and Genetic Algorithm: Synthesis and Applications, PHI, 2007.
5. David E. Goldberg, Genetic Algorithms in Search, Optimization, and Machine Learning, 1st Edition, Addison-Wesley Professional, 2006.

ADDITIONAL REFERENCE BOOKS

1. S. N. Sivanandam and S. N. Deepa, Principles of Soft Computing, Wiley India Edition, 2010.
2. F. Hoffmann, M. Koeppen, F. Klawonn and R. Roy, Soft Computing: Methodologies and Applications, Springer, 2005.
3. Rafik Aziz OglyAliev and R. R. Aliev, Soft Computing and Its Applications, World Scientific, 2001.
4. F. Martin, Mc Neill, and Ellen Thro, Fuzzy Logic: A Practical approach , AP Professional, 2000.

21|07|2020

B.Tech. III (CSE) Semester – V
INFORMATION SECURITY (INSTITUE ELECTIVE-1)
CS363

	L	T	P	Credit
Scheme	3	0	0	03

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1. Course Outcomes (COs):
At the end of the course, the students will be able to

CO1	describe the concepts related to cryptography and system security.
CO2	apply the concept of security services and mechanisms from the application developers and network administrator's perspective.
CO3	analyse the security schemes for their use in different application scenarios.
CO4	evaluate and asses the computer and network systems for associated risks.
CO5	design the security schemes depending on the organisation's requirements.

2. Syllabus

- **INTRODUCTION** **(04 Hours)**

  Security Introduction, Characteristics of Information: Availability, Accuracy, Authenticity, Confidentiality, Integrity, Utility, Possession, CIA Traid, Reference Model of Information Assurance & Security (RMIAS), Components of an Information System: Software, Hardware, Data, People, Procedures, Networks, Securing Components, Balancing Information Security and Access, Approaches to Information Security Implementation.

- **NEED FOR SECURITY** **(04 Hours)**

  Business Needs: Protecting the Functionality, Enabling Safe Operation, Protecting Data, Safeguarding Technology Assets, Threats, Attacks: Malicious Code, Backdoors, Password Crack, Brute Force, Dictionary, DoS and DDoS, Spoofing, Man-in-the-Middle, Spamming, Sniffing, Social Engineering, Buffer Overflow, Timing Attack.

- **DIGITAL WATERMARKING AND STEGANOGRAPHY** **(04 Hours)**

  Properties of Watermarking: Embedding Effectiveness, Fidelity, Data Payload, Blind or Informed Detection, False Positive Rate, Robustness, Keys etc. Properties of Steganography: Embedding, Steganographic Capacity, Embedding Capacity, Embedding Efficiency, and Data Payload, Blind or Informed Extraction, Blind or Targeted Steganalysis, Statistical Undetectability, False Alarm Rate, Robustness, Security, Stego Key, Evaluating and Testing Steganographic Systems.

- **SECURITY RISK ASSESSMENT AND MITIGATION** **(04 Hours)**

21|9|22

Vulnerability, Threat and Risk, Risk Assessment and Mitigation + Quick Fixes, Introduction to BCP / DRP / Incident Management, Segregation and Separation of Duties & Roles and Responsibilities, IT ACT 2000.

- **INTRODUCTION TO SYMMETRIC KEY CRYPTOGRAPHY AND PUBLIC KEY CRYPTOGRAPHY** **(06 Hours)**

  Traditional and Modern Symmetric Key Ciphers, Block Ciphers and Stream Cipher, Block Cipher Modes of Operations, Security Analysis, Public Key Characteristics, PKC Applications, Public Key Requirements, RSA, Diffie-Hellman Key Agreement Protocol, Security Analysis.

- **TYPES OF ASSESSMENTS FOR INFORMATION SECURITY** **(04 Hours)**

  VAPT of Networks, Web Appln Audits, IT Assessments or Audits, Assessment of Network Equipment, Assessment of Security Devices (Web Filtering, Firewalls, IDS / IPS, Routers, Data Centre Assessment, Security of Application Software, SAP Security, Desktop Security, RDBMS Security, BCP / DRP assessments, Policy Reviews, Network Security & Common and Popular Tools Used.

- **OPERATING SYSTEMS SECURITY** **(04 Hours)**

  Windows and Linux Security, Types of Audits in Windows Environment: Server Security, Active Directory (Group Policy), Anti-Virus, Mails, Malware, End Point Protection, Shadow Passwords, SUDO Users, UNIX File Access Control, Access Control Lists in UNIX, Windows Security : Access Control Scheme, Access Token, Security Descriptors, Operating Systems Hardening.

- **CURRENT TRENDS IN INFORMATION SECURITY** **(04 Hours)**

  Securing Cloud Server, Standards of Information Security: Cobit, Cadbury, ISO 27001, OSSTMM, Security Laws and Policies, Privacy Breaches, Overview of Privacy Preserving Techniques.

- **WEB APPLICATION SECURITY** **(06 Hours)**

  Web Application Security: Common Issues in Web Apps, Basic Web Security Model, Cross Side Scripting, SQL Injection, Password Vulnerabilities, Session Hijacking, Local and Remote File Inclusion, Audit Trails, HTTPS, OWASP Security Knowledge Framework, CAPTCHA, User Authentication and Session Management for Web Apps, The Security Architecture of Web Browsers.

- **ADVANCED TOPICS** **(02 Hours)**

(Total Contact Time: 42 Hours)

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3. <u>Books Recommended:</u>

21|12|2022

1. William Stallings, Cryptography and Network Security – Principles and Practice, 7th Edition, Pearson Education, 2013.
2. William Stallings, Network Security Essentials: Applications and Standards, 3rd Edition, Pearson Education, 2009.
3. Forouzan and Mukhopadhyay, Cryptography and Network Security, 3rd Edition, McGraw Hill, 2015.
4. Menezes Bernard, Network Security and Cryptography, 1st Edition, Cengage Learning India, 2010.
5. Douglas Stinson, Cryptography: Theory and Practice, 3rd Edition, CRC Press, 2006.

ADDITIONAL REFERENCE BOOKS

1. Menezes, Oorschot and Vanstone, Handbook of Applied Cryptography, CRC Press, 1996.
2. Dhiren Patel, Information Security: Theory and Practice, PHI, 2008.

21/9/2020

B.Tech. III (CSE) Semester – V
MACHINE LEARNING (INSTITUE ELECTIVE-1)
CS365

	L	T	P	Credit
Scheme	3	0	0	03

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1. Course Outcomes (COs): **At the end of the course, the students will be able to**	
CO1	acquire knowledge of pattern recognition, regression, classification, clustering algorithms and statistics.
CO2	apply different classification, regression, machine learning algorithms and modelling.
CO3	analyze the data patterns and modelling for applying the learning algorithms.
CO4	evaluate the performance of an algorithm and comparison of different learning techniques.
CO5	design solution for real life problems like biometric recognition, natural language processing and its related applications using various tools and techniques of machine learning.

2. Syllabus

- **INTRODUCTION** **(09 Hours)**

  Pattern Representation, Concept of Pattern Recognition and Classification, Feature Extraction, Feature Selection, Basics of Probability, Bayes Decision Theory, Maximum-Likelihood and Bayesian Parameter Estimation, Error Probabilities, Learning of Patterns, Modelling, Regression, Discriminant Functions, Linear Discriminant Functions, Decision Surface, Learning Theory, Fisher Discriminant Analysis.

- **SUPERVISED LEARNING ALGORITHMS** **(09 Hours)**

  Linear Regression, Gradient Descent, Support Vector Machines, Artificial Neural, Networks, Decision Trees, ML and MAP Estimates, K-Nearest Neighbor, Naive Bayes, Bayesian Networks, Classification, Overfitting, Regularization, Multilayer Networks, Back-propagation, Bayes Classification, Nearest Neighbor Classification, Cross Validation and Attribute Selection, K Means Clustering, Agglomerative Hierarchical Clustering.

- **UNSUPERVISED LEARNING ALGORITHMS** **(09 Hours)**

  K-Means Clustering, Gaussian Mixture Models, Learning with Partially Observable Data, Expectation Maximization Approach. Dimensionality Reduction, Principal Component Analysis, Model Selection and Feature Selection.

- **TRANSFORM DOMAIN PATTERN ANALYSIS** **(06 Hours)**

Signal Transformation, Frequency Domain Representation of Signal, Feature Extraction and Analysis, Multiresolution Representation, Wavelet Transform, Discrete Cosine Transform.

- **APPLICATIONS** **(09 Hours)**

  Signal Processing Application, Image Processing, Biometric Recognition, Face and Speech Recognition, Information Retrieval, Natural Language Processing.

(Total Contact Time: 42 Hours)

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3. Books Recommended:

1. Geoff Dougherty, Pattern Recognition and Classification: An Introduction, 1st Edition, Springer, 2013.
2. Theodoridis and K. Koutroumbas, Pattern Recognition, 4th Edition, Academic Press, 2009.
3. Christopher M. Bishop, Pattern Recognition and Machine Learning, 1st Edition, Springer, 2006.
4. Richard O. Duda, Peter E. Hart and David G. Stork, Pattern Classification, 2nd Edition, Wiley, 2001.
5. K. Fukunaga, Introduction to Statistical Pattern Recognition, 2nd Edition, Academic Press, 2000.

ADDITIONAL REFERENCE BOOKS

1. Ranjjan Shinghal, Pattern Recognition Techniques and Application, 1st Edition, Oxford university press, 2006.

2|7|20

B.Tech. III (CSE) Semester – V
SIGNALS AND SYSTEMS (INSTITUE ELECTIVE-1)
CS367

	L	T	P	Credit
Scheme	3	0	0	03

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1. Course Outcomes (COs): **At the end of the course, the students will be able to**	
CO1	acquire knowledge about basics signals and their classification, different types of systems, the process of sampling.
CO2	apply the Laplace transform and Z – transform for analysis of continuous-time and discrete-time signals and systems and designing the filters.
CO3	analyze system properties based on impulse response and Fourier analysis for different applications.
CO4	evaluate the laplace transform, fourier transform and Z-transform, system performance, filter performance etc.
CO5	design and innovate a solution using the knowledge about various filter design and signal processing concepts.

2. Syllabus

- **INTRODUCTION TO SIGNALS** **(06 Hours)**

  Signal Classification: Analog vs. Digital Signal, Energy, Power, Even-odd, Periodic-aperiodic, Deterministic-random Signals, Standard Signals: Unit Step, Unit Impulse, Ramp, Exponential, Sinusoids, Continuous-time Signals and Discrete Signals and their Properties, Discrete Exponential Functions and their Properties, Discrete Unit Step and Impulse Signals and their Properties.

- **INTRODUCTION TO SYSTEMS** **(08 Hours)**

  System Classifications, Analog-digital Systems, Continuous-discrete Time Systems, Linearity, Time Invariance, Memory, Linear-time-invariant Systems, Causality, System Stability, System Response: Impulse Response, Unit Step Response, Convolution.

- **SIGNAL TRANSFORMS AND SAMPLING** **(08 Hours)**

  Laplace Transform, Fourier Series and Fourier Transform, Digital Sequences, Linear Difference Equations with Constant Coefficients, Realizations, Frequency-domain Representation of Discrete-time Signals and Systems, Sampling of Continuous-time Signals: Periodic Sampling, Frequency-Domain Representation of Sampling, Reconstruction of a Band-limited Signal, Changing the Sampling Rate Using Discrete-time Processing, Quantization, Aliasing, Interpolation, Decimation.

- **Z-TRANSFORM** **(04 Hours)**

21|7|22

Properties of the Z-transform, Transfer Function Representation, Inverse Z-transform, Z-transform Applied to Difference Equations, The Complex Convolution Theorem, Stability of Discrete-time Systems, Frequency Response of Discrete-time Systems.

- **DISCRETE FOURIER TRANSFORM** **(04 Hours)**

  Discrete-Time Fourier Transform (DTFT), The Discrete Fourier Series, The Fourier Transform of Periodic Signals, Discrete Fourier Transform (DFT), Properties of the DFT, System Analysis via the DTFT and DFT, Circular Convolution, Linear Convolution Using the DFT, Implementation of the DFT Using Convolution

- **FAST FOURIER TRANSFORM (FFT) ALGORITHMS** **(04 Hours)**

  Decimation in Time FFT, Introduction to Radix-2 FFTs, Some Properties of Radix-2 Decimation in Time FFT, Decimation in Frequency Algorithm, Computing the Inverse DFT by Doing a Direct DFT.

- **FILTERS AND ADVANCED SIGNAL PROCESSING** **(08 Hours)**

  Multirate Signal Processing, Finite Impulse Response (FIR) and Infinite Impulse Response (IIR) Filter Design, Power Spectral Density, Applications of Digital Signal Processing.

(Total Contact Time: 42 Hours)

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3. <u>Books Recommended:</u>

1. Alan V. Oppenheim and Alan S. Willsky, Signals and Systems, 2nd Edition, Pearson Education, 2014.
2. Vinay K. Ingle and John G. Proakis, Digital Signal Processing using MATLAB, 2nd Edition, Companion Series 2000.
3. Johnny Johnson, Introduction to Digital Signal Processing, PHI, New Delhi, 1997.
4. John G. Proakis and Dimitris G. Manolakis, Digital Signal Processing: Principles, Algorithms, and Applications, 3rd Edition, PHI,1996
5. Alan W. Oppenheim and Ronald W. Schafer, Discrete-Time Signal Processing , 2nd Edition, PHI, New Delhi, 1992.

21/7/2020

B.Tech. III (CSE) Semester – V
LOGIC AND FUNCTIONAL PROGRAMMING
(INSTITUTE ELECTIVE-1)
CS369

	L	T	P	Credit
Scheme	3	0	0	03

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1. Course Outcomes (COs):	
At the end of the course, the students will be able to	
CO1	explain the concepts and terms used to describe languages that support the imperative, functional, object-oriented, and logic programming paradigms.
CO2	solve complex problems using logic as well as functional programming.
CO3	explain on a simple problem how logic programming differs from functional programming.
CO4	critically evaluate what approach and language is best suited for an upcoming problem.
CO5	implement/design wide range of algorithms and data structures as correct, elegant and efficient functional programs.

2. Syllabus

- **LOGIC** **(03 Hours)**

  Propositional Logic and Predicate Logic, Converse and Contrapositive, Reasoning with Propositions, Natural Deduction – Rules, Provable Equivalence, Semantics, Logical Connectives, Soundness and Completeness of Propositional Logic, Normal Forms, Identities of Propositions and Dual, Use of Identities, Reasoning with Propositions, Semantic Equivalence, Satisfiability and Validity, Conjunctive Normal Forms.

- **PREDICATE LOGIC** **(03 Hours)**

  Terms, Formulas - Well Formed Formula (WFF) of Predicate Logic, Constructing Formulas; Free and Bound Variables, Reasoning with Predicate Logic, Deduction Rules, Quantifier, Semantics, Un-Decidability of Predicate Logic, Expressiveness, Second-Order Logic.

- **VERIFICATION** **(03 Hours)**

  Linear-Time Temporal (LTL) Logic, Syntax and Semantics, Model Checking: Systems, Tools, Properties, Branching-Time Temporal Logic – Syntax and Semantics of CTL, Model-Checking Algorithms. Program Verification: Partial and Total Correctness, Proof Calculus, Modal Logic – Syntax and Semantics, Binary Decision Diagrams.

- **THE LAMBDA CALCULAS** **(04 Hours)**

  The Syntax of the Lambda Calculus, Lambda Abstractions, Operational Semantics of the Lambda Calculus, Bound and Free Variables, Recursive Functions, The Denotational Semantics of the Lambda

21/7/2020

Calculus, Defining the Semantics of Built-In Functions and Constants, Strictness and Laziness, The Correctness of the Conversion Rules.

- **TRANSLATING A HIGH-LEVEL FUNCTIONAL LANGUAGE INTO THE LAMBDA CALCULUS** **(02 Hours)**

Structure of the Translation Process, Translating Miranda Into the Enriched Lambda Calculus, The TE Translation Scheme.

- **STRUCTURED TYPES AND THE SEMANTICS OP PATTERN-MATCHING** **(03 Hours)**

Introduction to Structured Types, Introduction to Pattern-Matching, Introducing Pattern-Matching Lambda Abstractions, The Semantics of Pattern-Matching Lambda Abstractions: Variable Patterns, Constant Patterns, Sum-Constructor Patterns, Product-Constructor Patterns.

- **EFFICIENT COMPILATION OF PATTERN-MATCHING** **(02 Hours)**

The Pattern-Matching Compiler Algorithm: Function Match, Variable Rule, Constructor Rule, Empty Rule, Example.

- **TRANSFORMING THE ENRICHED LAMBDA CALCULUS** **(05 Hours)**

Transforming Pattern–Matching Lambda Abstractions: Constant Patterns, Product-Constructor Patterns, Sum-Constructor Patterns, Dependency Analysis, Transforming Case-Expressions: Case-Expressions Involving a Product Type, Case-Expressions Involving a Sum Type.

- **LIST COMPREHENSIONS** **(02 Hours)**

Introduction to List Comprehensions, Reduction Rules for List Comprehensions, Translating List Comprehensions.

- **POLYMORPHIC TYPE-CHECKING** **(02 Hours)**

Informal Notation for Types: Types, Lists, Structured Types, Functions, Polymorphism: The Identity Function, Rule for Applications, Lambda Abstractions, and Let-Expressions.

- **TYPE-CHECKER** **(02 Hours)**

Representation of Programs, Representation of Type Expressions, Solving Equations, Keeping Track of Types, The Type-Checker.

- **PROGRAM REPRESENTATION** **(03 Hours)**

Abstract Syntax Trees, The Graph, Concrete Representation of the Graph, Tags and Type-Checking, Boxed and Unboxed Objects, Tagged Pointers, Storage Management, Garbage Collection, Data Constructors, Input and Output, Evaluating Arguments of Built-In Functions.

- **GRAPH REDUCTION OF LAMBDA EXPRESSIONS** **(03 Hours)**

21/7/2023

Reducing a Lambda Application: Substituting Pointers to the Argument, Overwriting The Roots of the Redex, Constructing a New Instance of the Lambda Body. Reducing a Built-In Function Application, Reduction Algorithm, Indirection Nodes.

- **SUPERCOMBINATORS AND LAMBDA-LIFTING** **(03 Hours)**

  Solving Problems of Free Variables, Transforming Lambda Abstractions Into Supercombinators: Eliminating Redundant Parameters, Parameter Ordering, Recursive Supercombinators: Notation, Generating Supercombinators with Graphical Bodies, Compile-Time Simplifications.

- **FULLY-LAZY LAMBDA-LIFTING** **(02 Hours)**

  Full Laziness, Maximal Free Expressions, Lambda-Lifting Using Maximal Free Expressions.

(Total Contact Time: 42 Hours)

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3. Books Recommended:

1. Greg Michaelson, An Introduction to Functional Programming Through Lambda Calculus, Dover Publications, 2011.
2. Michael Huth and Mark Ryan, Logic in Computer Science: Modelling and Reasoning about Systems, Cambridge University Press, 2004.
3. Anthony J. Field and Peter Harrison, Functional Programming, Addison Wesley Publishing Company, 2000.
4. Richard S. Bird and Philip Wadler, Introduction to Functional Programming, Prentice Hall, 1998.
5. Simon L. Peyton Jones, The Implementation of Functional Programming Languages , Prentice Hall International, 1987.

ADDITIONAL REFERENCE BOOKS

1. George Metakides and Anil Nerode, Principles of Logic and Logic Programming, Elsevier Science Ltd., 1996.
2. Kees Doets, From Logic to Logic Programming, MIT Press, 1994.

21|7|2020

B.Tech. III (CSE) Semester – V
DATA SCIENCE (CORE ELECTIVE-1)
CS321

	L	T	P	Credit
Scheme	3	0	0	03

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1. Course Outcomes (COs):
At end of the Course student will be able to

CO1	describe types of data and various data science approaches.
CO2	apply various data pre-processing and manipulation techniques including various distributed analysis paradigm using hadoop and other tools and perform advance statistical analysis to solve complex and large dataset problems.
CO3	analyse different large data like text data, stream data, graph data.
CO4	interpret and evaluate various large datasets by applying Data Mining techniques like clustering, filtering, factorization.
CO5	design the solution for the real life applications.

2. Syllabus

- **INTRODUCTION** **(02 HOURS)**

  Examples, Applications and Results Obtained Using Data Science Techniques, Overview of the Data Science Process.

- **MANAGING LARGESCALE DATA** **(02 HOURS)**

  Types of Data and Data Representations, Acquire Data (E.G., Crawling), Process and Parse Data, Data Manipulation, Data Wrangling and Data Cleaning.

- **PARADIGMS FOR DATA MANIPULATION, LARGE SCALE DATA SET** **(08 HOURS)**

  Mapreduce (Hadoop), Query Large Data Sets in Near Real Time with Pig and Hive, Moving from Traditional Warehouses to Map Reduce, Distributed Databases, Distributed Hash Tables.

- **TEXT ANALYSIS** **(10 HOURS)**

  Data Flattening, Filtering and Chunking, Feature Scaling, Dimensionality Reduction, Nonlinear Factorization, Shingling of Documents, Locality Sensitive Hashing for Documents, Distance Measures, LSH Families for Other Distance Measures, Collaborative Filtering.

- **MINING DATA STREAM** **(08 HOURS)**

  Sampling Data in a Stream, Filtering Streams, Counting Distinct Elements in a Stream, Moments, Windows, Clustering for Streams.

21/7/2020

- **ADVANCE DATA ANALYSIS** **(12 HOURS)**

  Graph Visualization, Data Summaries, Hypothesis Testing, ML Model-Checking and Comparison, Link Analysis, Mining of Graph, Frequent Item Sets Analysis, High Dimensional Clustering, Hierarchical Clustering, Recommendation Systems.

Total Contact Time: 42 Hours

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3. Books Recommended:

1. Tom White, Hadoop: The Definitive Guide, 4th Edition, O'reilly Media, 2015, ISBN: 9781491901687.
2. Anand Rajaraman and Jeffrey David Ullman, Mining of Massive Datasets, 2nd Edition, Cambridge University Press, 2014, ISBN: 9781107077232.
3. Peter Bruce and Andrew Bruce, Practical Statistics for Data Scientists: 50 Essential Concepts, 1st Edition, O'reilly Publishing House, 2017, ISBN: 9781491952962.
4. Joel Grus, Data Science From Scratch, 1st Edition, O'Reilly Media, 2015, ISBN: 9781491901410.
5. Montgomery, C. Douglas and George C. Runger, Applied Statistics And Probability For Engineers, 7th Edition, John Wiley & Sons, 2018, ISBN: 9781119400363.

2|7|2020

B.Tech. III (CSE) Semester – V
ADVANCED MICROPROCESSOR (CORE ELECTIVE-1)
CS323

	L	T	P	Credit
Scheme	3	0	0	03

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1. Course Outcomes (COs):
At the end of the course, the students will be able to

CO1	describe different modes of operations of a typical microprocessor.
CO2	design and develop 80x86 assembly language programs using software interrupts and various assembler directives.
CO3	develop Interface microprocessors with various external devices.
CO4	analyse and compare the features of 80x86 microprocessors, Multicore architecture, ARM processors and microcontrollers.
CO5	design and develop assembly language programs using 8051 microcontroller.

2. Syllabus

- **ARCHITECTURAL FEATURES OF 16/32/64 MICROPROCESSORS** **(06 Hours)**

  Internal Architecture, Register Organization (General-Purpose Register, Segment Register, Status and Control Register, Instruction Pointer, Segment Descriptor Cache Register, System Address Registers LDTR, GDTR, Debug Register, Test Registers, Control Registers. Addressing Modes , Real, PVAM, Paging, Address Translation in Real, PVAM, Paging, Enabling and Disabling Paging (Machine Status Word), Salient Features of 32/64 System Architecture, Superscalar Execution, Separate Code & Data Cache, Floating Point Exceptions, Branch Prediction, Intel MMX Architecture.

- **MICROCONTROLLER** **(06 Hours)**

  Overview of Micro Controllers-8051 Family Microcontrollers, Instruction Set, Pin Out, Memory Interfacing.

- **ARM PROCESSOR FUNDAMENTALS** **(07 Hours)**

  Registers, Current Program Status Registers, Pipeline Exceptions, Interrupts and Vector Table, Architecture Revisions, ARM Processor Families, ARM Instruction Set, Thumb Instruction Set-Exceptions Handing, Interrupts, Interrupt Handling Schemes, Firmware, Embedded Operating Systems, Caches-Cache Architecture, Cache Policy, DSP on the ARM7TDMI, ARM9TDMI.

- **ADVANCED INTEL PROCESSORS** **(06 Hours)**

  Architecture and Programming Including Xeon and Others, Dual Processors, DSP Processors, Various Peripherals and Interfacing Including Memory and I/O.

21/8/2020

- **INTRODUCTION TO MULTICORE PROCESSORS** **(05 Hours)**

  Hyper Threading Technology, Define Core, Limitations of Single Core Processor, Concept of Multi Core Processing and Its Advantages, Homogeneous and Heterogeneous Multicore Processors, Single Core and Multicore Processors Comparison, Major Issues in Multicore Processing, Internal Architecture of Intel Core2 Duo, Important Technological Features of IA Processors, Comparison of Core I3, I5 and I7 Processors.

- **INTERFACE C/C++ WITH ASSEMBLY LANGUAGE** **(06 Hours)**

  C and Assembly, Inline Assembly, Linked Assembly, Calling Conventions.

- **I/O BUSES, PARALLEL & SERIAL PORTS, USB** **(03 Hours)**

  Bus Characteristics, Bus Design Considerations, Bus Communications, Bus Standards, Bus Details.

- **CHIPSET, MOTHERBOARD AND CURRENT TRENDS OF PC** **(03 Hours)**

  Chipset Architecture, North/South Bridge Architecture, Hub Architecture, Case Study of Intel Chipsets.

(Total Contact Time: 42 Hours)

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3. Books Recommended:

1. Douglas V Hall, Microprocessors and Interfacing: Programming & Hardware, 3rd Edition, TMH, 2013.
2. Barry B. Brey, The Intel Microprocessors: 8086/8088, 80186/80188, 80286, 80386, 80486, Pentium, Pentium Pro Processor, Pentium II, Pentium III, Pentium 4, and Core2 with 64-bit Extensions, 8th Edition, 2008.
3. Mohamed Ali Mazidi, Janice Gillispie Mazidi and Rolin McKinlay, The 8051 Microcontroller and Embedded Systems: Using Assembly and C, 2nd Edition, Pearson Education, 2011.
4. James L. Antonakos, An Introduction to the Intel Family of Microprocessors, 3rd Edition, Pearson Education, Reprint 2001.
5. Shameem Akhter and Jason Roberts, Multi-Core Programming: Increasing Performance through Software Multi-Threading, Intel Press, 2006.

ADDITIONAL REFERENCE BOOKS

1. Maurice Herlihy and NirShavit, The Art of Multiprocessor Programming, Revised 1st Edition, Elsevier Publication, 2012.

B.Tech. III (CSE) Semester – V
PARALLEL PROCESSING ARCHITECTURE
(CORE ELECTIVE-1)
CS325

	L	T	P	Credit
Scheme	3	0	0	03

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1. Course Outcomes (COs): **At the end of the course, the students will be able to**	
CO1	explain implicit and explicit parallel platforms and its physical organization.
CO2	decompose given problem into many sub problems using different decomposition techniques.
CO3	use different performance metrics for analyzing parallel algorithms.
CO4	evaluate performance of various existing parallel algorithms.
CO5	develop parallel algorithms for tightly coupled and loosely coupled parallel systems for various applications.

2. Syllabus

- **INTRODUCTION** **(04 Hours)**

  Implicit Parallelism: Microprocessor Architectures, Limitations of Memory System Performance, Dichotomy of Parallel Computing Platforms, Parallel Platforms and Its Physical Organization, Routing Mechanisms for Networks, Communication Costs in Parallel Machines, Impact of Process-Processor Mapping and Mapping Techniques.

- **PARALLEL ALGORITHM DESIGN ALGORITHMS** **(06 Hours)**

  Preliminaries, Decomposition Techniques, Load Balancing in Parallel System, Mapping Techniques for Load Balancing, Tasks and Interactions, Interaction Overheads, Parallel Algorithm and its Models.

- **COMMUNICATION OPERATIONS** **(06 Hours)**

  One-To-All Broadcast and All-To-One Reduction, All-To-All Broadcast and Reduction, All-Reduce and Prefix-Sum Operations, Scatter and Gather, All-To-All Personalized Communication, Circular Shift, Improving the Speed of Some Communication Operations.

- **ANALYTICAL MODELING** **(06 Hours)**

  Sources of Overhead in Parallel Programs, Performance Metrics, Effect of Granularity and Data Mapping on Performance, Scalability, Minimum Execution Time and Minimum Cost-Optimal Execution Time, Asymptotic Analysis of Parallel Programs.

- **MESSAGE PASSING PARADIGM** **(06 Hours)**

  Principles of Message-Passing Programming, The Building Blocks for Send and Receive Operations, MPI for The Message Passing Interface, Topologies, Embedding, Overlapping Communication with

21/7/2020

Computation, Collective Communication and Computation Operations, Groups and Communicators.

- **SHARED ADDRESS SPACE PLATFORMS THREAD BASICS** **(04 Hours)**
  Thread Application Programmer Interface, Synchronization Primitives, Controlling Thread and Synchronization Attributes, Thread Cancellation, Composite Synchronization Constructs.
- **ALGORITHMIC APPROACHES** **(05 Hours)**
  Matrix-Vector Multiplication, Matrix-Matrix Multiplication, Issues in Sorting on Parallel Computers, Sorting Networks, Bubble Sort and its Variants, Quick Sort: Definitions and Representation, Minimum Spanning Tree: Prim's Algorithm, Single-Source Shortest Paths: Dijkstra's Algorithm, All-Pairs Shortest Paths.
- **ADVANCE TOPICS AND TOOLS** **(05 Hours)**
  Counting Problems, Interactive Proofs, Probabilistically Checkable Proofs, OpenMP Tools, OpenMP Compilers, High Performance Parallel Programming, CUDA.

(Total Contact Time: 42 Hours)

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3. Books Recommended:

1. Kai Hwang and F. Briggs, Computer Architecture and Parallel Processing, McGraw Hill International Edition, Reprint 2006.
2. M. Flynn, Computer Architecture: Pipelined and Parallel Processor Design, 1st Edition, Jones and Bartlett, 1995.
3. Harry F. Jordan, Fundamentals of Parallel Processing, 1st Edition, Prentice Hall, 2002.
4. Kai Hwang, Advanced Computer Architecture: Parallelism, Scalability, Programmability, 1st Edition, Tata McGraw Hill, Reprint 2008.
5. Ananth Grama, Anshul Gupta, George Karypis and Vipin Kumar, Introduction to Parallel Computing, 2nd Edition, Pearson Publication, 2003.

4/7/22

B.Tech. III (CSE) Semester – V
INFORMATION THEORY AND CODING (CORE ELECTIVE-1)
CS327

	L	T	P	Credit
Scheme	3	0	0	03

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1. Course Outcomes (COs): **At the end of the course, the students will be able to**	
CO1	acquire knowledge about the basics of information measure, Entropy, bit error, various error control encoding and decoding techniques, communication channel capacity and rate.
CO2	apply principles of information theory and linear algebra in source coding, channel coding and efficient error correcting codes.
CO3	analyse the performance of error control codes and communication channel.
CO4	evaluate different types of the channel modelling and codes.
CO5	design and innovate efficient codes, communication channel in terms of higher rate and less distortion.

2. Syllabus

- **INTRODUCTION** **(04 Hours)**

  Information Source, Symbols and Entropy, Mutual Information, Information Measures for Continuous Random Variable, Joint and Conditional Entropy, Relative Entropy, Applications Based on Information Theoretic Approach.

- **SOURCE CODING** **(08 Hours)**

  Source Coding Theorem, Kraft Inequality, Shannon-Fano Codes, Huffman Codes, Run Length Code, Arithmetic Codes, Lempel-Ziv-Welch Algorithm, Universal Source Codes, Prefix Codes, Variable Length Codes, Uniquely Decodable Codes, Instantaneous Codes, Shannon's Theorem, Shannon Fano Encoding Algorithm, Shannon's Noiseless Coding Theorem, Shannon's Noisy Coding Theorem.

- **COMMUNICATION CHANNEL** **(08 Hours)**

  Channel and its Capacity, Continuous and Gaussian Channels, Discrete Memory-Less Channels, Symmetric Channel, Binary Erasure Channel, Estimation of Channel Capacity, Noiseless Channel, Channel Efficiency, Shannon's Theorem on Channel Capacity, MIMO Channels, Channel Capacity with Feedback.

- **VIDEO AND SPEECH CODING** **(08 Hours)**

21/7/24

Video Coding Basics, Quantization, Symbol Encoding, Intraframe Coding, Predictive Coding, Transform Coding, Subband Coding, Vector Quantization, Interframe Coding, Motion Compensated Coding, Image Compression, JPEG, LZ78 Compression, Dictionary Based Compression, Statistical Modelling, Variable Length Coding, Bit Allocation.

- **ERROR CONTROL CODING** **(10 Hours)**

  Overview of Field, Group, Galois Field, Types of Codes, Hamming Weight, Minimum Distance Based Codes, Error Detection and Error Correction Theorems, Maximum Likelihood Decoder, MAP Decoder, Linear Block Codes and Their Properties, Equivalent Codes, Generator Matrix and Parity Check Matrix, Systematic Codes, Cyclic Codes, Convolution Codes and Viterbi Decoding Algorithm, Turbo Codes and Low Density-Parity-Check Codes, Asymptotic Equipartition Property.

- **RATE DISTORTION THEORY** **(04 Hours)**

  Rate Distortion Function, Random Source Codes, Joint Source-Channel Coding and the Separation Theorem.

(Total Contact Time: 42 Hours)

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3. Books Recommended:

1. R. Bose, Information Theory, Coding and Cryptography, 3rd Edition, McGraw-Hill, 2016.
2. R. Johannesson and K.S. Zigangirov, Fundamentals of Convolutional Coding, 2nd Edition, Wiley-IEEE Press, 2015.
3. T. M. Cover and J. A. Thomas, Elements of Information Theory, 2nd Edition, John Wiley & Sons, New York, 2012.
4. A. B. Robert, Information Theory, 2nd Edition, Dover Special Priced Titles, 2007.
5. R. M. Roth, Introduction to Coding Theory, Cambridge University Press, 2006.

ADDITIONAL REFENCE BOOKS

1. R.H. Morelos-Zaragoza, The Art of Error Correcting Coding, Wiley and sons, 2006.
2. T. K. Moon, Error Correction Coding: Mathematical Methods and Algorithms, Wiley, 2005.
3. S. Lin and D. J. Costello, Error Control Coding, 2nd Edition, Prentice-Hall, 2004.
4. Mark Nelson and Jean-Loup Gailly, Data Compression, 2nd Edition, BPB Publication, 1996.
5. R. Hill, A First Course in Coding Theory, Oxford University Press, 1986.

21/7/2021

B.Tech. III (CSE) Semester – V
OBJECT ORIENTED TECHNOLOGY (CORE ELECTIVE-1)
CS329

	L	T	P	Credit
Scheme	3	0	0	03

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1. Course Outcomes (COs): **At the end of the course, the students will be able to**	
CO1	acquire knowledge about the Project development life cycle, software requirements, model concepts.
CO2	apply models' concepts for different perspective to solve the given problem statement.
CO3	analyze the problem requirement, refinement of requirement, model and resolve errors.
CO4	evaluate object oriented models using various testing concepts and matrices.
CO5	utilize the standard tools for the design and development of solution for given problems.

2. Syllabus

- **INTRODUCTION** **(04 Hours)**

  Information Systems, Problems in Information Systems Development, Project Life Cycles, Structured System Analysis and Design, Managing Information System Development, User Involvement and Methodological Approaches, Basic Concepts and Origins of Object Orientation Modelling Concepts, Iterative Development and Unified Process.

- **MODELLING REQUIREMENT** **(02 Hours)**

  Requirement Capture, Requirement Analysis, Refining the Requirement Models, Object Interaction.

- **STRUCTURAL MODELLING** **(06 Hours)**

  Object Oriented Fundamentals, Basic Structural Modelling, UML Model, Class Diagrams, Object Diagrams, Packages and Interfaces, Case Studies.

- **BEHAVIOURAL AND ARCHITECTURAL MODELLING** **(10 Hours)**

  Use Case Diagrams, Interaction Diagrams, State Chart Diagrams, Collaborations, Design Patterns, Component Diagrams, Deployment Diagrams, Case Studies.

- **OBJECT ORIENTED TESTING METHODOLOGIES** **(10 Hours)**

  Implications of Inheritance on Testing, State Based Testing, Adequacy and Coverage, Scenario Based Testing, Testing Workflow, Case Studies, Object Oriented Metrics.

- **COMPONENTS** **(10 Hours)**

  Abuses of Inheritance, Danger of Polymorphism, Mix-In Classes, Rings of Operations, Class Cohesion and Support of States and Behaviour, Components and Objects, Design of a Component, Lightweight and Heavyweight Components, Advantages and Disadvantages of Using Components.

(Total Contact Time: 42 Hours)

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3. Books Recommended:

1. A. Bahrami, Object Oriented System Development, 1st Edition, McGraw Hill, 2017, ISBN: 9780070265127.
2. M. Page Jones, Fundamentals of Object Oriented Design in UML, 2nd Edition, Pearson Education, 2005, ISBN: 9780321267979.
3. J. Baugh, I. Jacobson and G. Booch, The Unified Modelling Language Reference Manual, 2nd Edition, Addison Wesley, 2004, ISBN-13: 978-0321718952.
4. G. Booch, J. Rumbaugh and I. Jacobsons, The Unified Modelling Language User Guide, 3rd Edition, Addison Wesley, 2004, ISBN: 9789332553941.
5. Simon Benett, Steve McRobb and Ray Farmer, Object Oriented System Analysis and Design using UML, 2nd Edition, McGraw Hill, 2004, ISBN: 9780070597914.

ADDITIONAL REFERENCE BOOKS

1. C. Larman, Applying UML ans Patterns: An Introduction to Object-Oriented Analysis and Design, Addison Wesley, 2002, ISBN: 9780201699463.

21/7/2020

B.Tech. III (CSE) Semester – VI
PRINCIPLES OF PROGRAMMING LANGUAGES (CORE-11)
CS302

	L	T	P	Credit
Scheme	3	1	2	05

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1. Course Outcomes (COs): **At the end of the course, the students will be able to**	
CO1	describe the language features of current programming languages.
CO2	program in different language paradigms and evaluate their relative benefits.
CO3	analyze object oriented constructs in different programming languages.
CO4	evaluate the programming solutions of different problems.
CO5	design programs in Functional and Logical Languages.

2. Syllabus

- **INTRODUCTION** **(06 Hours)**

  Introduction: Role of Programming Languages: Why Programming Languages, Towards Higher-Level Languages, Programming Paradigms, Programming Environments Language Description: Syntactic Structure, Language Translation Issues: Programming Language Syntax, Stages in Translation, Formal Translation Models.

- **BASICS OF PROGRAMMING LANGUAGE** **(08 Hours)**

  Data, Data Types, and Basic Statements: Names, Variables , Binding, Type Checking, Scope, Scope Rules , Lifetime and Garbage Collection, Primitive Data Types, Strings, Array Types, Associative Arrays ,Record Types, Union Types, Pointers and References , Arithmetic Expressions , Overloaded Operators, Type Conversions , Relational and Boolean Expressions, Assignment Statements, Mixed Mode Assignments, Control Structures, Selection ,Iterations, Branching, Guarded Statements.

- **SUBPROGRAMS** **(08 Hours)**

  Subprograms and Implementations: Subprograms, Design Issues, Local Referencing, Parameter Passing, Overloaded Methods, Generic Methods, Design Issues for Functions, Semantics of Call and Return, Implementing Simple Subprograms, Stack and Dynamic Local Variables, Nested Subprograms, Dynamic Scoping.

- **OBJECT-ORIENTED PROGRAMING** **(10 Hours)**

  Object-Orientation, Concurrency, and Event Handling: Grouping of Data and Operations - Constructs for Programming Structures, Abstraction Information Hiding, Program Design with Modules, Defined Types, Object Oriented Programming - Concept of Object, Inheritance, Derived

21|7|2020

Classes and Information Hiding - Templates, Semaphores, Monitors, Message Passing, Threads, Statement Level Concurrency Exception Handling (Using C++ and Java as Example Language).

- **FUNCTIONAL AND LOGIC PROGRAMMING LANGUAGES: (10 Hours)**
  Introduction to Lambda Calculus, Fundamentals of Functional Programming Languages, Programming with Programming with ML, Introduction to Logic and Logic Programming - Programming with Prolog. Types of Logic, WFF, Symbolic Logic, Facts, Clauses, Predicates, Unification, Backtracking, Cut, Fail & Built-In Predicates, Recursion in Prolog, Arithmetic Operators & Relational Operators, LIST Processing, String manipulation & Built-In Predicates, Compound Objects, Dynamic Database.

Tutorials will be based on topics discussion in the class (14 Hours)

Practicals will be based on topics discussion in the class (28 Hours)

(Total Contact Time: 42 Hours+14 Hours+28 Hours= 84 Hours)

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3. Tutorials:

1 Programming languages paradigm.

2 Study of programming language and its benefits. Success and Failure of language.

3 Prolog programming.

4 Object oriented programming constructs.

5 Mapping complex problems with available technologies and evaluate its usefulness.

4. Practicals:

1 Convert prolog predicates into semantic net.

2 Implement travelling salesman problem using prolog.

3 Implement 8 puzzle problem using prolog.

4 Implement N-Queens problem using prolog.

5 Implement C++/Java program for class & object, constructor & destructor.

6 Implement C++/Java programs for operator overloading, inheritance, and polymorphism, file operation.

7 Implement of string operation using prolog.

8 Implement of artificial intelligence based application using prolog.

5. Books Recommended:

1. Terrance W. Pratt, Marvin V. Zelkowitz and T. V. Gopal, Programming Languages: Design and Implementations, 4th Edition, Prentice Hall, 2000.

2. David A. Watt, Programming Language Design Concept, 1st Edition, Willey India, Jan 1, 2009.
3. Ravi Sethi, Programming languages: Concepts and Constructs, 2nd Edition, Pearson, Jan 7, 1996.
4. Benjamin C. Pierce, Types and programming Languages, The MIT Press Cambridge, Massachusetts, London, England, Jan 4, 2002.
5. Robert W. Sebesta, Concepts of Programming Languages, 11th Edition, Pearson, Feb 16, 2015.

B.Tech. III (CSE) Semester – VI
DISTRIBUTED SYSTEMS (CORE-12)
CS304

	L	T	P	Credit
Scheme	3	1	2	05

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1. Course Outcomes (COs): **At the end of the course, the students will be able to**	
CO1	describe the concepts of distributed System and design and implementation issues.
CO2	define key mechanism for designing distributed algorithms for different primitives like mutual exclusion, deadlock detection, agreement etc.
CO3	analyze different types of faults and fault handling techniques in order to implement fault tolerant systems.
CO4	correlate different election algorithm, file system, time synchronization and naming services.
CO5	design and develop distributed programs subject for specific design and performance constraints.

2. Syllabus

- **INTRODUCTION TO DISTRIBUTED SYSTEMS** **(04 Hours)**

  Review of Networking Protocols, Point to Point Communication, Operating Systems, Concurrent Programming, Characteristics and Properties of Distributed Systems, Goals of Distributed Systems, Multiprocessor and Multicomputer Systems, Distributed Operating Systems, Network Operating Systems, Middleware Concept, The Client-Server Model, Design Approaches-Kernel Based-Virtual Machine Based, Application Layering.

- **COMMUNICATIONIN DISTRIBUTED SYSTEMS** **(04 Hours)**

  Layered Protocols, Message Passing-Remote Procedure Calls-Remote Object Invocation, Message Oriented Communication, Stream Oriented Communication, Case Studies.

- **PROCESS MANAGEMENT** **(04 Hours)**

  Concept of Threads, Process, Processor Allocation, Process Migration and Related Issues, Software Agents, Scheduling in Distributed System, Load Balancing and Sharing Approaches, Fault Tolerance, Real Time Distributed System.

- **SYNCHRONIZATION** **(06 Hours)**

Clock Synchronization, Logical Clocks, Global State, Election Algorithms-The Bully algorithm-A Ring algorithm, Mutual Exclusion-A Centralized Algorithm-A Distributed Algorithm-A token ring Algorithm, Distributed Transactions.

- **CONSISTENCY AND REPLICATION** **(06 Hours)**

Introduction to Replication, Object Replication, Replication as Scaling Technique, Data Centric Consistency Models-Strict-Linearizability and Sequential-Causal-FIFO-Weak-release-Entry, Client Centric Consistency Models-Eventual Consistency-Monotonic Reads and Writes-Read your Writes-Writes Follow Reads, Implementation Issues, Distribution Protocols-Replica Placement-Update Propogation-Epidemic Protocols, Consistency Protocols.

- **FAULT TOLERANCE** **(04 Hours)**

Introduction, Failure Models, Failure Masking, Process Resilience, Agreem in Faulty Systems, Reliable Client Server communication, Group communication, Distributed Commit, Recovery.

- **DISTRIBUTED OBJECT BASED SYSTEMS** **(06 Hours)**

Introduction to Distributed Objects, Compile Time Vs Run Time Objects, Persistent and Transient Objects, Enterprise JAVA Beans, Stateful and Stateless Sessions, Global Distributed Shared Objects, Object Servers, Object Adaptors, Implementation of Object References, Static And Dynamic Remote Method Invocations, Replica Framework.

- **DISTRIBUTED FILE SYSTEMS** **(04 Hours)**

Introduction, Architecture, Mechanisms for Building Distributed File Systems-Mounting-Caching-Hints-Bulk Data Transfer-Encryption, Design Issues-Naming and Name Resolution-Caches on Disk or Main Memory-Writing Policy-Cache consistency-Availability-Scalability-Semantics, Case Studies, Log Structured File Systems.

- **DISTRIBUTED WEB BASED SYSTEMS** **(04 Hours)**

Architecture, Processes, Communication, Naming, Synchronization, Web Proxy Caching, Replication of Web Hosting Systems, Replication of Web Applications.

Practicals will be based on the coverage of the above topics. **(28 Hours)**

Tutorials will be based on the coverage of the above topics. **(28 Hours)**

(Total Contact Time 42 Hours + 14 Hours + 28 Hours = 84 Hours)

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3. Practicals:

1 Implementation of concepts of communication protocols using UDP and TCP IP.

2 Implement the remote procedure call with an application.

21/7/12

3 Implementation of object based system using RMI or CORBA.

4 Implementation of distributed system for file sharing and message passing.

5 Implementation of Socket programming.

6 Implementation of distributed client-server application.

7 Implementation of client-server application with scheduling in distributed environment.

8 Implementation of distributed load balancing and resource sharing.

4. Tutorials:

1 Concepts of communications (UDP and TCP IP).

2 Concepts of fault tolerance.

3 Concept of time Synchronization.

4 Concepts of process management.

5 Concepts of replication and consistency.

6 Object based system (RMI and CORBA).

5. Books Recommended:

1. Andrew S Tanenbaum, Distributed systems: Principles and Paradigms, 2nd Edition, Pearson Education Inc., 2007.
2. Mukesh Singhal and Niranjan G. Shivaratri, Advanced Concepts in Operating Systems, TMH, McGraw-Hill Inc., New York, USA 1994.
3. Pradeep K. Sinha, Distributed Operating System: Concept and Design, PHI, New Delhi 2019.
4. W. Richard Stevens, Unix Network Programming: Vol 1, Networking APIS: Sockets & XTI, 2nd Edition, Pearson Education, 1998.
5. Colouris, Dollimore and Kindberg, Distributed Systems Concepts & Design, 4th Edition, Pearson Ed. 2005.

21/7/2024

B.Tech. III (CSE) Semester – VI
SYSTEM SOFTWARE (CORE – 13)
CS306

	L	T	P	Credit
Scheme	3	1	2	05

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1. <u>Course Outcomes (COs):</u> At the end of the course, the students will be able to	
CO1	have knowledge of systems software components, finite automata, regular expression and context free grammar.
CO2	apply the knowledge of assembler and macro processors to convert assembly language into machine code.
CO3	analyse working phases of Compiler, various parsing techniques, semantic analysis, Error handling, code generation and code optimization techniques to undertake meaningful language translation.
CO4	evaluate Linkers, Loaders, interpreters and debugging methods to manages system memory and provide a portable runtime environment.
CO5	create a language translator application and mimic a simple compiler.

2. Syllabus

- **INTRODUCTION** **(04 Hours)**

  Introduction to System Software, Utility Software, Systems Programming, Recent Trends in Software Development, Programming Languages and Language Processors, Data Structures for Language Processing.

- **ASSEMBLERS** **(06 Hours)**

  Overview of the Assembly Process, Cross Assembler, Micro Assembler, Meta Assembler, Single Pass Assembler, Two Pass Assembler, Design of Operation Code Table, Symbol Table, Literal Table, Advanced Assembly Process .

- **MACRO PROCESSORS** **(06 Hours)**

  Introduction of Macros, Macro Processor Design, Forward Reference, Backward Reference, Positional Parameters, Keyword Parameters, Conditional Assembly, Macro Calls within Macros, Implementation of Macros Within Assembler. Designing Macro Name Table, Macro Definition Table, Kew Word Parameter Table, Actual Parameter Table, Expansion Time Variable Storage.

- **COMPILERS** **(14 Hours)**

  Phases of Compiler, Analysis-Synthesis Model of Compilation, Interface with Input, Parser and Symbol Table, Token, Lexeme, Patterns and Error Reporting in Lexical Analysis, Programming

Language Grammars, Classification of Grammar, Ambiguity in Grammatical Specification, Top Down Parsing, Recursive Descent Parsing, Transformation on The Grammars, Predictive Parsing, Bottom Up Parsing, Operator Precedence Parsing, LR Parsers, Language Processor Development Tools – LEX & YACC, Semantic Gap, Binding and Binding Times, Memory Allocation, Compilation of Expression, Intermediate Representations, Basic Code Optimization.

- **LINKERS AND LOADERS** **(06 Hours)**

  Design of a Linker, Program Relocation, Linking of Overlay Structured Programs, Dynamic Linking, General Loader Schemes, Absolute Loader, Relocating Loader, Dynamic Loader, Bootstrap Loader, Linking Loader, other Loading Schemes, Linkers v/s Loaders.

- **INTERPRETERS & DEBUGGERS** **(06 Hours)**

  Overview of Interpretation and Debugging Process, Types of Errors, Classification of Debuggers, Dynamic/Interactive Debugger, The Java Language Environment, Java Virtual Machine and Recent Developments.

- **Tutorials will be based on the coverage of the above topics separately** **(14 Hours)**

(Total Contact Time: 42 Hours + 14 Hours + 28 Hours = 84 Hours)

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3. Practicals:

1 Study, install and setup various system software tools.

2 Implementation of single pass and two pass assembler.

3 Design and implement scanner using lexical analyzer (LEX) tool.

4 Design and implement parser using YACC tools.

5 Design and configure a compiler application using modern tools and softwares.

6 Implementation of different stages of compiler.

7 Implementation of interpreter and debugger.

8 Implementation of optimization based compiler design.

4. Tutorials

1 Problem solving on the basics of assembler.

2 Problem solving on the basics of macro processor.

3 Problem solving on the basics of lexical analysis.

4 Problem solving on the basics of parsing.

5 Problem solving on the basics of linkers and loaders.

21/7/22

6 Problem solving on the basics of interpreters & debuggers.

BOOKS RECOMMENDED

1. D. M. Dhamdhere, Systems Programming, 1st Edition, McGraw Hill, 2011.
2. Leland L. Beck, System Software - An Introduction to System Programming, 3rd Edition, Pearson Education, 2002.
3. John Donovan, Systems Programming, 1st Edition, McGraw Hill, 2017.
4. Santanu Chattopadhyay, System Software, 1st Edition, Prentice-Hall India,2007.
5. A. V. Aho, R. Sethi and J. D. Ullman, Compilers-Principles, Techniques and Tools, 2nd Edition, Pearson India, 2013.

ADDITIONAL REFERENCE BOOKS

1. Allen Holub, Compiler Design in C, 1st Edition, Pearson India, 2015.
2. Ronald Mak, Writing Compilers and Interpreters: A Software Engineering Approach, 3rd Edition, Wiley, 2009.

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B.Tech. III (CSE) Semester – VI
ARTIFICIAL INTELLIGENCE (CORE-14)
CS308

	L	T	P	Credit
Scheme	3	0	2	04

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1. Course Outcomes (COs): **At end of the program, students will be able to**	
CO1	explain the role of agents and how it is related to environment and the way of evaluating it and how agents can act by establishing goals.
CO2	apply various knowledge representation technique, searching techniques, constraint satisfaction problem and example problems- game playing techniques.
CO3	analyse the current scope, potential, limitations, and implications of intelligent systems.
CO4	evaluate the AI techniques suitable for recent areas of applications like expert systems, neural networks, fuzzy logic, robotics, natural language processing, and computer vision.
CO5	design a real world problem for implementation and describe the dynamic behaviour of a system.

2. Syllabus

- **INTRODUCTION TO AI** **(03 Hours)**

  Intelligent Agents, AI Techniques, AI-Problem formulation, AI Applications, Production Systems, Control Strategies.

- **KNOWLEDGE REPRESENTATION** **(06 Hours)**

  Knowledge Representation Using Predicate Logic, Introduction to Predicate Calculus, Resolution, Use of Predicate Calculus, Knowledge Representation Using other Logic-Structured Representation of Knowledge.

- **PRODUCTION SYSTEM** **(06 Hours)**

  Defining the Problems as a State Space Search, Production Systems, Production Characteristics, Production System Characteristics, Forward and Backward, State-Space Search, Problem Solving Methods – Problem Graphs, Matching, Indexing.

- **PROBLEM-SOLVING THROUGH SEARCH** **(06 Hours)**

21/7/2020

Generate and Test, BFS, DFS, Blind, Heuristic, Problem-Reduction, A, A*, AO*, Minimax, Constraint Propagation, Neural, Stochastic, and Evolutionary Search Algorithms, Sample Applications, Measure of Performance and Analysis of Search Algorithms, Problem Reduction, Constraint Satisfaction, Means-Ends Analysis, Issues in the Design of Search Programs.

- **KNOWLEDGE INFERENCE** **(06 Hours)**

  Knowledge Representation -Production Based System, Frame Based System. Inference – Backward Chaining, Forward Chaining, Rule Value Approach, Fuzzy Reasoning – Certainty Factors, Bayesian Theory-Bayesian Network-Dempster – Shafer Theory. Symbolic Logic Under Uncertainty : Non-Monotonic Reasoning, Logics for Non-Monotonic Reasoning, Statistical Reasoning : Probability and Bayes Theorem, Certainty Factors, Probabilistic Graphical Models, Bayesian Networks, Markov Networks, Fuzzy Logic.

- **GAME PLAYING AND PLANNING** **(06 HOURS)**

  Overview and Example Domain: Overview, Minimax, Alpha-Beta Cut-Off, Refinements, Iterative Deepening, The Blocks World, Components of a Planning System, Goal Stack Planning, Nonlinear Planning Using Constraint Posting, Hierarchical Planning, Reactive Systems, Other Planning Techniques.

- **NATURAL LANGUAGE PROCESSING** **(04 Hours)**

  Introduction, Syntactic Processing, Semantic Analysis, Discourse and Pragmatic Processing, Spell Checking.

- **EXPERT SYSTEMS** **(05 Hours)**

  Expert Systems – Architecture of Expert Systems, Roles of Expert Systems – Knowledge Acquisition – Meta Knowledge, Heuristics, Typical Expert Systems – MYCIN, DART, XOON, Expert Systems Shells.

- **Practicals will be based on the coverage of the above topics using prolog.** **(28 Hours)**

(Total Contact Time: 42 Hours + 28 Hours = 70 Hours)

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3. Practicals:

1 Practical assignment to understand basic concepts of prolog.

2 Practical assignment to implement various search strategies.

3 Practical assignment to implement various algorithm based on game theory.

4 Implementation of heuristic based search techniques.

5 Implementation of neural network based application.

6 Implementation of fuzzy logic based application.

2/1/2022

7 Implementation of fuzzy inference engine for an application.

8 Implementation of neuro-fuzzy based system.

4. Books Recommended:

1. Elaine Rich and Kevin Knight, Artificial Intelligence, 2nd Edition, Tata McGraw-Hill, 2003.
2. Stuart Russell and Peter Norvig, Artificial Intelligence: A Modern Approach, 3rd Edition, Prentice Hall, 2009.
3. Nils Nilsson, Artificial Intelligence: A New Synthesis, Morgan Kaufmann, 1998,
4. W. Patterson, Introduction to Artificial Intelligence and Expert Systems, Prentice Hall of India, 2010.
5. I. Bratko, Prolog Programming for Artificial Intelligence, 3rd Edition, Addison-Wesley, 2001.

21/7/2020

B.Tech. III (CSE) Semester – VI
CRYPTOGRAPHY (INSTITUE ELECTIVE-2)
CS362

	L	T	P	Credit
Scheme	3	0	0	03

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1. Course Outcomes (COs):	
At the end of the course, the students will be able to	
CO1	explain the key concepts and mathematical background of cryptography.
CO2	apply the concepts of security mechanisms from the application developer's perspective.
CO3	analyse security mechanisms while trying to satisfy the required security services.
CO4	evaluate different information hiding and authentication techniques.
CO5	design and develop the security solutions depending on the organisation's requirements.

2. Syllabus

- **CLASSICAL CRYPTOGRAPHY** **(04 Hours)**

  Shift Cipher, Substitution Cipher, Affine Cipher, Vigenere Cipher, Hill Cipher, Permutation Cipher, Stream Ciphers, Cryptanalysis of Classical Ciphers.

- **SHANNON'S THEORY** **(04 Hours)**

  Elementary Probability Theory, Computational, Provable and Perfect Secrecy, Entropy, Huffman Encodings, Properties of Entropy, Spurious Key and Unicity Distance, Product Cryptosystems.

- **NUMBER THEORY** **(04 Hours)**

  Modular Arithmetic, Algebraic Structures-Group, Ring, Fields, Galois Fields GF(P), GF(2^n), Euclidean Algorithm, Polynomials and its Operations, Chinese Remainder Theorem, Euler's Phi Function, Fermat's Theorem.

- **MODERN BLOCK CIPHERS** **(04 Hours)**

  The Substitution-Permutation Networks, Linear Cryptanalysis-Piling-up Lemma, Linear Approximation of S-Boxes, Linear Attack on SPN, Differential Cryptanalysis, The Data Encryption Standard (DES), The Advanced Encryption Standard (AES), Block Cipher Modes of Operation.

- **CRYPTOGRAPHIC HASH FUNCTIONS** **(04 Hours)**

  Hash Functions and Data Integrity, Security of Hash Functions-The Random Oracle Model, Iterated Hash Functions- Merkel Damgard Construction, Secure Hash Algorithm (SHA), Message

21/12/2020

Authentication Codes (MAC), HMAC, CBC-MAC and Authenticated Encryption, Unconditionally Secure MACs.

- **PUBLIC KEY CRYPTOGRAPHY AND DISCRETE LOGARITHMS** **(08 Hours)**

  The El-Gamal Cryptosystem and its Security, Algorithms for Discrete Logarithm Problem-Shank, Pollard-rho, Pohlig- Hellman, Index Calculus, Finite Fields, The Diffie-Hellman Problems, Elliptic Curves-Elliptic Curves over Real numbers and Finite Fields, Properties, Point Compression and ECIES, Point Addition, Scalar Multiplication.

- **RSA CRYPTOSYSTEM AND FACTORING INTEGERS** **(06 Hours)**

  RSA Key Generation, Encryption, Decryption, The Integer Factorization Problem, Primality Testing-Legendre and Jacobi Symbols, The Solovay-Strassen Algorithm, The Miller-Rabin Algorithm, Square root modulo a composite, Factoring Algorithm, Attacks on RSA-Computing $\phi(n)$, Low Decryption Exponent Attack, Optimal Asymmetric Encryption Padding.

- **DIGITAL SIGNATURE SCHEMES** **(04 Hours)**

  Security Requirements, Signature and Hash Functions, ElGamal Digital Signature Scheme and its Security, Variants of ElGamal Digital Signature-Schnorr, Digital Signature Algorithm(DSA), Elliptic Curve DSA, Provably Secure Signature Schemes, One Time Signatures, Full Domain Hash, Undeniable Signatures, Blind Signatures, Fail-Stop Signatures.

- **IDENTIFICATION SCHEMES AND ENTITY AUTHENTICATION** **(02 Hours)**

  Challenge Response Protocols, Password Based Authentication, Zero Knowledge Schemes.

- **ADVANCED TOPICS** **(02 Hours)**

  Lightweight Security Protocols, Security Requirements in Various Application Domains viz., IoT, Big Data, Cloud Computing and Social Networks.

(Total Contact Time: 42 Hours)

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3. Books Recommended:

1. Douglas R. Stinson, Cryptography: Theory and Practice, 3rd Edition, Chapman and Hall/CRC, 2005.
2. William Stallings, Cryptography and Network Security: Principles and Practice, 7th Edition, Upper Saddle River: Pearson, 2017.
3. Behrouz A. Forouzan, Cryptography & Network Security, 3rd Edition, McGraw-Hill Inc., 2007.
4. Bruce Schneier, Applied cryptography: Protocols, Algorithms, and Source Code in C, 2nd Edition, John Wiley & Sons, 2007.
5. Dhiren R. Patel, Information Security: Theory and Practice , 1st Edition, PHI Learning Pvt. Ltd., 2008.

2/1/7/2020

B.Tech. III (CSE) Semester – VI
DIGITAL FORENSICS (INSTITUE ELECTIVE-2)
CS364

	L	T	P	Credit
Scheme	3	0	0	03

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1. Course Outcomes (COs): **At the end of the course, the students will be able to**	
CO1	explain digital forensic, cryptography and investigation techniques on different computing platforms as well as mobile devices.
CO2	analyse cyber-attacks to assist conventional forensic to investigate digital platforms.
CO3	create disk images, recover deleted files and extract hidden information.
CO4	describe the representation and organization of data and metadata within modern computer systems with the use of various forensic tools.
CO5	design research problems and develop effective solutions for digital forensic and can compose a draft which can be used for legal procedure.

2. Syllabus

- **INTRODUCTION** **(04 Hours)**

  Introduction to Computer Forensics: Computer Crimes, Evidence, Extraction, Preservation, Analogies to Traditional Forensics and Differences from Traditional Forensics, Hardware and Operating Systems: Structure of Storage Media/Devices; Windows / Macintosh / Linux -- Registry, Boot Process, File Systems, File Metadata.

- **DATA RECOVERY** **(02 Hours)**

  Identifying Hidden Data, Encryption/Decryption, Steganography, Recovering Deleted Files.

- **DIGITAL EVIDENCE ON WINDOWS SYSTEM** **(06 Hours)**

  Deleted Data, File Carving, Hibernation, Sleep, Hybrid Sleep, Registry Structure, Attribution, External Devices, Print Spooling, Recycle Bin, Date and Time Stamp, Thumbnail Cache, Restore Points, Shadow Copy, Link Files.

- **DIGITAL EVIDENCE ON UNIX SYSTEM** **(04 Hours)**

  UNIX Boot Disk, File System, Data Recovery, Log Files, File System Traces, Internet Traces.

- **NETWORK FORENCIS** **(04 Hours)**

Collecting and Analysing Network-Based Evidence, Reconstructing Web Browsing, Email Activity, and Windows Registry Changes, Intrusion Detection, Tracking Offenders, etc.

- **INTERNET AND EMAIL FORENSICS** **(06 Hours)**

  Internet Overview, Role of Internet in Criminal Investigation, Online Anonymity and Self-Protection, Web Technology, Web Browsers, Cookies, Cache, History, Browser Artifacts in Registry, Chat Clients, Email Protocols, Email Evidence, Tracing Email, Email Forgery, Social Networking Sites.

- **MOBILE DEVICE FORENSICS** **(04 Hours)**

  Cellular Network-Basics-Components-Types, Mobile Operating Systems, Cellphone Evidences-Call-detail Records-Collection-Handling-Subscriber Identity Modules-Cellphone Acquisition, Cellphone Forensics Tools, GPS.

- **SOFTWARE REVERSE ENGINEERING** **(04 Hours)**

  Software Reverse Engineering Defend Against Software Targets for Viruses, Worms and Other Malware, Improving Third-Party Software Library, Identifying Hostile Codes-Buffer Overflow, Provision of Unexpected Inputs, etc.

- **ADVANCE TOPICS AND LEGAL ISSUES** **(08 Hours)**

  Forensic tools, Forensic report writing, Criminal Law, Expectation of Privacy, Private Searches, Privacy Law, Search Warrant.

(Total Contact Time: 42 Hours)

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3. Books Recommended:

1. Eoghan Casey, Digital Evidence and Computer Crime: Forensic Science, Computers, and the Internet, 3rd Edition, Academic Press, 2011.
2. Dejey and Murugan, Cyber Forensics, 1st Edition, Oxford University Press, 2018.
3. John Sammons, The Basics of Digital Forensics: The Primer for Getting Started in Digital Forensics, 2nd Edition, Elsevier, 2012.
4. Sherri Davidoff and Jonathan Ham, Network Forensics: Tracking Hackers Through Cyberspace, Prentice Hall, 2012.
5. Computer Forensics: Hard Disk and Operating Systems, 2nd Edition, EC Council, September 17, 2009.

ADDITIONAL REFERENCE BOOKS

1. Computer Forensics Investigation Procedures and response, EC-Council Press, 2010.
2. Brian Carrier, File System Forensic Analysis, Addison-Wesley Professional, March 27, 2005.
3. Michael Hale Ligh, Andrew Case, Jamie Levy and Aaron Walters, The Art of Memory Forensics: Detecting Malware and Threats in Windows, Linux, and Mac Memory, ISBN: 978-1-118-82509-9, July 2014.

2/7/2020

B.Tech. III (CSE) Semester – VI
EMBEDDED SYSTEMS (INSTITUTE ELECTIVE-2)
CS366

	L	T	P	Credit
Scheme	3	0	0	03

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1. Course Outcomes (COs):
At the end of the course, the students will be able to

CO1	explain basic concept of embedded systems.
CO2	apply and analyse the applications in various processors and domains of embedded system.
CO3	analyse and develop embedded hardware and software development cycles and tools.
CO4	evaluate different Embedded Computing and IoT systems.
CO5	design the embedded systems using different concepts of a RTOS, sensors, memory interface, and communication interface.

2. Syllabus

- **INTRODUCTION: HARDWARE** **(04 Hours)**

  Introduction to Embedded System Hardware Needs, Typical and Advanced, Timing Diagrams, Memories (RAM, ROM, EPROM), Tristate Devices, Buses, DMA, UART and PLD's Built-ins on the Microprocessor.

- **INTERRUPTS** **(04 Hours)**

  Interrupts Basics ISR, Context Saving, Shared Data Problem, Atomic and Critical Section, Interrupt Latency.

- **SOFTWARE AND OS** **(04 Hours)**

  Survey of Software Architectures, Round Robin, Function Queue Scheduling Architecture, Use of Real Time Operating System, RTOS, Tasks, Scheduler, Shared Data Re-entrancy, Priority Inversion, Mutex Binary Semaphore and Counting Semaphore.

- **INTER-PROCESS COMMUNICATION** **(05 Hours)**

  Inter Task Communication, Message Queue, Mailboxes and Pipes, Timer Functions, Events Interrupt Routines in an RTOS Environment.

- **EMBEDDED COMPUTING** **(07 Hours)**

  Embedded Design Process, System Description Formalisms, Instruction Sets- CISC and RISC, Embedded Computing Platform- CPU bus, Memory Devices, I/O Devices, Interfacing, Designing with Microprocessors, Debugging Techniques, Hardware Accelerators- CPUs and Accelerators, Accelerator

21/9/2020

System Design, Embedded System Software Design using an RTOS Hard Real-Time and Soft Real-Time System Principles, Task Division, Need of Interrupt Routines, Shared Data.

- **INTERNET OF THINGS** **(04 Hours)**

  Introduction, IoT Work Flow, IoT Protocols: HTTP, CoAP, MQTT, 6LoWPAN, Building IoT Applications.

- **TOOLS** **(06 Hours)**

  Embedded Software Development Tools, Host and Target Systems, Cross Compilers, Linkers, Locators for Embedded Systems, Getting Embedded Software into the Target System, Debugging Techniques like JTAGS, Testing on Host Machine, Instruction Set Emulators, Logic Analysers In-Circuit Emulators and Monitors.

- **NETWORK** **(04 Hours)**

  Distributed Embedded Architectures, Networks for Embedded Systems, Network-Based Design, and Internet Enabled Systems.

- **SYSTEM DESIGN TECHNIQUES** **(04 Hours)**

  Design Methodologies, Requirements Analysis, System Analysis and Architecture Design, Quality Assurance.

(Total Contact Time: 42 Hours)

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3. Books Recommended:

1. Mohamed Ali Mazidi, Janice Gillispie Mazidi and Rolin McKinlay, The 8051 Microcontroller and Embedded Systems: Using Assembly and C , 2nd Edition, Pearson Education, 2011.
2. Raj Kamal, Embedded Systems-Architecture, Programming and Design, 2nd Edition, TMH, 2007.
3. Jonathan W. Valvano, Embedded Microcomputer Systems-Real Time Interfacing, 2nd Edition, Thomson Learning, 2006.
4. David A. Simon, An Embedded Software Primer, 1st Edition, Pearson Education, 2001.
5. Louis L. Odette, Intelligent Embedded Systems, Addison-Wesley, 1991.

ADDITIONAL REFERENCE BOOKS

1. W. Wolf, Computers as Components- Principles of Embedded Computing System Design, Academic Press (Indian edition available from Harcourt India Pvt. Ltd., 27M Block market, Greater Kailash II, New Delhi-110 048).
2. Denial D. Gajski and Frank Vahid, Specification and Design Embedded Systems, Prentice Hall; Facsimile Edition, 1994.

21/7/2020

B.Tech. III (CSE) Semester – VI
IMAGE PROCESSING (INSTITUTE ELECTIVE-2)
CS368

	L	T	P	Credit
Scheme	3	0	0	03

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1. Course Outcomes (COs): **At the end of the course, the students will be able to**	
CO1	describe building approaches of digital image processing systems, image models and mathematical tools for image processing.
CO2	apply spatial filtering, frequency domain filtering, image restoration and color image processing techniques for overall image improvement.
CO3	analyse various image compression methods for effective storage management without degrading the image quality.
CO4	evaluate various morphology, segmentation and object recognition methods to gain high level understanding of content of an image.
CO5	create an image processing application in the development of computer vision, machine learning, deep learning domains.

2. Syllabus

- **INTRODUCTION** **(02 Hours)**

  Image Model, Image Sensing and Acquisition, Sampling and Quantization, Mathematical Tool for Digital Image Processing, Types of Digital Images, Image File Formats, Colour Fundamentals and Models.

- **INTENSITY TRANSFORMATION AND SPATIAL FILTERING** **(06 Hours)**

  Basic Intensity Transformation Functions, Histogram Processing, Fundamentals of Spatial Filtering, Smoothing and Sharpening Spatial Filters.

- **FILTERING IN FREQUENCY DOMAIN** **(06 Hours)**

  Sampling and Fourier Transform, Discrete Fourier Transform (DFT), 2-D DFT, Filtering in the Frequency Domain, Smoothing and Sharpening Frequency Domain Filters, Selective Filtering.

- **IMAGE RESTORATION** **(06 Hours)**

  Image Degradation/ Restoration Process, Noise Models, Spatial Filtering and Frequency Domain Filtering for Noise Reduction, Linear Position-Invariant Degradations, Estimating the Degradation Function, Filtering, Image Reconstruction from Projection.

- **COLOR IMAGE PROCESSING** **(06 Hours)**

Color Models, Pseudocolor Image Processing, Full Color Image Processing, Color Transformation, Smoothing and Sharpening, Color Based Image Segmentation.

- **IMAGE COMPRESSION** **(06 Hours)**

  Image Compression Fundamentals, Classification of Image Compression Algorithms, Types of Redundancy, Lossless Compression Algorithms, Lossy Compression Algorithms, Image and Video Compression Standards and its Variations.

- **MORPHOLOGY AND SEGMENTATION** **(06 Hours)**

  Erosion and Dilation, Opening and Closing, Morphological Algorithms, Grey Scale Morphology, Point, Line and Edge Detection, Thresholding, Region based Segmentation, Segmentation using Morphological Watersheds, Use of Motion in Segmentation.

- **ADVANCED TOPICS** **(04 Hours)**

  Image Representation and Description, Object Recognition and Recent Developments.

(Total Contact Time = 42 Hours)

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3. <u>Books Recommended:</u>

1. Rafael C. Gonzales and Richard E. Woods, Digital Image Processing, 4th Edition, Pearson Education, 2018.
2. Anil K. Jain, Fundamentals of Digital Image Processing, 1st Edition, Pearson India, 2015.
3. S. Jayaraman, T. Veerakumar and S. Esakkirajan, Digital Image Processing, 1st Edition, TMG, 2017.
4. S. Sridhar, Digital Image Processing, 2nd Edition, Oxford University Press, 2016.
5. S. Annadurai and R. Shanmugalakshmi, Fundamentals of Digital Image Processing, 1st Edition, Pearson Education, 2006.

21/7/2020

B.Tech. III (CSE) Semester – VI
ADAPTIVE SIGNAL PROCESSING (INSTITUTE ELECTIVE-2)
CS372

	L	T	P	Credit
Scheme	**3**	**0**	**0**	**03**

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1. Course Outcomes (COs): **At the end of the course, the students will be able to**	
CO1	acquire knowledge about the adaptive signal processing, approaches of least mean square and adaptive filters.
CO2	apply recursive least square algorithm for estimation of least mean square and adaptive filtering of stationary process.
CO3	utilize theory and software implementation to solve adaptive signal problem and analyse the results obtained.
CO4	evaluate the accuracy and performance of the Kalman filtering utilized in adaptive signal processing.
CO5	design an efficient and innovative solution for the real time problems using different adaptive signal processing techniques.

2. Syllabus

- **INTRODUCTION** **(08 Hours)**

  Adaptive Processing of Signals, Adaptive Filters, Stochastic Processes, Correlation, System Modeling, Minimum Mean Squared Error (MMSE) Estimation, Linear MMSE Estimation, Sequential Linear MMSE Estimation, Introduction to Applications – Noise Cancellation, Inverse Modeling, Discrete Time Wiener Filter, Hilbert Space Formulation, Levinson Filtering, Orthogonalization and Orthogonal project, Orthogonal Decomposition of Signal Subspace.

- **LEAST MEAN SQUARE ALGORITHM** **(08 Hours)**

  FIR Adaptive Filters, Newton's Method, Steepest Descent Method, Convergence Analysis, Performance Surface, LMS Adaption Algorithms, Convergence, Excess Mean Square Error, Leaky LMS, Normalized LMS, Block LMS.

- **LINEAR LEAST SQUARE ESTIMATION** **(08 Hours)**

  Least Square Estimation Problem, Geometric Approach, Projection Theorem, Stochastic Linear Least Square Estimation, Recursive Least Square (RLS) Algorithm for Adaptive Filtering of Stationary Process, RLS Adaptive Lattice, RLS Lattice Recursions, Matrix Inversion, Comparison with LMS, RLS for Quasi-Stationary Signals, Exponentially Weighted RLS, Sliding Window RLS, RLS

21/7/2020

Algorithm for Array Processing, Adaptive Beam Forming, Other Applications of Adaptive Filters, Echo Cancellation, Channel Equalization.

- **KALMAN FILTERING** **(09 Hours)**

  State Space Model, Dynamic State Estimation, Statistical Filtering for Non-Stationary Signals, Kalman filtering Principles, Initialization and Tracking, Scalar and Vector Kalman filter, Derivation of Kalman Filter using Innovations Approach, Continuous time Kalman Filter, Discrete Kalman Filter, Convergence, Applications in Signal Processing, Time Varying Channel Estimation, Radar Target Tracking.

- **SYSTEM IDENTIFICATION AND APPLICATIONS** **(09 Hours)**

  Process of System Identification, Least Square System Identification Method, RLS based System Identification, Levinson Type Identification, Adaptive Blind Equalization, MIMO, Multi User Detection Application, Channel Estimation, Interference Cancelling, Beam-Forming, Speech Processing.

(Total Contact Time: 42 Hours)

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3. Books Recommended:

1. Simon O. Haykin, Adaptive Filter Theory, 5th Edition, Pearson Education Limited, 2014.
2. Monson H. Hayes, Statistical Digital Signal Processing and Modeling, 1st Edition, Wiley India Pvt. Ltd, 2008.
3. Alexander D. Poularikas and Zayed M. Ramadan, Adaptive Filtering Primer with MATLAB, 1st Edition, CRC Press, 2006.
4. Dimitris G. Manolakis, Vinay K. Ingle and Stephen M. Kogon, Statistical and Adaptive Signal Processing: Spectral Estimation, Signal Modeling, Adaptive Filtering, and Array Processing, 1st Edition, McGraw-Hill, 2005.
5. Bernard Widrow, Samuel D Stearns and Adaptive Signal Processing , 1st Edition, Pearson Education, 2002.

ADDITIONAL REFERENCE BOOKS

1. Ali H. Sayed, Fundamentals of Adaptive Filtering, 1st Edition, Wiley-IEEE Press, 2003.
2. Michael G. Larimore and C. Richard Johnson, Theory and Design of Adaptive Filters, 1st Edition, Pearson, 2001.

21/7/2020

B.Tech. III (CSE) Semester – VI
DATA VISUALIZATION (CORE ELECTIVE-2)
CS322

	L	T	P	Credit
Scheme	**3**	**0**	**0**	**03**

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1. Course Outcomes (COs): **At the end of the course, the students will be able to**	
CO1	acquire knowledge about the design principles of data visualization, categories of data visualization, and data visualization tools.
CO2	apply visualization approaches for animation, representing geospatial, network and other high dimensional data.
CO3	analyse the data visualization categories applicability according to the given data.
CO4	evaluate data visualization both in qualitative and quantitative manner by using various mapping.
CO5	represent real-time data using various visualizations tools and techniques.

2. Syllabus

- **INTRODUCTION** **(06 HOURS)**

  Data Visualization, Design, Data and Tasks, Data Types, Dataset Types, Basic Charts and Plots, Use of Statistical Indicators, Multivariate Data Visualization, Principles of Perception, Color, Design, and Evaluation, Graphical Integrity, Data-Ink Ratio, Aspect Ratios & Scales.

- **VISUALISATION FORMATS AND STRATEGIES** **(06 HOURS)**

  Formats-Static Graphs, Interactive Graphs, Infographics, Websites, Animated Videos, GIFs. Strategies-Qualitative and Text-Based Data, Color-Coding, Timelines, Calendars, and Diagrams, Filtering, Parallel Coordinates, Aggregation.

- **DATA VISUALIZATION CATEGORY** **(10 HOURS)**

  Text Data Visualization, Document Visualization, Images and Video, Interactivity and Animation, Temporal Data Visualization, Part-to-Whole Relationships Visualization, Geospatial Data Visualization, Hierarchical Data Visualization, Network Data Visualization, High-Dimensional Data Visualization, Maps.

- **DATA VISUALISATION SYSTEM** **(10 HOURS)**

Visual Story Telling, Messaging, Effective Presentations, Design for Information, Visualization and Arts, Visualization Systems, Database Visualization, Redesign Principles and Design Dimensionality, Rapidly Prototype Visualizations, Quantitatively and Qualitatively Evaluation of Visualizations.

- **DATA-DRIVEN DOCUMENTS (D3) (06 HOURS)**

Introduction, Relative vs. Absolute Judgments, Luminance Perception, D3 Key Features and Concepts, Visualization Process, Design Iterations, Sketching, Data Types, Statistical Graphs, Interaction Design, Brushing and Linking, Animation, Trees and Networks, Radial Layouts, Linear Layouts, Maps, Tree maps, Choropleth Maps, Cartograms, Symbol Maps, Flow Maps, Real-Time Maps.

- **OTHER DATA VISUALISATION TOOLS (04 HOURS)**

Excel, R, Tableau, Python

(Total Contact Time: 42 Hours)

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3. Books Recommended:

1. Scott Murray, Interactive Data Visualization for the Web, 2nd Edition, O'Reilly Media, 2017.
2. Alberto Cairo, The Truthful Art: Data, Charts, and Maps for Communication, 1st Edition, Berkeley, California: New Riders, 2016, ISBN: 9780321934079.
3. Colin Ware, Visual Thinking for Design, 1st Edition, Morgan Kaufman Series, 2008, ISBN: 9780123708960.
4. Ben Fry, Visualizing Data: Exploring and Explaining Data with the Processing Environment, 1st Edition, O'Reilly Media, 2008, ISBN: 9780596514556.
5. S. Few, Information Dashboard Design: The effective Visual Communication of Data Sebastopol, 1st Edition, O'Reilly, 2006, ISBN: 9780596100162.

ADDITIONAL REFERENCE BOOKS

1. Edward Tufte, The Visual Display of Quantitative Information, 2nd Edition, Graphics Press, 2001, ISBN: 9781930824133.

4/7/2020

B.Tech. III (CSE) Semester – VI
NATURAL LANGUAGE PROCESSING (CORE ELECTIVE-2)
CS324

	L	T	P	Credit
Scheme	3	0	0	03

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1. Course Outcomes (COs): **At the end of the course, the students will be able to**	
CO1	explain basics principles of natural language processing.
CO2	apply machine learning techniques for NLP based different tasks.
CO3	perform statically analysis and classification, recognition using NLP knowledge acquired.
CO4	evaluate the performance of machine translation solutions through statistical parameters.
CO5	design efficient solution for parser, translator and different applications based on NLP for day to day usage.

2. Syllabus

- **INTRODUCTION** **(04 Hours)**

  Human Languages, Language Models, Computational Linguistics , Ambiguity and Uncertainty in Language, Processing Paradigms, Phases in Natural Language Processing, Basic Terminology, Overview of Different Applications, Regular Expressions and Automata, Finite State Transducers and Morphology, Automata, Word Recognition, Lexicon, Morphology, Acquisition Models, Linguistics Resources, Introduction to Corpus, Elements in Balanced Corpus.

- **SYNTAX AND SEMANTICS** **(08 Hours)**

  Natural Language Grammars, Lexeme, Phonemes, Phrases and Idioms, Word Order, Tense, Probabilistic Models of Spelling, N-grams, Word Classes and Part of Speech Tagging using Maximum Entropy Models, Transformation Based Tagging (TBL), Context Free Grammars for English, Features and Unification, Lexicalized and Parsing, Treebanks, Language and Complexity, Representing Meaning, Semantic Analysis, Lexical Semantics, Word Sense Disambiguation.

- **PROBBILISTIC LANUAGE MODELING** **(08 Hours)**

  Statistical Inference, Hidden Markov Models, Probabilistic (weighted) Finite State Automata, Estimating the Probability of a Word, and Smoothing, Probabilistic Parsing, Generative Models of Language, Probabilistic Context Free Grammars, Probabilistic Parsing, Statistical Alignment and Machine Translation, Clustering, Text Categorization, Viterbi Algorithm for Finding Most Likely HMM Path.

21/9/2020

- **PRAGMATICS** **(06 Hours)**

  Discourse, Dialogue and Conversational Agents, Natural Language Generation, Machine Translation, Dictionary Based Approaches, Reference Resolution, Algorithm for Pronoun Resolution, Text Coherence, Discourse Structure, Applications of NLP- Spell-Checking.

- **MACHINE TRANSLATION** **(08 Hours)**

  Probabilistic Models for Translating One to Another Language, Alignment, Translation, Language Generation, Expectation Maximization, Automatically Discovering Verb Subcategorization, Language Modelling Integrated into Social Network Analysis, Automatic Summarization, Question-Answering, Interactive Dialogue Systems.

- **ADVANCED TOPICS** **(08 Hours)**

  Summarization, Information Retrieval, Vector Space Model, Term Weighting, Homonymy, Polysemy, Synonymy, Improving User Queries, Document Classification, Sentence Segmentation, and Other Language Tasks, Automatically-Trained Email Spam Filter, Automatically Determining the Language, Speech Recognition.

(Total Contact Time: 42 Hours)

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3. Books Recommended:

1. Daniel Jurafsky and James H. Martin, Speech and Language Processing, 2nd Edition, Pearson Education, 2009.
2. James Allen, Natural Language Understanding, 2nd Edition, Addison-Wesley, 1994.
3. Christopher D. Manning and Hinrich Schutze, Foundations of Statistical Natural Language Processing, 1st Edition, MIT Press, 1999.
4. Steven Bird, Natural Language Processing with Python, 1st Edition, O'Reilly, 2009.
5. Jacob Perkins, Python Text Processing with NLTK 2.0 Cookbook, 2nd Edition, Packt Publishing, 2010.
6. A. Bharati, R. Sangal and V. Chaitanya, Natural Language Processing: A Paninian Perspective, PHI, 2000.
7. T. Siddiqui and U. S. Tiwary, Natural Language Processing and Information Retrieval, 1st Edition, Oxford University Press, 2008.

21/7/2022

B.Tech. III (CSE) Semester – VI
CLOUD COMPUTING (CORE ELECTIVE-2)
CS326

	L	T	P	Credit
Scheme	3	0	0	03

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1. Course Outcomes (COs): **At the end of the course, the students will be able to**	
CO1	acquire knowledge of important concepts, key technologies, strengths, and limitations of cloud computing along with its state of the art applications.
CO2	give cloud enabled solutions.
CO3	analyze effectiveness of cloud based solutions.
CO4	identify and evaluate services being offered by different cloud providers.
CO5	design, develop and deploy cloud based applications.

2. Syllabus

- **INTRODUCTION** **(06 Hours)**

  Nutshell of Cloud Computing, Feature Characteristics and Components of Cloud Computing, Challenges, Risks and Approaches of Migration into Cloud, Evaluating the Cloud's Business Impact and Economics, Future of the Cloud.

- **CLOUD COMPUTING ARCHITECTURE** **(14 Hours)**

  Virtualization Technology: Definition, Understanding and Benefits of Virtualization. Implementation Level of Virtualization, Virtualization Structure/Tools and Mechanisms, Hypervisor, VMware, KVM, Xen. Virtualization of CPU, Memory, I/O Devices, Virtual Cluster and Resources Management, Virtualization of Server, Desktop, Network, and Virtualization of Datacentre, Cloud Reference Model, Layer and Types of Clouds, Services Models, Datacentre Design and Interconnection Network, Architectural Design of Computer and Storage Clouds, Micro Service Architecture.

- **CLOUD SERVICE MODELS** **(04 Hours)**

  Introduction, PAAS – Working Principle, Example, SAAS – Working Principle, Example, IAAS – Working Principle, Examples, Service Level Agreements (SLAs), Billing & Accounting, Comparing Scaling Hardware, Economics of Scaling, Managing Data.

- **CLOUD SECURITY** **(06 Hours)**

21/7/18

Infrastructure Security, Data Security and Storage, Identity and Access Management, Access Control, Trust and Reputation, Authentication in Cloud Computing.

- **CASE STUDY ON OPEN SOURCE AND COMMERCIAL CLOUDS** **(12 Hours)**

Eucalyptus, VMware Cloud, GCP, AWS, MS AZURE, IBM CLOUD, Elastic Search.

(Total Contact Time: 42 Hours)

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3. Books Recommended:

1. Nikos Antonopoulos and Lee Gillam, Cloud Computing: Principles, Systems and Applications, 2nd Edition, Springer, 2012.
2. Rajkumar Buyya, James Broberg and Andrzej M. Goscinski, Cloud Computing: Principles and Paradigms, 1st Edition, Wiley, 2011.
3. Ronald L. Krutz and Russell Dean Vines, Cloud Security: A Comprehensive Guide to Secure Cloud Computing, 1st Edition, Wiley-India, 2010.
4. Barrie Sosinsky, Cloud Computing Bible, 1st Edition, Wiley-India, 2010.
5. Tim Mather, Subra Kumara Swamy and Shahed Latif, Cloud Security and Privacy: An Enterprise Perspective on Risks and Compliance, 1st Edition, O'Reilly Media, 2009.

21/7/2020

B.Tech. III (CSE) Semester – VI
WIRELESS NETWORKS (CORE ELECTIVE-2)
CS328

	L	T	P	Credit
Scheme	3	0	0	03

1. Course Outcomes (COs): **At the end of the course, the students will be able to**	
CO1	describe wireless communication technologies, communication standards and multiple access scheme.
CO2	apply mobile adhoc networks routing methods and forwarding strategies.
CO3	analyse routing protocols for Delay Tolerant Networks, Vehicular Ad-hoc Networks, Wireless Access Protocol and GPS.
CO4	evaluate IoT Design & Deployment, IoT System Management and Platforms Design Methodology.
CO5	create a wireless network using modern tools and simulation software's.

2. Syllabus

- **INTRODUCTION** **(06 Hours)**

  Overview of Wireless Technologies and Communication Standards, Medium Access Control in Wireless LANs, Bluetooth Technology, Personal Area Networks, Delay Tolerant Networks and Cellular Networks.

- **MULTIPLE ACCESS SCHEMES** **(06 Hours)**

  Time Division Multiple Access (TDMA), Frequency Division Multiple Access (FDMA), Spread Spectrum Technique, Code Division Multiple Access (CDMA).

- **MOBILE AD HOC NETWORKS** **(08 Hours)**

  Topology-Based Versus Position Based Approaches, Proactive Routing Protocols, Reactive Routing Protocols, Hybrid Routing Protocols, Position Based Routing Issues and Forwarding Strategies.

- **WIRELESS SENSOR NETWORKS** **(08 Hours)**

  Routing Protocols, Localization Methods, Sensor Deployment Strategies, Traffic Flow Pattern in WSN, One to Many, Many to One and Many to Many, Routing Protocols for Delay Tolerant Networks, Routing protocols for Vehicular Ad-hoc Networks, Wireless Access Protocol, GPS (Global Positioning System) and Applications, RFID and its Applications.

- **INTERNET OF THINGS & ITS APPLICATIONS** **(06 Hours)**

21/9/2020

Physical Design, Logical Design, IoT Enabling Technologies, IoT Levels & Deployment Templates, Domain Specific IoTs, IoT and M2M, IoT System Management, IoT Platforms Design Methodology.

- **ADVANCED TOPICS** **(08 Hours)**

5G and Related Technology and Standards, Recent Trends in Wireless Networks.

(Total Contact Time = 42 Hours)

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3. Books Recommended:

1. M. S. Gast, 802.11 Wireless Networks: The Definitive Guide, 3rd Edition, O'Reilly, 2017.
2. J. Schiller, Mobile Communications, 2nd Edition, Pearson India, 2008.
3. Charles Perkins, Adhoc Networking, 1st Edition, Addison Wesley, 2000.
4. W. C. Y. Lee, Mobile Cellular Telecommunications: Analog and Digital Systems, 2nd Edition, TMH, 2017.
5. J. W. Mark and W. Zhuang, Wireless Communications and Networking, 1st Edition, Pearson, 2002.

ADDITIONAL REFERENCE BOOKS

1. Robert Faludi, Building Wireless Sensor Networks, 1st Edition, O'REILLY, 2011.
2. Maciej Kranz, Building the Internet of Things, 1st Edition, Wiley, 2016.

21/7/2020

B.Tech. III (CSE) Semester – VI
OPTIMIZATION METHODS (CORE ELECTIVE-2)
CS332

	L	T	P	Credit
Scheme	3	0	0	03

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1. Course Outcomes (COs): **At the end of the course, the students will be able to**	
CO1	acquire knowledge about optimization methods to model real-life problems.
CO2	apply the knowledge of optimization techniques to solve engineering optimization problems.
CO3	analyse the complexity and efficiency of optimization techniques.
CO4	evaluate various optimization methods for a given problem.
CO5	design and develop a solution to complex engineering problem with the help of suitable optimization technique.

2. Syllabus

- **INTRODUCTION AND MATHEMATICAL REVIEW** **(04 Hours)**

  Methods of Proof, Vector Spaces and Matrices, Real Vector Space, Rank of a Matrix, Linear Equations, Inner Product and Norms, Linear Transformations, Eigen Values and Eigen Vectors, Orthogonal Projections, Quadratic Forms, Matrix Norms, Line Segments, Hyperplanes and Linear Varieties, Convex Sets, Neighbourhood, Polytopes and Polyhedral, Sequences and Limits, Differentiability, The Derivative Matrix, Differentiation Rules, Level Sets and Gradients, Taylor Series.

- **UNCONSTRAINED OPTIMIZATION** **(12 Hours)**

  Basics of Set-Constrained and Unconstrained Optimization, Conditions for Local Minimizers, Golden Section Search, Fibonacci Search, Newton's Method, Secant Method, Gradient Methods, The Method of Steepest Descent, Analysis of Gradient Methods, Convergence, Convergence Rate, Levenberg-Marquardt Modification, Newton's Method for Nonlinear Least-Squares, Conjugate Direction Methods, Quasi-Newton Methods, Approximating the Inverse Hessian, The Rank One Correction Formula, The DFP Algorithm, The BFGS Algorithm, Solving Ax = b, Least-Squares Analysis , Recursive Least-Squares Algorithm, Kaczmarz's Algorithm, Unconstrained Optimization and Neural Networks, Single-Neuron Training, Backpropagation Algorithm, Genetic Algorithms, Chromosomes and Representation Schemes, Selection and Evolution, Real-Number Genetic Algorithms.

- **LINEAR PROGRAMMING** **(10 Hours)**

Introduction, Examples, Two-Dimensional Linear Programs, Convex Polyhedra and Linear Programming, Standard Form Linear Programs, Basic Solutions, A Geometric View of Linear Programs, Simplex Methods, Solving Linear Equations Using Row Operations, The Canonical Augmented Matrix, Updating the Augmented Matrix, The Simplex Algorithm, Matrix Form of the Simplex Method, The Two-Phase Simplex Method, The Revised Simplex Method, Duality, Dual Linear Programs, Properties of Dual Problems, Non-Simplex Methods, Khachiyan's Method, Affine Scaling Method, Karmarkar's Method.

- **NONLINEAR CONSTRAINED OPTIMIZATION** **(10 Hours)**

  Problems with Equality Constraints, Tangent and Normal Spaces, Lagrange Condition, Second-Order Conditions, Minimizing Quadratics Subject to Linear Constraints, Problems with Inequality Constraints, Karush-Kuhn-Tucker Condition, Second-Order Conditions, Convex Optimization Problems, Convex Functions, Algorithms for Constrained Optimization, Projections, Projected Gradient Methods, Penalty Methods.

- **SPECIAL TOPICS FOR APPLIED AREAS** **(6 Hours)**

  Accelerated First Order Methods, Bayesian Methods, Coordinate Methods, Cutting Plane Methods, Interior Point Methods, Optimization Methods for Deep Learning, Parallel and Distributed Methods, Robust Optimization Problems and Methods, Stochastic Mini-batch Methods, Submodular Optimization Problems and Methods, Variance Reduced Stochastic Methods, Zeroth Order Methods.

(Total Contact Time: 42 Hours)

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3. Books Recommended:

1. E. K. P. Chong and S. Zak, An introduction to Optimization, 2nd Edition, John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2004.
2. T. Hastie, R. Tibshirani and M. J. Wainwright, Statistical Learning with Sparsity: The Lasso and Generalizations, 1st Edition, Chapman and Hall/CRC Press, 2015.
3. S. Sra, S. Nowozin and S. Wright, Optimization for Machine Learning , 1st Edition, The MIT Press, 2011.
4. Y. Nesterov, Introductory Lectures on Convex Optimization, 2nd Edition, Kluwer-Academic, 2003.
5. S. Boyd and L. Vandenberghe, Convex Optimization, 1st Edition, Cambridge University Press, 2003.

ADDITIONAL REFERENCE BOOKS

1. D. Bertsekas, Nonlinear Programming, 3rd Edition, Athena Scientific, 1999.
2. R. Fletcher, Practical Methods of Optimization, 2nd Edition, Wiley, 2000, New York.

21/9/2020

B.Tech. IV (CSE) Semester – VII
SOFTWARE ENGINEERING (CORE-15)
CS401

	L	T	P	Credit
Scheme	3	1	2	05

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1. Course Outcomes (COs): **At the end of the course, the students will be able to**	
CO1	explain various phases of software development lifecycle.
CO2	apply appropriate software modelling and testing techniques for the given application scenario.
CO3	analyse various tools and techniques used in software development lifecycle.
CO4	evaluate the software for quality and risk factors.
CO5	design and develop software systems using appropriate software processes.

2. Syllabus

- **INTRODUCTION** **(02 Hours)**

  Software Process - Software Development Life Cycle – Software Qualities - Problems with Software Production – Brooke's No Silver Bullet.

- **SOFTWARE LIFE-CYCLE MODELS** **(04 Hours)**

  Build-and-Fix, Waterfall, Rapid Prototyping, Incremental, Spiral, Agile, Comparison, ISO 9000 – CMM levels – Comparing ISO 9000 and CMM.

- **SOFTWARE REQUIREMENTS AND ANALYSIS** **(06 Hours)**

  Techniques - Feasibility Analysis - Requirements Elicitation – Validation - Rapid Prototyping - OO Paradigms vs. Structured Paradigm - OO Analysis (Modules, Object, Cohesion, Coupling, Objects and Reuse) - CASE tools.

- **SOFTWARE SPECIFICATIONS** **(12 Hours)**

  Specification Document – Specification Qualities, Uses, Classification – Operational Behavioural – DFD, Overview of UML Diagrams, Finite State Machines, Petri nets – Descriptive Specifications – ER Diagrams, Logic, Algebraic Specs - Comparison of Various Techniques and CASE Tools.

- **FORMAL METHODS IN SOFTWARE ENGINEERING** **(06 Hours)**

  Formal Specifications, Software Verification & Validation, Clean Room Engineering, - Formal Approaches, Model Checking – SPIN Tool for Distributed Software.

21/7/2020

- **CASE TOOLS, ISO AND CAPABILITY MATURITY MODEL** **(04 Hours)**

  CASE Tools - Stepwise Refinement - Cost-Benefit Analysis - Scope of CASE - Versions Control - Current State of the Art in Software Engineering-Current State of the Art.
- **SOFTWARE TESTING PRINCIPLES** **(06 Hours)**

  Non-execution & Execution based Testing – Automated Static Analysis – Test-Case Selection - Black-Box and Glass-Box Testing - Testing Objects - Testing vs. Correctness Proof.
- **ADVANCED TOPICS** **(02 Hours)**
- **Tutorials will be based on the coverage of the above topics separately** **(14 Hours)**
- **Practicals will be based on the coverage of the above topics separately** **(28 Hours)**

(Total Contact Time: 42 Hours + 14 Hours + 28 Hours = 84 Hours)

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3. Tutorials:

1 Based on: SDLC.

2 Based on: Requirements engineering.

3 Based on: Data flow diagram.

4 Based On: Use case, Sequence diagrams, Collaboration diagrams.

5 Based on: FSM, Petri nets.

6 Based on: Logic specification, Algebraic specification.

7 Based on: Software cost estimation and quality assurance.

8 Based on: Software test case designing.

4. Practicals:

1 Splint tool- Introduction, Installation and Exploring Tool.

2 Designing C program fragment for all class of errors listed for splint tool and to Compare the outputs of Splint and the Standard C compiler.

3 Spin tool and Promela language introduction, Spin installation, Exploring tool and language usage.

4 Designing promela models and their verification in Spin.

5 Mini project : Identifying and formulating a software engineering problem, identifying it's specifications, designing it using various models introduced in classes, implementing prototype of that system, and testing the software systems that meets specification, performance, maintenance and quality requirements.

21/9/2020

6 Implementation of testing tools.
7 Implementation of software development models.
8 Implementation of agile technology based software development.

5. Books Recommended:

1. Rajib Mall, Fundamentals of Software Engineering , 4th Edition, PHI Learning, 2015.
2. Sommerville, Software Engineering, 9th Edition, Pearson Education, 2010.
3. Stephen R. Schach, Object Oriented and Classical Software Engineering, 8th Edition, McGraw-Hill, 2010.
4. Roger S. Pressman, Software Engineering – A Practitioner's Approach, 7th Edition, McGraw-Hill, 2010.
5. Pankaj Jalote, An Integrated Approach to Software Engineering, 3rd Edition, Narosa, 2005.

ADDITIONAL REFERENCE BOOKS

1. Ghezzi, Jazayeri and Mandrioli, Fundamentals of Software Engineering, 2nd Edition, Pearson Education, 2002.
2. Stephen R. Schach, Software Engineering with JAVA, TMH, 1999.

21/7/2020

B.Tech. IV (CSE) Semester – VII
INNOVATION, INCUBATION AND ENTREPRENEURSHIP
HU410

	L	T	P	Credit
Scheme	3	0	0	03

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1. Course Outcomes (COs): **At the end of the course, the students will be able to**	
CO1	explain the concepts of entrepreneurship.
CO2	develop skills related to various functional areas of management (Marketing Management, Financial Management, Operations Management, Personnel Management etc.).
CO3	develop skills related to Project Planning and Business Plan development.
CO4	demonstrate the concept of Innovation, Intellectual Property Rights (IPR) and Technology Business incubation.
CO5	build knowledge about Sources of Information and Support for Entrepreneurship.
CO6	develop entrepreneurial culture.

2. Syllabus

- **CONCEPTS OF ENTREPRENEURSHIP** **(10 Hours)**

  Scope of Entrepreneurship, Definitions of Entrepreneurship and Entrepreneur, Characteristics of an Entrepreneur, Entrepreneurial Development models and Theories, Entrepreneurs Vs Managers Classification of Entrepreneurs; Major types of Entrepreneurship – Techno Entrepreneurship, Women Entrepreneurship, Social Entrepreneurship, Intrapreneurship (Corporate entrepreneurship), Rural Entrepreneurship, Family Business etc.; Problems for Small Scale Enterprises and Industrial Sickness; Entrepreneurial Trait Tests; Entrepreneurial Environment – Political, Legal, Technological, Natural, Economic, Socio – Cultural etc.; Motivation; Business Opportunity Identification.

- **FUNCTIONAL MANAGEMENT AREA IN ENTREPRENEURSHIP** **(12 Hours)**

  Marketing Management: Basic concepts of Marketing, Development of Marketing Strategy and Marketing plan, Online Marketing, New Product Development Strategy.

  Operations Management: Basic concepts of Operations management, Location problem, Development of Operations strategy and plan.

  Personnel Management: Main operative functions of a Personnel Manager, Development of H R strategy and plan.

  Financial Management: Basics of Financial Management, Ratio Analysis, Capital Budgeting, Working Capital Management, Cash Flow Statement, Break Even Analysis.

- **PROJECT PLANNING** **(06 Hours)**

  Product Development – Stages in Product Development; Feasibility analysis – Technical, Market, Economic, Financial etc.; Project report; Project appraisal; Setting up an Industrial unit – procedure and formalities in setting up an Industrial unit; Business Plan Development.

- **PROTECTION OF INNOVATION THROUGH IPR** **(04 Hours)**

  Introduction to Intellectual Property Rights – IPR, Patents, Trademarks, Copy Rights.

- **INNOVATION AND INCUBATION** **(06 Hours)**

  Innovation and Entrepreneurship, Creativity, Green Technology Innovations, Grassroots Innovations, Issues and Challenges in Commercialization of Technology Innovations, Introduction to Technology Business Incubations, Process of Technology Business Incubation.

- **SOURCES OF INFORMATION AND SUPPORT FOR ENTREPRENEURSHIP** **(04 Hours)**

  State level Institutions, Central Level institutions and other agencies.

(Total Contact Time: 42 Hours)

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3. <u>Books Recommended:</u>

1. Desai Vasant, Dynamics of Entrepreneurial Development and Management, 6th Edition, Himalaya Publishing House, India, 2011.
2. P. M. Charantimath, Entrepreneurial Development and Small Business Enterprises, 3rd Edition, Pearson Education, 2018.
3. David H. Holt, Entrepreneurship: New Venture Creation, Pearson Education, 2016.
4. P. Chandra, Projects: Planning, Analysis, Selection, Financing, Implementation and Review, 9th Edition, Tata McGraw Hill, 2019.
5. T. R. Banga and S. C. Shrama, Industrial Organisation & Engineering Economics, 25th Edition, Khanna Publishers, 2015.

ADDITIONAL REFERENCE BOOKS

1. L. M. Prasad, Principles & Practice of Management, 8th Edition, Sultan Chand & Sons, 2015.
2. Everett E. Adam and Ronald J. Ebert, Production and Operations Management, 5th Edition, Prentice Hall of India, 2012.
3. P. Kotler, K. L. Keller, A. Koshi and M. Jha, Marketing Management – A South Asian Perspective , 14th Edition, Pearson, 2014.
4. P. C. Tripathi, Personnel Management & Industrial Relations, 21st Edition, Sultan Chand & Sons, 2013.
5. P. Chandra, Financial Management, 9th Edition, Tata McGraw Hill, 2015.

21/7/2020

B.Tech. IV (CSE) Semester – VII
COMPUTER GRAPHICS (CORE ELECTIVE-3)
CS421

	L	T	P	Credit
Scheme	3	0	0	03

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1. Course Outcomes (COs): **At the end of the course, the students will be able to**	
CO1	describe Computer Graphics Systems, scan conversion process, object representation, object filling and related algorithms.
CO2	use geometric transformations on graphics objects and apply them in composite form.
CO3	analyse various techniques of clipping, transformations and projection to extract scene and transform it to display device.
CO4	evaluate various techniques for effective scene generation with special effects and animation.
CO5	create an application using computer graphics tools and software's in the development of computer games, information visualization and business applications.

2. Syllabus

- **INTRODUCTION** **(06 Hours)**

  Overview, Classification, Characteristics and Advantages of Computer Graphics, Coordinate Representation, Raster Scan & Random Scan methods, Video Basics, Display devices, Interactive Devices and Hardcopy Devices. Digital Images, Image Formation, Image Representation and Modelling, Overview of Image and Graphics Applications, Graphics Libraries & Graphic Software's.

- **GRAPHICS PRIMITIVES** **(08 Hours)**

  Line, Circle, Ellipse Generating Algorithms, Character Generation, Polygon Drawing and Representation, Polygon Filling Algorithms – Scanline Algorithms, Edge List Algorithm, Edge Fill Algorithm, Fence Fill Algorithm, Edge Flag Algorithm, Seed Fill Algorithms, Simple Seed Fill, Scan Line Seed Fill Algorithms.

- **2D AND 3D TRANSFORMATIONS** **(08 Hours)**

  Representation of Objects in Matrix Form, 2-D Transformations, Homogeneous Coordinates, Combined Transformations, Transformation between Coordinate Systems, Affine Transformation, 3-D Transformation, Multiple Transformation, Coordinate Transformation.

- **3D PROJECTION** **(04 Hours)**

21/12/22

Introduction to Projection, Categories of Projection, Parallel Projection, Perspective Projection, 3-D Viewing and Viewing Parameters.

- **CLIPPING** **(08 Hours)**

  Viewing Transformation, Window to Viewport Coordinate Transformation, Point Clipping, Line Clipping, Cohen-Sutherland Line Clipping algorithm, Mid-Point Line Clipping Algorithm, Polygon Clipping, Sutherland-Hodgeman Algorithm, Weiler Atherton Algorithm; Curve Clipping, Text Clipping, Interior Exterior Clipping, 3- D Clipping, 3-D Mid-Point Subdivision Algorithm.

- **ADVANCE TOPICS** **(08 Hours)**

  Overview of Hidden Lines and Visible Surface Methods, Fundamentals of Curve Generation, Illumination, Shading Lighting, Color and Animation, Special-Purpose Graphics Hardware, Recent Developments.

- **Tutorials will be based on the coverage of the above topics separately.** **(14 Hours)**

(Total Contact Time: 42 Hours)

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3. Books Recommended:

1. Peter Shirley, Steve Marschner and others, Fundamentals of Computer Graphics, 4th Edition, A K Peters/CRC Press, 2015.
2. James D. Foley, Andries van Dam, Steven K. Feiner and F. Hughes John, Computer Graphics: Principles and Practice in C, 2nd Edition, Addison Wesley, 2012.
3. D. Hearn and M. Baker, Computer Graphics with OpenGL, 3rd Edition, Pearson India, 2013.
4. Edward Angel, Interactive Computer Graphics - A Top-Down Approach Using OpenGL, 5th Edition, Pearson Education, 2012.
5. F. S. Hill Jr. and S. M. Kelley, Computer Graphics using OpenGL, 3rd Edition, Pearson India, 2015.

21/7/2020

B.Tech. IV (CSE) Semester – VII
BLOCKCHAIN TECHNOLOGY (CORE ELECTIVE - 3)
CS423

	L	T	P	Credit
Scheme	3	0	0	03

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1. **Course Outcomes (COs):** **At the end of the course, the students will be able to**	
CO1	describe the need, functions and challenges of blockchain technology.
CO2	deploy smart contracts for given use cases.
CO3	analyse blockchain based system structure and security offered therein.
CO4	asses functions, benefits and limitations of various blockchain platforms.
CO5	design and develop solution using blockchain technology in various application domains.

2. Syllabus

- **INTRODUCTION** **(04 Hours)**

  Introduction to Blockchain Technology, Concept of Blocks, Transactions, Distributed Consensus, the Chain and the Longest Chain, Cryptocurrency, Blockchain 2.0, Permissioned Model of Blockchain, Permission less Blockchain.

- **DECENTRALIZATION USING BLOCKCHAIN** **(06 Hours)**

  Methods of Decentralization, Disintermediation, Contest-Driven Decentralization, Routes to Decentralization, the Decentralization Framework Example, Blockchain and Full Ecosystem Decentralization, Storage, Communication, Computing Power and Decentralization, Smart Contracts, Decentralized Autonomous Organizations, Decentralized Applications (DApps), Requirements and Operations of DApps, DApps Examples, Platforms for Decentralizations.

- **CRYPTO PRIMITIVES FOR BLOCKCHAIN** **(04 Hours)**

  Symmetric and Public Key Cryptography, Cryptographic Hard Problems, Key Generation, Secure Hash Algorithms, Hash Pointers, Digital Signatures, Merkle Trees, Patricia trees, Distributed Hash Tables.

- **BITCOINS AND CRYPTOCURRENCY** **(06 Hours)**

  Introduction, Digital Keys and Addresses, Private and Public Keys in Bitcoins, Base58Check Encoding, Vanity Addresses, Multi Signature Addresses, Transaction Lifecycle, Data Structure for Transaction, Types of Transactions, Transaction Verification, The Structure of Block in Blockchain, Mining, Proof of Work, Bitcoin Network and Payments, Bitcoin Clients and APIs, Wallets, Alternative Coins, Proof of Stake, Proof of Storage, Various Stake Types, Difficulty Adjustment and Retargeting Algorithms, Bitcoin Limitations.

- **SMART CONTRACTS** **(02 Hours)**

  Smart Contract Templates, Oracle, Smart Oracle, Deploying Smart Contract on Blockchain.

- **PERMISSIONED BLOCKCHAIN** **(05 Hours)**

  Models and Use-cases, Design Issues, Consensus, Paxos, RAFT Consensus, Byzantine General Problem, Practical Byzantine Fault Tolerance.

- **DEVELOPMENT TOOLS AND FRAMEWORKS** **(05 Hours)**

  Solidity Compilers, IDEs, Ganache, Metamask, Truffle, Contract Development and Deployment, Solidity Language, Types, Value Types, Literals, Enums, Function Types, Reference Types, Global Variables, Control Structures, Layout of Solidity Source Code File.

- **HYPERLEDGER** **(05 Hours)**

  The Reference Architecture, Requirements and Design Goals of Hyperledger Fabric, The Modular Approach, Privacy and Confidentiality, Scalability, Deterministic Transactions, Identity, Auditability, Interoperability, Portability, Membership Services in Fabric, Blockchain Services, Consensus Services, Distributed Ledger, Sawtooth Lake, Corda.

- **BLCOKCHAIN USE-CASES AND CHALLENGES** **(05 Hours)**

  Finances, Government, Supply Chain, Security, Internet of Things, Scalability and Challenges, Network Plane, Consensus Plane, Storage Plane, View Plane, Block Size Increase, Block Interval Reduction, Invertible Bloom Lookup Tables, Private Chains, Sidechains, Privacy Issues, Indistinguishability Obfuscation, Homomorphic Encryption, Zero Knowledge Proofs, State Channels, Secure Multiparty Computation, Confidential Transactions.

(Total Contact Time = 42 Hours)

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3. Books Recommended:

1. Imran Bashir, Mastering Blockchain, 2nd Edition, Packt publishing, Mumbai, 2018.
2. Andreas Antonopoulos, Mastering Bitcoin: Unlocking Digital Cryptocurrencies, 2nd Edition, O'Reilly, 2014.
3. Melanie Swan, Blockchain Blueprint for a New Economy, 1st Edition, O'Reilly Media, 2015.
4. Don and Alex Tapscott, Blockchain Revolution, 1st Edition, Penguin Books Ltd, 2018.
5. Alan T. Norman, Blockchain Technology Explained, 1st Edition, CreateSpace Independent Publishing Platform, 2017.

B.Tech. IV (CSE) Semester – VII
SMARTPHONE COMPUTING AND APPLICATIONS
(CORE ELECTIVE-3)
CS425

	L	T	P	Credit
Scheme	3	0	0	03

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1. Course Outcomes (COs): **At the end of the course, the students will be able to**	
CO1	acquire knowledge about different types of mobile operating systems and architecture.
CO2	setup, configure, deploy and run applications on smart phone using state of the art IDE and/or tools.
CO3	debug and troubleshoot the issues related to operating system, database, security, etc.
CO4	evaluate effectiveness of different mobile operating systems.
CO5	design and develop different smart phone applications.

2. Syllabus

- **INTRODUCTION** **(09 Hours)**

  Introduction to Mobile Computing, Introduction to Android Development Environment, Mobile Devices vs. Desktop Devices, ARM and Intel Architectures, Power Management, Screen Resolution, Touch Interfaces, Application Deployment, App Store, Google Play, Windows Store, Development Environments: XCode, Eclipse, VS2012, PhoneGAP, etc., Native vs. Web Applications, Factors in Developing Mobile Applications: Mobile Software Engineering, Frameworks and Tools, Generic UI Development, Android User, Graphics and Multimedia: Performance and Multithreading, Graphics and UI Performance, Android Graphics, Mobile Agents and Peer-to-Peer Architecture, Android Multimedia.

- **MOBILE OS ARCHITECTURE** **(09 Hours)**

  Comparing and Contrasting Architectures of All Three – Android, iOS and Windows, Underlying OS, Kernel Structure and Native Level Programming. Approaches to Power Management, Security. Android/iOS/Win 8 Survival and Basic Apps: Building a Simple Hello World App in All Three Applications, App-structure, Built-in Controls, File Access, Basic Graphics. Platforms and Additional Issues: Development Process, Architecture, Design, Technology Selection, Mobile App Development Hurdles, Testing.

- **ANDROID/IOS/WIN APPLICATIONS** **(12 Hours)**

  DB Access, Network Access, Contacts/Photos/etc. Underneath the Frameworks: Native Level Programming on Android, Low-Level Programming on (jailbroken) iOS, Windows Low Level APIs.

21/7/22

Intents and Services: Android Intents and Services, Characteristics of Mobile Applications, Successful Mobile Development; Storing and Retrieving Data: Synchronization and Replication of Mobile Data, Getting the Model Right, Android Storing and Retrieving Data, Working with a Content Provider; Putting It All Together: Packaging and Deploying, Performance Best Practices, Android Field Service App.

- **ADVANCE TOPICS** **(06 Hours)**

  Power Management: Wake Locks and Assertions, Low-Level OS Support, Writing Power-Smart Applications. Augmented Reality via GPS and Other Sensors: GPS, Accelerometer, Camera. Mobile Device Security in Depth: Mobile Malware, Device Protections, iOS Jailbreaking , Android rooting and Windows defenestration ; Security and Hacking: Active Transactions, More on Security, Hacking Android.

- **MOBILE PRIVACY AND SECURITY** **(06 Hours)**

  Side Channel Attacks, Inference Algorithms, Hardware Loopholes, Sensor Data Leaks, Case Studies.

(Total Contact Time: 42 Hours)

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3. Books Recommended:

1. Tomasz Nurkiewicz and Ben Christensen, Reactive Programming with RxJava, O'Reilly Media, 2016.
2. Bill Phillips, Chris Stewart, Brian Hardy, and Kristin Marsicano, Android Programming: The Big Nerd Ranch Guide, 2nd Edition, Big Nerd Ranch LLC, 2015.
3. Cristian Crumlish and Erin Malone, Designing Social Interfaces, 2nd Edition, O'Reilly Media, Inc., 2014.
4. Maximiliano Firtman, Programming the Mobile Web, 2nd Edition, O'Reilly Media Inc., 2013.
5. Suzanne Ginsburg, Designing the iPhone User Experience: A User-Centered Approach to Sketching and Prototyping iPhone Apps, Addison-Wesley Professional, 2010.

ADDITIONAL REFERENCE BOOKS

1. Brian Fling, Mobile Design and Development, O'Reilly Media Inc., 2009.
2. Valentino Lee, Heather Schneider and Robbie Schell, Mobile Applications: Architecture, Design and Development, Prentice Hall, 2004.

21/9/2020

B.Tech. IV (CSE) Semester – VII
VIDEO CODEC STANDARD AND DESIGN
(CORE ELECTIVE - 3)
CS427

	L	T	P	Credit
Scheme	3	0	0	03

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1. Course Outcomes (COs): **At the end of the course, the students will be able to**	
CO1	describe image and video compression standards and related algorithms.
CO2	apply motion Estimation and Compensation techniques to enhance Motion Model.
CO3	analyse working of various coding methods and Video Coding Standards to undertake meaningful CODEC design.
CO4	evaluate Control Parameters and Status Parameters for design of a CODEC to improve Performance.
CO5	carry out design and testing of a video CODEC for the given application.

2. Syllabus

- **IMAGE AND VIDEO COMPRESSION FUNDAMENTALS** **(06 Hours)**

  Image Compression Fundamentals, Classification of Image Compression Algorithms, Lossless and Lossy Compression Algorithms, Various Image and Video Standards.

- **MOTION ESTIMATION AND COMPENSATION** **(06 Hours)**

  Introduction, Motion Estimation and Compensation, Full Search Motion Estimation, Comparison of Motion Estimation Algorithms, Sub-Pixel Motion Estimation, Choice of Reference Frames, Enhancements to the Motion Model, Implementation.

- **CODING** **(06 Hours)**

  Discrete Wavelet Transform, Fast Algorithms for the DCT, Separable Transforms, Flow Graph Algorithms, Distributed Algorithms, Other DCT Algorithms, Implementing the DCT, Software DCT, Hardware DCT, Quantization, Types of Quantizing methodologies: Related Design, Implementation, Vector Quantization.

- **VIDEO CODING STANDARDS : H.261, H.263 AND H.26L** **(06 Hours)**

  H.261, H.263 and H.26L, Motion Estimation and Compensation, Transform Coding, Entropy Coding, Pre and Post Processing, Rate, Distortion and Complexity, Transmission of Coded Video, Platforms, And Video CODEC Design.

- **VIDEO CODING STANDARDS : JPEG AND MPEG** **(06 Hours)**

  Introduction, The International Standard Bodies, The Expert Groups, The Standardization Process, Understanding and Using the Standards, JPEG, Motion JPEG, MPEG , JPEG-2000, IMPEG- 1, MPEG-2, MPEG-4.

- **VIDEO CODEC DESIGN** **(06 Hours)**

  Introduction, Video CODEC Interface, Coded Data In/Out, Control Parameters , Status Parameters, Design of a Software CODEC, Design Goals, Specification and Partitioning, Designing the Functional Blocks, Improving Performance, Testing, Design of a Hardware CODEC: Design Goals.

- **ADVANCED TOPICS** **(06 Hours)**

  Current Standard Evolution, Video Coding Research, Platform Trends, Application Trends, Video CODEC Design, Contemporary Research Topics.

(Total Contact Time = 42 Hours)

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3. Books Recommended:

1. Iain E. Richardson, Video Codec Design: Developing Image and Video Compression Systems, 1st Edition, Wiley, 2002.
2. Iain E. Richardson, H.264 and MPEG-4 Video Compression: Video Coding for Next Generation Multimedia, 1st Edition, Wiley, 2008.
3. M. Ghanbari, Standard Codecs: Image Compression to Advanced Video Coding (Telecommunications), 3rd Edition, Institution of Engineering and Technology, 2010.
4. Khalid Sayood, Lossless Compression Handbook (Communications, Networking and Multimedia), 1st Edition, Academic Press, 2002.
5. Aaron Owen and Andy Beach, Video Compression Handbook, 2nd Edition, Peachpit Press, ISBN:9780134846736, July 2018.

B.Tech. IV (CSE) Semester – VII
COMPUTATIONAL GEOMETRY (CORE ELECTIVE - 3)
CS429

	L	T	P	Credit
Scheme	3	0	0	03

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1. Course Outcomes (COs): **At the end of the course, the students will be able to**	
CO1	explain fundamental problems within computational geometry and general techniques for solving problems.
CO2	apply geometric techniques to real-world problems in various application domains viz., graphics rendering, geographical information systems and robotics.
CO3	analyse geometrical algorithmic techniques for large domains.
CO4	evaluate geometric algorithms and determine its significance and merits with respect to given criteria.
CO5	design and develop algorithms and data structures to solve geometric problems.

2. Syllabus

- **INTRODUCTION** **(02 Hours)**

  Convex Hulls, Degeneracies and Robustness, Application domains.

- **LINE SEGMENT INTERSECTION** **(04 Hours)**

  Line Segment Intersection, Doubly-Connected Edge List, Computing the Overlay of Two Subdivisions, Boolean Operations.

- **POLYGON TRIANGULATION AND PARTITIONING** **(04 Hours)**

  Art Gallery Theorems, Triangulation, Area of Polygon, Monotone Partitioning, Trapezoidalization, Partition into Monotone Mountains, Linear Time Triangulation, Convex Partitioning.

- **CONVEX HULLS** **(04 Hours)**

  The Complexity of Convex Hulls in 2D and 3D Space, Computing Convex Hulls, The Analysis, Convex Hulls and Half-Space Intersection.

- **LINEAR PROGRAMMING** **(04 Hours)**

  The Geometry of Casting, Half-Plane Intersection, Incremental Linear Programming, Randomized Linear Programming, Unbounded Linear Programs, Linear Programming in Higher Dimensions, Smallest Enclosing Discs.

11/7/2024

- **ORTHOGONAL RANGE SEARCHING** **(04 Hours)**

  1-Dimensional Range Searching, Kd-Trees, Range Trees, Higher-Dimensional Range Trees, General Sets of Points.

- **VORONOI DIAGRAMS** **(04 Hours)**

  Definition and Basic Properties, Computing the Voronoi Diagram, Voronoi Diagrams of Line Segments, Farthest-Point Voronoi Diagrams, Connection to Convex hulls.

- **POINT LOCATION** **(04 Hours)**

  Point Location and Trapezoidal Maps, Randomized Incremental Algorithm, Dealing with Degenerate Cases, Tail Estimate.

- **MOTION PLANNING** **(04 Hours)**

  Shortest Path, Moving a Disk, Translating a Convex Polygon, Moving a Ladder, Robot Arm Motion, Separability.

- **ARRANGEMENT AND DUALITY** **(04 Hours)**

  Computing the Discrepancy, Duality, Arrangements of Lines, Levels and Discrepancy.

- **ADVANCED TOPICS** **(04 Hours)**

  Interval Trees, Priority Search Trees, Segment Trees, Binary Space Partitions, Robot Motion Planning, Quadtrees, Visibility Graphs.

(Total Contact Time = 42 Hours)

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3. <u>Books Recommended:</u>

1. Joseph O'Rourke, Computational geometry in C, Cambridge University Press, 1998.
2. Mark de Berg, Otfried Cheong, Marc van Kreveld and Mark Overmars, Computational Geometry - Algorithms and Applications, 3rd Edition, Springer, 2008.
3. Franco P. Preparata and Michael Ian Shamos, Computational geometry, Springer, 1985.
4. Csaba D. Toth, Joseph O'Rourke and Jacob E. Goodman, Handbook of Discrete and Computational Geometry (Discrete Mathematics and Its Applications), 3rd Edition, Chapman and Hall/CRC, 2017.
5. Mark de Berg, Marc van Kreveld and Mark Overmars, Computational Geometry: Algorithms and Applications, 1st Edition, Springer, 2013.

21/7/2023

B.Tech. IV (CSE) Semester – VII
DATA WAREHOUSING AND MINING (CORE ELECTIVE - 4)
CS441

	L	T	P	Credit
Scheme	3	0	0	03

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1. Course Outcomes (COs): **At end of the course, student will be able to**	
CO1	describe the concepts of Data Warehouse and Data Mining and various application domains of DW and DM.
CO2	apply high dimensional modelling and OLAP operations of DW along with Data Mining solutions.
CO3	analyse DM algorithms to solve real world problems.
CO4	evaluate different data mining techniques like data compression, classification, prediction, clustering and association rule mining.
CO5	design and innovate a solution for the given problem.

2. Syllabus

- **OVERVIEW** **(02 Hours)**

  Motivation for Data Mining , Definition and Functionalities, Classification of DM Systems, Integration of a Data Mining System with a Database/Data Warehouse, Issues in DM – KDD Process.

- **DATA PREPROCESSING AND DATA MINING PRIMITIVES** **(06 Hours)**

  Need to Pre-process the Data, Data Cleaning, Data Integration and Transformation, Data Reduction, Discretization and Concept Hierarchy Generation, Data Mining Primitives: What Defines a Data Mining Task?

- **CLASSIFICATION** **(07 Hours)**

  Issues Regarding Classification and Prediction, Categorization of Classification Methods, Decision Tree, Bayesian Classification, Rule Based, CART, Neural Network, CBR, Rough set Approach, Fuzzy Logic, Genetic Algorithms, Prediction Methods, Linear and Nonlinear Regression, Logistic Regression.

- **CLUSTERING** **(07 Hours)**

  Types of Data in Cluster Analysis, Categorization of Major Clustering Methods, Similarity and Distance Measures, Hierarchical Algorithms, Partitioned Algorithms, Clustering Large Databases.

- **ASSOCIATION RULE MINING** **(06 Hours)**

  Data Generalization and Summarization-Based Characterization, Attribute Relevance, Class Comparisons, Association Rule Mining Introduction, Market Basket Analysis - Basic Concepts, Finding Frequent Item Sets, Apriori Algorithm, Generating Rules, Improved Apriori Algorithm, Incremental ARM, Associative Classification – Rule Mining, FP Growth Rule Mining Algorithm.

- **INTRODUCTION TO DATA WAREHOUSING** **(04 Hours)**

  Need of Reporting and Analysing data, Raw Data to Valuable Information-Lifecycle of Data, Business Intelligence (BI) and DW in Today's Perspective, Decision Support Systems, Difference Between database System and Data Warehouse, Overview of the Components of DW, Data Warehouse Life Cycle, Data Warehousing Components, Data Warehousing Architecture, On Line Analytical Processing, Categorization of OLAP Tools.

- **ARCHITECTURE OF BUSINESS INTELLIGENCE AND DATAWAREHOUSE** **(06 Hours)**

  BI and DW Architectures and its Types - Relation Between BI and DW - OLAP (Online analytical processing) Definitions - Difference between OLAP and OLTP, Multi-dimensional Analysis , Data Cubes, Drill-down and Roll-up - Slice and Dice or Rotation, OLAP Models , ROLAP versus MOLAP – defining.

- **DM AND DW FOR BUSINESS APPLICATION** **(04 Hours)**

  Data Mining for Business Applications like Balanced Scorecard, Fraud Detection, Clickstream Mining, Market Segmentation, Retail Industry, Telecommunications Industry, Banking & Finance and CRM, Social Media Data Analysis etc.

(Total Contact Time = 42 Hours)

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3. Books Recommended:

1. J. Han and M. Kamber, Mining: Data Concepts and Techniques, 3rd Edition, Morgan Kaufman, 2011. ISBN 978-0-12-381479-1.
2. Margaret Dunham, Data Mining: Introductory and Advanced Topics, 3rd Edition, Published by Prentice Hall, ISBN-13: 978-8177587852.
3. Alex Berson and Stephen J. Smith, Data Warehousing, Data Mining, and OLAP, 2nd Edition, Tata McGraw- Hill, 2004. ISBN 13: 9780070587410.
4. George M Marakas, Modern Data Warehousing, Mining and Visualization, 2nd Edition, Pearson Education, ISBN 13: 9780131014596.
5. Ralph Kimball and Margy Ross, The Data Warehouse Toolkit: The Complete Guide to Dimensional Modeling, 3rd Edition, Pearson Education Limited, ISBN-13: 978-1118530801.

B.Tech. IV (CSE) Semester – VII
HIGH PERFORMANCE COMPUTING (CORE ELECTIVE - 4)
CS443

	L	T	P	Credit
Scheme	3	0	0	03

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1. Course Outcomes (COs): **At the end of the course, the students will be able to**	
CO1	learn concepts, issues and limitations related to parallel computing architecture and software development.
CO2	apply different parallel models of computation, parallel architectures, interconnections and various memory organization in modern high performance architectures.
CO3	analyze the algorithms to map them onto parallel architectures for parallelism.
CO4	evaluate the performance of different architectures and parallel algorithms with different aspects of real time problems.
CO5	design parallel programs for shared-memory architectures and distributed-memory architectures using modern tools like OpenMP and MPI, respectively for given problems.

2. Syllabus

- **PARALLEL PROCESSING CONCEPTS** **(08 Hours)**

Levels of Parallelism (Instruction, Transaction, Task, Thread, Memory, Function), Models (SIMD, MIMD, SIMT, SPMD, Dataflow Models, Demand-driven Computation etc.), Architectures: N-wide Superscalar Architectures, Multi-core, Multi-threaded.

- **FUNDAMENTAL DESIGN ISSUES IN PARALLEL COMPUTING** **(06 Hours)**

Synchronization, Scheduling, Job Allocation, Job Partitioning, Dependency Analysis, Mapping Parallel Algorithms onto Parallel Architectures, Performance Analysis of Parallel Algorithms.

- **FUNDAMENTAL LIMITATIONS FACING PARALLEL COMPUTING** **(06 Hours)**

Bandwidth Limitations, Latency Limitations, Latency Hiding/Tolerating Techniques and their Limitations, Power-Aware Computing and Communication, Power-Aware Processing Techniques, Power-Aware Memory Design, Power-Aware Interconnect Design, Software Power Management

- **PARALLEL PROGRAMMING** **(10 Hours)**

Programming Languages and Programming-Language Extensions for HPC, Inter-Process Communication, Synchronization, Mutual Exclusion, Basics of Parallel Architecture, Parallel

Programming Parallel Programming with OpenMP and (Posix) Threads, Message Passing with MPI.

- **PARALLEL PROGRAMMING WITH CUDA** **(08 Hours)**

  Processor Architecture, Interconnect, Communication, Memory Organization, and Programming Models in High Performance Computing Architectures: (Examples: IBM CELL BE, Nvidia Tesla GPU, Intel Larrabee Micro architecture and Intel Nehalem Micro architecture), Memory Hierarchy and Transaction Specific Memory Design, Thread Organization.

- **ADVANCE TOPICS** **(04 Hours)**

  Petascale Computing, Optics in Parallel Computing, Quantum Computers.

(Total Contact Time = 42 Hours)

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3. Books Recommended:

1. John L. Hennessy and David A. Patterson, Computer Architecture -- A Quantitative Approach, 4th Edition, Morgan Kaufmann Publishers, 2017, ISBN 13: 978-0-12-370490-0.
2. Barbara Chapman, Gabriele Jost and Ruud van der Pas, Using OpenMP: Portable Shared Memory Parallel Programming , The MIT Press, 2008, ISBN-13: 978-0-262-53302-7.
3. Marc Snir, Jack Dongarra, Janusz S. Kowalik, Steven Huss-Lederman, Steve W. Otto and David W. Walker, MPI: The Complete Reference, Volume 2, The MIT Press, 1998, ISBN: 9780262571234.
4. Pacheco S. Peter, Parallel Programming with MPI, Morgan Kaufman Publishers, 1992, Paperback ISBN: 9781558603394.
5. https://docs.nvidia.com/cuda/cuda-c-programming-guide/index.html.

B.Tech. IV (CSE) Semester – VII
SECURITY IN RESOURCE CONSTRAINED ENVIRONMENT
(CORE ELECTIVE - 4)
CS445

Scheme	L	T	P	Credit
	3	0	0	03

1. Course Outcomes (COs): **At the end of the course, the students will be able to**	
CO1	explain the significance of security in embedded devices, design issues in the security protocols, characteristics of Wireless Sensor Network along with types of probable attacks.
CO2	apply the security mechanisms in embedded systems and Wireless Sensor Networks using various tools.
CO3	debug, trouble shoot basic issues in RTOSs, resource constrained devices and provide security to devices.
CO4	create and evaluate the solution thoroughly using simulators like TOSSIM, Contiki, Cooja.
CO5	design security protocols for a typical Wireless Sensor Network/IoT Systems.

2. Syllabus

- **INTRODUCTION TO EMBEDDED SECURITY** **(04 Hours)**

  Introduction, Review of Security Basics, Services & Mechanisms, Security Requirements in Embedded Systems. Design Challenges in Security for Embedded Systems, Security Gap, Typical Generic Security Threats in Embedded Systems.

- **WIRELESS SENSOR NETWORKS AS EMBEDDED SYSTEMS** **(06 Hours)**

  Evolution of Human Computer Interfaces, Ubiquitous Computing, Pervasive Computing, The Illustrative Sensor Motes, Typical Configurations, Deployment Models and Issues, Typical Applications, Security Issues, Security in Wireless Sensor Networks, Typical Attacks and Countermeasures. The Denial of Service Attacks on Wireless Sensor Networks.

- **TINYOS OPERATING ENVIRONMENT** **(03 Hours)**

  Hands-on on the TinyOS Operating Environment, the NesC Programming Language. The TOSSIM Simulator. The Avrora Emulator. The TinySec Environment and its Files. Hands-on on ContikiCooja Simulator.

- **SECURE DATA AGGREGATION IN WIRELESS SENSOR NETWORKS** **(08 Hours)**

  Motivation for Secure Data Aggregation in Wireless Sensor Networks. End-to-End and Hop-by-Hop Secure Data Aggregation and Issues, Design of a Hop-by-Hop Link Layer Security Protocol in

29/7/20

Wireless Sensor Networks. Design Issues Viz. Security Issues, Performance Issues, Ciphers, Initialization Vector, Message Authentication Code, Authenticated Encryption Modes. Investigating Replay attacks in Link Layer Security Architectures and Typical Mitigation Approaches. The Replay Protection Algorithms Continued. Flexibly Configurable Link Layer Security Architecture for Wireless Sensor Networks.

- **END-TO-END SECURE DATA AGGREGATION IN WIRELESS SENSOR NETWORKS (05 Hours)**

The End-to-End Secure Data Aggregation in Wireless Sensor Networks. The Concept of Fully Homomorphic Encryption, Using the Classical Homomorphic Encryption Algorithms for Privacy in WSNs. Different Approaches to Offer Data Integrity viz. using Conventional MAC - Aggregate MAC, Homomorphic MAC Hybrid Secure Data Aggregation, Malleability Resilient Concealed Data Aggregation.

- **CIPHERS IN THE RESOURCE CONSTRAINED DEVICES (07 Hours)**

Lightweight Ciphers for RFID Devices. The AES Cipher Working and Demo in WSNs. Assignment on AES Encryption Decryption Routines. The TEA Cipher Operation, Demo of Executing RC5 and XXTEA Ciphers in TinySec Environment. Case Study of the Ciphers – Representative Ciphers from the List viz. TEA, XXTEA, RC5, miniAES, PRESENT, Simon, Speck – their Encryption, Decryption and Key Management Routines. Doing Hand Computation of the Intermediate Ciphertext at each Stage in all these Ciphers.

Public Key Infrastructure in Wireless Sensor Networks, The TinyPK Protocol as a Case Study. Attribute Based Encryption and its Motivation for Embedded Systems.

- **SECURITY AND PRIVACY ISSUES IN IOT SYSTEMS (05 Hours)**

The Internet of Things, Architecture, Constituent Elements, The Security and Privacy Issues in IoT Systems, Overview of the IoT Protocols Viz. Continua for Home Health Devices, DDS, DPWS: WS-Discovery-SOAP-WS Addressing-WDSL-XML Schema, HTTP/REST, MQTT, UPnP, XMPP, ZeroMQ. The IoT Security Protocols viz. ZigBee, Bluetooth, 6LowPAN, RPL. The CoAP.

- **SIDE CHANNEL ATTACKS IN EMBEDDED SYSTEMS (02 Hours)**

Introduction, Side Channel Attacks, Passive Versus Active Attacks, Timing, Analysis, Power Analysis, Electromagnetic Analysis, Analysis Tools and Equipment.

- **MISCELLANEOUS TOPICS (02 Hours)**

Overview of Security Support in Data Protection Protocols for the Embedded Systems. SSL, IPSec, IKE, and TLS in Resource Constrained Devices.

(Total Contact Time = 42 Hours)

21/7/22

3. **Books Recommended:**

1. Fei Hu., Security and Privacy in Internet of Things (IOT's): Models, Algorithms and Implementations Handcover, 1st Edition, CRC Press, 2016.
2. R.Giladi and N. Dimitrios, Security and Embedded Systems, Volume 2, IOS Press, 2006.
3. A. G. Voyiatzis, A. G. Fragopoulos and D. N. Serpanos, Security in Embedded Systems Design Issues in Secure Embedded Systems, 1st Edition, CRC press, 2005.
4. R. Zurawski, Embedded Systems Handbook, 1st Edition, CRC Press, 2006.
5. T. Stapko, Practical Embedded Security: Building Secure Resource-Constrained Systems, 2nd Editions, Newnes, 2007.

B.Tech. IV (CSE) Semester – VII
AUDIO AND SPEECH SIGNAL PROCESSING
(CORE ELECTIVE - 4)
CS447

Scheme	**L**	**T**	**P**	**Credit**
	3	0	0	03

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1. Course Outcomes (COs): **At the end of the course, the students will be able to**	
CO1	acquire knowledge of audio and speech production mechanism with signal processing fundamentals.
CO2	apply the knowledge of time and frequency domain analysis methods for audio and speech signal processing.
CO3	analyse the signals for feature extraction as per the requirement of different applications.
CO4	evaluate signals using different modelling, classification and regression techniques.
CO5	build the efficient applications for recognition, classification, synthesis and translation for usage in different fields.

2. Syllabus

- **INTRODUCTION** **(06 Hours)**

  Basic of Signal, Fundamentals of Sound, Speech Production, Frequency Spectrum, Transforms, Human Auditory System, Physics of Audio Signal Generation, Acoustics and Hearing, Discrete Signal Representation and Formats, Convolution, Linearity, Time Variant and Invariant System, Different Types of Digital Filters.

- **SIGNAL PROCESSING** **(06 Hours)**

  Properties of Audio and Speech Signal, Audio Signal Features, Short Time Fourier Transform, Audio Effects, Harmonics, Spectrogram, Audio and Speech Signal Compression, Speech Production, Equalization, Perceptual Audio Coding, Sound Synthesis, Pattern Recognition, Acoustics and Auditory Perception, Auto Correlation Function, Power Spectral Density Function, Wiener Filter.

- **AUDIO PROCSSING** **(10 Hours)**

  Psychoacoustic Representation, Compression Schemes, MP3 and Other Formats, Sound Mixture Organization, Code Book, Audio Coding, Linear Prediction Coding, Noise Reduction, Music Signal Processing, Modulation, Filters for Audio Signal Processing, Echo Cancellation, Music Analysis and Retrieval, Acoustic Source Localization and Tracking.

11/9/2020

- **SPEECH SIGNAL** **(10 Hours)**

  Articulatory Phonetics, Models of Speech Production, Waveform Coding, Time Domain Analysis, Frequency Domain Analysis, Speech Features: Energy, Magnitude, Zero-crossing, Autocorrelation, Silence, Linear Prediction, Acoustic Feature Extraction, Ceptral Processing, Pitch, Mel Frequency Cepstral Coefficients, Speech Recognition, Speaker Recognition, Linear Discriminant Analysis, Principle Component Analysis, Hidden Markov Models, Acoustic Classification Methods: Bayes Methods, Gaussians Mixture Models.

- **ADVANCE TOPICS** **(10 Hours)**

  Independent Component Based Analysis, Neural Network Based Processing, Blind Source Separation, Recognition, Transcription, Enhancement, Coding, Synthesis as well as Applications to Advanced Fixed and Wireless Communication Systems, Speech Conversion, Deep Learning and Audio Activity Detection.

(Total Contact Time = 42 Hours)

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3. Books Recommended:

1. Zölzer Udo, Digital Audio Signal Processing, 2nd Edition, John Wiley & Sons Ltd., 2008.
2. T. F. Quatier, Discrete-time Speech Signal Processing: Principles and Practice, 1st Edition, Upper Saddle River, NJ: Prentice Hall, 2002.
3. B. Gold, N. Morgan and D. Ellis, Speech and Audio Signal Processing: Processing and Perception of Speech and Music , 2nd revised Edition, Wiley-Blackwell, 2011.
4. T. Dutoit, F. Marqués and L. R. Rabiner, Applied Signal Processing: a MATLAB-based Proof of Concept, 1st Edition, New York, London, Springer, 2009.
5. L. R. Rabiner and R. W. Schafer, Theory and Applications of Digital Speech Processing, 1st Edition, Prentice Hall, 2010.

ADDITIONAL REFERENCE BOOKS

1. Y. A. Huang and J. Benesty, Audio Signal Processing for Next-generation Multimedia Communication Systems, New York: Kluwer Academic Publishing, 2004.

21/7/2024

B.Tech. IV (CSE) Semester – VII
SERVICE ORIENTED SYSTEM (CORE ELECTIVE - 4)
CS449

Scheme	L	T	P	Credit
	3	0	0	03

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1. Course Outcomes (COs): **At the end of course, students will be able to**	
CO1	acquire knowledge of SOA ecosystem from a business/technical perspective.
CO2	apply SOA and web services concepts for application design and development.
CO3	analyze different web services in terms of business/technical perspective.
CO4	evaluate SOA based system in terms of business/technical perspective.
CO5	design and develop SOA based system.

2. Syllabus

- **INTRODUCTION** **(10 Hours)**

  XML Document Structure, Well Formed and Valid Documents, Namespaces, DTD, XML Schema, X-Files, Parsing XML using DOM –SAX, XML Transformation and XSL, XSL Formatting, Modelling Databases in XML.

- **SERVICE ORIENTED ARCHITECTURE** **(10 Hours)**

  Characteristics of Service Oriented Architecture, Comparing SOA with Client-Server and Distributed Architectures, Characteristics of SOA, Benefits of SOA, Principles of Service Orientation, Service Layers, Business Process Management.

- **WEB SERVICES** **(14 Hours)**

  SOA and Web Services, Web Services Protocol Stack, Service Descriptions, WSDL, Messaging with SOAP, Service Discovery, UDDI, Service Level Interaction Patterns, XML and Web Services, Enterprise Service Bus, Message Exchange Patterns, WS Transactions, Web Services Technologies, JAX-RPC, JAX-WS, Web Service Standards, WS-RM, WS-Addressing, WS-Policy, Service Orchestration and Choreography, Composition Standards , BPEL, Service Oriented Analysis and Design, Search Engine Optimization.

- **BUILDING SOA-BASED APPLICATIONS** **(08 Hours)**

  Service Oriented Analysis and Design, Service Modelling, Design Standards and Guidelines, Composition, WS-BPEL, WS-Coordination, WS-Policy, WS-Security, SOA Support in Java, B2B and

21/9/2020

B2C E-commerce Development, REST Architecture, REST Full APIs, Micro Service Architecture for Highly Scalable Applications.

(Total Contact Time = 42 Hours)

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3. Books Recommended:

1. Thomas Erl, Service Oriented Architecture: Concepts, Technology and Design, 1st Edition, Pearson Education, 2005.
2. Eric Newcomer and Greg Lomow, Understanding SOA with Web Services, 1st Edition, Pearson Education, 2005.
3. Sandeep Chatterjee and James Webber, Developing Enterprise Web Services: An Architect's Guide, Prentice Hall, 2004.
4. James McGovern, Sameer Tyagi, Michael E. Stevens and Sunil Mathew, Java Web Services Architecture, 1st Edition, Morgan Kaufmann Publishers, 2003.
5. Ron Schmelzer et al., XML and Web Services, 1st Edition, Pearson Education, 2002.

ADDITIONAL REFERENCE BOOKS

1. Frank P. Coyle, XML, Web Services and the Data Revolution, Pearson Education, 2005.

21/7/2020

B.Tech. IV (CSE) Semester – VIII
SOCIAL NETWORK ANALYSIS (CORE ELECTIVE - 5)
CS422

	L	T	P	Credit
Scheme	3	0	0	03

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1. Course Outcomes (COs):
At the end of the course, the students will be able to

CO1	acquire knowledge about the social network data, relations among data, identification of network structure and relevant programming.
CO2	apply the model for the solution of social network problem statement to generate data sets, relations, graph.
CO3	analyze the problem solution for social network analysis considering social influence.
CO4	evaluate programming solutions with different aspects of social network analysis.
CO5	design an innovative optimised solution for the social network application problem using network dynamics.

2. Syllabus

- **INTRODUCTION** **(08 Hours)**

  Introduction of Social Networks, Social Networks Data, Development of Social Network Analysis, Analyzing Social Network Data, Formal Methods, Paths and Connectivity, Graphs to Represent Social Relations, Working with Network Data, Network Datasets, Strong and Weak Ties, Closure, Structural Holes, and Social Capital, Measures for Social Network Analysis.

- **SOCIAL INFLUENCE** **(09 Hours)**

  Homophily, Mechanisms Underlying Homophily, Social Influence, Affiliation, Identification of Roles, Tracking Link Formation in OnLine Data, Spatial Model of Segregation - Positive and Negative Relationships , Structural Balance, Applications of Structural Balance, Weaker Form of Structural Balance.

- **WEB INFORMATION NETWORKS** **(09 Hours)**

  The Structure of the Web, World Wide Web, Information Networks, Hypertext, and Associative Memory, Web as a Directed Graph, Bow-Tie Structure of the Web, Link Analysis and Web Search, Searching the Web: Ranking, Link Analysis using Hubs and Authorities, Page Rank, Link Analysis in Modern Web Search, Applications, Spectral Analysis, Random Walks, and Web Search, Social Network Visualization.

- **SOCIAL NETWORK MINING** **(08 Hours)**

Social Networks, Geography, Neighbourhood Effects, Clustering of Social Network Graphs: Betweenness, Girvan Newman Algorithm, Discovery of Communities, Cliques and Bipartite Graphs, Graph Partitioning Methods, Matrices, Eigen Values, Simrank.

- **NETWORK DYNAMICS** **(08 Hours)**

Network Effects of Local Social Networks and Global Social Networks, Spread of Behaviour, Cascading Behaviour in Networks: Diffusion in Networks, Modelling Diffusion, Cascades and Cluster, Thresholds, Extensions of the Basic Cascade Model, Six Degrees of Separation, Structure and Randomness, Decentralized Search, Empirical Analysis and Generalized Models, Analysis of Decentralized Search, Problem Solving.

(Total Contact Time = 42 Hours)

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3. Books Recommended:

1. Jure Leskovec, Anand Rajaraman and Jeffrey D. Ullman, Mining of Massive Datasets, 2nd Edition, Cambridge University Press, 2014, ISBN: 9781316638491.
2. S. P. Borgatti, M. G. Everett and J. C. Johnson, Analyzing Social Networks , 1st Edition, SAGE Publications Ltd, 2013, ISBN: 9781446247419.
3. David Easley and Jon Kleinberg, Networks, Crowds, and Markets: Reasoning about a Highly Connected World , Cambridge Univ. Press, 2010, ISBN: 9780521195331.
4. Robert A. Hanneman and Mark Riddle, Introduction to Social Network Methods, University of California, 2005.
5. John Scott, Social Network Analysis: A Handbook, 2nd Edition, SAGE Publications Ltd, 2000, ISBN: 9780761963394.

ADDITIONAL REFERENCE BOOKS

1. S. Wasserman and K. Faust, Social Network Analysis: Methods and Applications, 1st Edition, Cambridge University Press, 1994, ISBN: 9780521387071.

21/7/23

B.Tech. IV (CSE) Semester – VIII
NETWORK AND SYSTEM SECURITY (CORE ELECTIVE - 5)
CS424

	L	T	P	Credit
Scheme	3	0	0	03

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1. Course Outcomes (COs): **At the end of the course, the students will be able to**	
CO1	gain knowledge of network and system security attacks and its prevention mechanisms.
CO2	apply different security mechanisms for given application scenario.
CO3	perform security analysis of network and system security protocols.
CO4	evaluate security protocols for different metrics like functionality, cost and efficiency.
CO5	design and integrate security protocols depending on organization's requirement.

2. Syllabus

- **INTRODUCTION** **(04 Hours)**

  Introduction to Network and System Security, Security Attacks, Security Requirements, Confidentiality, Integrity, and Availability, Security Mechanisms, NIST Security Standards, Assets and Threat Models.

- **REVIEW OF CRYPTOGRAPHIC TOOLS** **(04 Hours)**

  Number Theory, Prime Numbers, Modular Arithmetic, Confidentiality with Symmetric Encryption, Message Authentication and Hash Functions, Public-Key Encryption, Digital Signatures and Key Management, Random and Pseudorandom Numbers.

- **SYSTEM SECURITY** **(10 Hours)**

  User Authentication - Means of Authentication, Password-Based Authentication, Token-Based Authentication, Biometric Authentication, Remote User Authentication, Access Control-Access Control Principles, Subjects, Objects, and Access Rights, Discretionary Access Control, Example: UNIX File Access Control, Role-Based Access Control, Database Security-The Need for Database Security, Database Access Control, Inference, Statistical Databases, Database Encryption, Cloud Security, Malicious Software, Intruders, Denial of Service and Distributed Denial of Service attacks, Intrusion Detection and Prevention.

- **SOFTWARE SECURITY AND TRUSTED SYSTEMS** **(12 Hours)**

  Buffer Overflow-Stack Overflows, Defending Against Buffer Overflows, Other Forms of Overflow Attacks, Software Security-Software Security Issues, Handling Program Input, Writing Safe Program Code, Interacting with the Operating System and Other Programs, Handling

2/7/2020

Program Output, Operating System Security-System Security Planning, Operating Systems Hardening, Application Security, Security Maintenance, Linux/Unix Security, Windows Security, Virtualization Security, Trusted Computing and Multilevel Security-The Bell-LaPadula Model for Computer Security, Other Formal Models for Computer Security, The Concept of Trusted Systems, Application of Multilevel Security, Trusted Computing and the Trusted Platform Module, Common Criteria for Information Technology Security Evaluation, Assurance and Evaluation.

- **NETWORK SECURITY** **(10 Hours)**

  Internet Security Protocols and Standards-Secure E-mail and S/MIME, Pretty Good Privacy (PGP), Domain Keys Identified Mail, Secure Sockets Layer (SSL) and Transport Layer Security (TLS), HTTPS, IPv4 and IPv6 Security, IPSec Protocol, Internet Authentication Applications-Kerberos, X.509, Public-Key Infrastructure, Federated Identity Management, Wireless Network Security-Wireless Security Overview, IEEE 802.11 Wireless LAN Overview, IEEE 802.11i Wireless LAN Security, Network Management Security-SNMP Protocol.

- **ADVANCED TOPICS** **(02 Hours)**

(Total Contact Time = 42 Hours)

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3. Books Recommended:

1. William Stallings, Computer Security: Principles and Practice, 2nd Edition, Pearson, 2012.
2. John Vacca, Network and System Security, 2nd Edition, Elsevier, 2013.
3. William Stallings, Network Security Essentials: Applications and Standards, 4th Edition Prentice Hall, 2010.
4. Alfred J. Menezes, Paul C. van Oorschot and Scott A. Vanstone, Handbook of Applied Cryptography, CRC Press, 2001.
5. William Stallings, Cryptography and Network Security, 7th Edition, Pearson, 2018.

2/7/2020

B.Tech. IV (CSE) Semester – VIII
ADVANCED COMPUTER ARCHITECTURE
(CORE ELECTIVE - 5)
CS426

	L	T	P	Credit
Scheme	3	0	0	03

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1. Course Outcomes (COs): **At the end of the course, the students will be able to**	
CO1	describe the various architectural concepts to optimize and enhance the classical Von Neumann architecture into high performance computing hardware systems.
CO2	interpret performance of different pipelined processors and multiprocessor architecture.
CO3	identify, compare and assess issues related to memory, control and I/O functions.
CO4	evaluate the programming solution based on parallelism.
CO5	design solutions in the area of advanced computer architecture.

2. Syllabus

- **OVERVIEW OF VON NEUMANN ARCHITECTURE** **(04 Hours)**

  Instruction Set Architecture, The Arithmetic and Logic Unit, The Control Unit, Memory and I/O Devices and Their Interfacing to the CPU; Measuring and Reporting Performance; CISC and RISC Processors.

- **PIPELINING** **(04 Hours)**

  Basic Concepts of Pipelining, Data Hazards, Control Hazards, and Structural Hazards; Techniques for Overcoming or Reducing the Effects of Various Hazards.

- **INSTRUCTION LEVEL PARALLELISM** **(06Hours)**

  ILP Concepts, Pipelining Overview, Compiler Techniques for Exposing ILP, Dynamic Branch Prediction, Dynamic Scheduling, Multiple instruction Issue, Hardware Based Speculation, Static Scheduling, Multi-threading, Limitations of ILP, Case Studies.

- **DATA-LEVEL PARALLELISM** **(06 Hours)**

  Vector Architecture, SIMD Extensions, Graphics Processing Units, Loop Level Parallelism.

- **THREAD LEVEL PARALLELISM** **(06 Hours)**

21/9/20

Symmetric and Distributed Shared Memory Architectures, Performance Issues, Synchronization, Models of Memory Consistency, Case studies: Intel i7 Processor, SMT & CMP Processors.

- **MEMORY AND I/O** **(06 Hours)**

  Cache Performance, Reducing Cache Miss Penalty and Miss Rate, Reducing Hit Time, Main Memory and Performance, Memory Technology, Types of Storage Devices, Buses, RAID, Reliability, Availability and Dependability, I/O Performance Measures.

- **MULTIPROCESSOR ARCHITECTURE** **(06 Hours)**

  Taxonomy of Parallel Architectures; Centralized Shared-Memory Architecture, Synchronization, Memory Consistency, Interconnection Networks; Distributed Shared-Memory Architecture, Cluster Computers.

- **NON VON NEUMANN ARCHITECTURES:** **(04 Hours)**

  Data Flow Computers, Reduction Computer Architectures, Systolic Architectures.

(Total Contact Time = 42 Hours)

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3. **Books Recommended:**

1. J. L. Hennessy and D. A. Patterson, Computer Architecture: A Quantitative Approach, 5th Edition, Morgan Kaufman Publication, 2012.
2. M. J. Flynn, Computer Architecture: Pipelined and Parallel Processor Design, 1st Edition, Narosa Publishing House, 2011.
3. J. P. Shen and M. H. Lipasti, Modern Processor Design, 1st Edition, MC Graw Hill, Crowfordsville, 2005.
4. Kai Hwang and Faye Briggs, Computer Architecture and Parallel Processing, 1st Edition, MC Graw-Hill International Edition, 2000.
5. D. Sima, T. Fountain and P. Kacsuk, Advanced Computer Architectures: A Design Space Approach, 1st Edition, Addison Wesley, 2000.

B.Tech. IV (CSE) Semester – VIII
CELLULAR NETWORK AND MOBILE COMPUTING
(CORE ELECTIVE - 5)
CS428

	L	T	P	Credit
Scheme	3	0	0	03

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1. Course Outcomes (COs): **At the end of the course, the students will be able to**	
CO1	acquire knowledge about the signalling system and different spread spectrum techniques.
CO2	apply the signal estimation and equalization techniques.
CO3	analyze the cellular system and mobile applications for different types of networks like GSM, GPRS, CDMA and Adhoc.
CO4	evaluate the performance of the protocols, mobile applications and network solutions for wireless communication.
CO5	design and develop the techniques to solve the issues of communication in different types of networks.

2. Syllabus

- **INTRODUCTION** **(06 Hours)**

  Wired Network vs. Wireless Network, Overview of Wireless Applications, Wireless Transmission: Path Loss, Multi-path Propagation, Doppler Shift, Fading, Time Division Multiplexing, Frequency Division Multiplexing, Spread Spectrum Technique, Direct Sequence Spread Spectrum, Frequency Hopping Spread Spectrum, CDMA - Code Division Multiple Access, OFDM - Orthogonal Frequency Division Multiple Access, Satellite Communication.

- **WIRELESS CHANNEL** **(08 Hours)**

  Statistical Modeling of Multipath Fading Channel, Frequency Selective and Non-selective Fading Channels, Flat Fading Channels, Path-loss, Propagation Model, Shadowing, Rayleigh Fading, Equalization, Channel Modeling and Estimation, Blind Channel Estimation, AWGN Channel.

- **CELLULAR SYSTEM** **(10 Hours)**

  Cellular Network Organization, Cellular System Evolution, Cellular Fundamentals: Capacity, Topology, Operation of Cellular Systems, Cellular Geometry, Frequency Reuse, Cell Spitting, Sectoring, Handoff, Power Control, Case study: Global System for Mobile communication

(GSM) Network, General Packet Radio Service (GPRS), Code Division Multiple Access (CDMA 2000), Cordless System, Wireless Local Loop, Mobility Management-Location Management, HLR-VLR Scheme, Hierarchical Scheme, Predictive Location Management Schemes, Types of Interference, Estimation of Adjacent Channel Interference and Co-channel Interference, Trunk Efficiency, Grade of Service, Blocking Probabilities, Propagation Models, Frequency Management and Channel Assignment.

- **AD HOCWIRELESS NETWORK** **(08 Hours)**

  Cellular vs. Ad Hoc, Applications, Issues, MAC protocols, Routing Protocols, Transport Layer Protocol, Multicasting protocols, Wireless Access Protocol, Standards: IEEE 802.11, Wi-Fi, Wireless Broadband-Wi-MAX, Bluetooth, IEEE 802.15, Security in Wireless Network, Hyper LAN.

- **MOBILE COMPUTING** **(10 Hours)**

  Mobile Computing, Issues: Resource Management, Interference, Bandwidth, Frequency Reuse, Mobile Data Transaction Models, File Systems, Mobility Management, Security, Mobile Computing Architecture, Mobile IP Protocol, Mobile TCP Protocol, Wireless Application Protocol, Security Issues in Mobile Computing, Server-Client programming.

(Total Contact Time = 42 Hours)

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3. Books Recommended:

1. William Stallings, Wireless Communications & Networks, 2nd Edition, Pearson Education India, Reprint 2007.
2. Jochen Schiller, Mobile Communications, 2nd Edition, Pearson Education India, reprint 2007.
3. T. S. Rappaport, Wireless Communications: Principles & Practice, 2nd Edition, Pearson Education, 2002.
4. C. E. Perkins, Ad Hoc Networking, 1st Edition, Addison Wesley, 2000.
5. Asoke K. Talukder and Roopa R. Yavagal, Mobile Computing: Technology, Applications and Service Creation, 2nd Reprint, Tata McGraw-Hill, 2006.

ADDITIONAL REFERENCE BOOKS

1. Sandeep Singhal, The Wireless Application Protocol, Addison Wesley, India, reprint 2001.
2. C. Siva Ram Murthy and B. S. Manoj, Ad Hoc Wireless Networks: Architectures and Protocols, Pearson Education, 2007.
3. Gottapu Sasibhushana Rao, Mobile Cellular Communication, Pearson, 2013.

21/7/020

B.Tech. IV (CSE) Semester – VIII
SYSTEM ANALYSIS AND SIMULATION
(CORE ELECTIVE - 5)
CS432

	L	T	P	Credit
Scheme	3	0	0	03

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1. **Course Outcomes (COs):** **At the end of the course, the students will be able to**	
CO1	acquire knowledge about the important elements of discrete event simulation and modelling paradigm.
CO2	interpret the model and apply the results to resolve critical issues in a real world environment.
CO3	identify and analyse the system requirements using various system analysis techniques.
CO4	use computer simulation software to solve and interpret the results.
CO5	develop skills to apply simulation software to construct and execute goal-driven system models.

2. Syllabus

- **INTRODUCTION** **(09 Hours)**

  Introduction, Organizational and Business Context of System Development.

- **APPROACHES TO SYSTEMS DEVELOPMENT AND PROJECT MANAGEMENT** **(08 Hours)**

  System Development Methodologies, Models, Tools and Techniques for Developing Quality Software.

- **SYSTEM ANALYSIS ACTIVITIES** **(08 Hours)**

  Define, Prioritise, and Evaluate Requirements of an Information System as well as Build General and Detailed Models that Specify the System Requirements.

- **ESSENTIALS OF SYSTEM DESIGN** **(09 Hours)**

  Describe, Organize and Structure the Components of a System, Including Decisions About the System's Hardware, Software, and Network Environment, Designing Effective User and System Interfaces Considering Human-Computer Interaction Principles.

- **ADVANCE SYSTEM DESIGN CONCEPTS** **(08 Hours)**

  Apply Object-Oriented Design in Order to Build Detailed Models that Assist Programmers in Implementing the System, Store and Exchange Data in the System by Considering Database

Management and Security Issues, and Creating Database Models and Controls, Making the System Operational.

(Total Contact Time: 42 Hours)

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3. Books Recommended:

1. J. W. Satzinger, R. B. Jackson and S. D. Burd, Systems Analysis and Design in a Changing World, 6th Edition, Boston, USA: Thomson Course Technology, 2012.
2. Averill M. Law, Simulation Modelling and Analysis (SIE), 4th Edition, Tata McGraw Hill India, 2007.
3. David Cloud and Larry Rainey, Applied Modelling and Simulation, Tata McGraw Hill, India.
4. Gabriel A. Wainer, Discrete-event Modelling and Simulation: a Practitioner's Approach, 1st Edition, CRC Press, 2009.
5. Bernard P. Zeigler, Herbert Praehofer and Tag Gon Kim, Theory of Modelling and Simulation: Integrating Discrete Event and Continuous Complex Dynamic Systems, 2nd Edition, Academic Press, 2000.

ADDITIONAL REFERENCE BOOKS

1. Walter J. Karplus, George A. Bekey and Boris Yakob Kogan, Modelling and Simulation: Theory and Practice, 1st Edition, Springer, 2003.

B.Tech. IV (CSE) Semester – VIII
BIG DATA ANALYTICS (CORE ELECTIVE - 6)
CS434

Scheme	L	T	P	Credit
	3	0	0	03

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1. Course Outcomes (COs): **At the end of the course, the students will be able to**	
CO1	describe the key requirements and issues in big data management and its associated applications in intelligent business and scientific computing.
CO2	use state of the art big data analytics techniques and algorithms.
CO3	analyze large sets of data to discover patterns and other useful information.
CO4	compare and evaluate the impact of big data analytics tools and techniques.
CO5	develop big data solutions using state of the art analytics tools/techniques.

2. Syllabus

- **INTRODUCTION – DATA WAREHOUSING, DATA MINING** **(09 Hours)**

  Define Data Warehousing and Data Mining - The Building Blocks, Defining Features – Data Warehouses and Data Marts, Overview of the Components, Metadata in the Data Warehouse, Need for Data Warehousing, Basic Elements of Data Warehousing, Trends in Data Warehousing.

- **CONCEPTS AND TECHNIQUES IN DATA WAREHOUSING** **(08 Hours)**

  OLAP (Online analytical processing) Definitions, Difference Between OLAP and OLTP, Dimensional Analysis, Define Cubes, Drill-down and Roll-up - Slice and Dice or Rotation, OLAP Models, ROLAP versus MOLAP, Defining Schemas: Stars, Snowflakes and Fact Constellations.

- **CONCEPT DESCRIPTION AND ASSOCIATION RULE MINING** **(08 Hours)**

  Introduction to Concept Description, Data Generalization and Summarization-based Characterization, Analytical Characterization, Class Comparisons, Descriptive Statistical Measures, Market Basket Analysis- Basic Concepts, Association Rule Mining, The Apriori Algorithm, Mining Multilevel Association Rule Mining, Mining Multidimensional Association Rule Mining.

- **INTRODUCTION TO CLASSIFICATION AND PREDICTION** **(09 Hours)**

  Introduction to Classification and Prediction, Issues Regarding Classification, Classification using Decision Trees, Bayesian Classification, Classification by Back Propagation, Prediction Classification Accuracy.

- **ADVANCED TOPICS** **(08 Hours)**

  Clustering, Spatial Mining, Web Mining, Text Mining, Map-Reduce and Hadoop Ecosystem.

(Total Contact Time: 42 Hours)

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3. Books Recommended:

1. J. Han and M. Kamber, Data Mining Concepts and Techniques, 3rd Edition, Morgan Kaufmann, Jun 22, 2011.
2. Paulraj Ponnian, Data Warehousing Fundamentals, 1st Edition, John Willey, May 24, 2010.
3. Robert D. Schneider, Hadoop for Dummies, 1st Edition, Wiley India, Apr 14, 2014.
4. M. Kantardzic, Data mining: Concepts, Models, Methods and Algorithms, 3rd Edition, John Wiley & Sons Inc., Nov 12, 2019.
5. M. Dunham, Data Mining: Introductory and Advanced Topics, 1st Edition, Pearson, Sep 1, 2002.

21/7/2020

B.Tech. IV (CSE) Semester – VIII
DEEP LEARNING (CORE ELECTIVE - 6)
CS436

Scheme

L	T	P	Credit
3	0	0	03

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1. Course Outcomes (COs): **At the end of the course, the students will be able to**	
CO1	explain fundamental principles, theory and approaches for learning with deep neural networks.
CO2	illustrate different types of Neural Network and Deep Neural Networks.
CO3	apply NN and DNN for various learning tasks in different domains.
CO4	evaluate various NN and DNN by performing complex statistical analysis for DL techniques.
CO5	design DL algorithms for real-world problems.

2. Syllabus

- **INTRODUCTION TO DEEP LEARNING** **(02 Hours)**

  Basics of Human learning, Attributes of learning algorithms, Applications, Learning techniques, Types of Learning algorithms, Basics of Deep learning.

- **NEURAL NETWORKS BASICS** **(08 Hours)**

  Biological Neuron, Idea of Computational Units, Output vs Hidden Layers; Linear vs Nonlinear Networks, McCulloch–Pitts Model, Thresholding Logic, Linear Perceptron, Perception Learning Algorithm, Linear Separability. Convergence Theorem for Perception Learning Algorithm, Learning via Gradient Descent, Logistic Regression, Back Propagation Models, Feed Forward Model Empirical Risk Minimization, Regularization, Auto Encoders, Continuous and Discrete Distributions; Maximum Likelihood, Cost Functions, Hypotheses and Tasks; Training Data; Cross Entropy, Bias-variance Trade Off, Regularization, Activation Function : Sigmoid, Tanh, RELU, Softmax; Types of Neural Network : Feed Forward Neural Network , Radial Basis Function Neural Network, Convolution Neural Network, Recurrent Neural Network(RNN) Long Short Term Memory, Modular Neural Network; Simple Word Vector Representations: Word2vec, GloVe.

- **DEEP NEURAL NETWORKS** **(12 Hours)**

  Deep Learning Models : Restricted Boltzmann Machines, Deep Belief Nets, Convolutional Model; Deep Neural Networks: Difficulty of Training Deep Neural Networks, Greedy Layerwise Training; Better Training of Neural Networks: Newer Optimization Methods for Neural Networks (Adagrad, Adadelta, Rmsprop, Adam, NAG), Second Order Methods for Training, Saddle Point Problem in Neural Networks, Regularization Methods (Dropout, Drop Connect, Batch Normalization);Recurrent Neural Networks: Back Propagation Through Time, Long Short Term

28/12/2020

Memory, Gated Recurrent Units, Bidirectional LSTMs, Bidirectional RNNs ;Convolution Neural Networks: LeNet, AlexNet; Generative models: Restrictive Boltzmann Machines (RBMs), Introduction to MCMC and Gibbs Sampling, Gradient Computations in RBMs, Deep Boltzmann Machines.

- **RECENT TRENDS** **(12 Hours)**

  Auto Encoders (Standard, Denoising, Contractive, etc), Variational Auto Encoders, Adversarial Generative Networks, Maximum Entropy Distributions, Guest Lecture, Generative Adversarial Networks, Multi-task Deep Learning, Multi-view Deep Learning.

- **APPLICATIONS** **(08 Hours)**

  Vision, NLP, Speech; Deep Learning Platforms and Software Libraries:-H2O.ai, DatoGraphLab, Theano, Caffe, TensorFlow etc.

(Total Contact Time: 42 Hours)

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3. Books Recommended:

1. Ian Goodfellow, Yoshua Bengio and Aaron Courville, Deep Learning (Adaptive Computation and Machine Learning series), MIT Press, 2016.
2. S. Russell and N. Norvig, Artificial Intelligence: A Modern Approach, 3rd Edition, Prentice Hall Series in Artificial Intelligence Pearson, 2015.
3. Christopher M. Bishop, Pattern Recognition and Machine Learning (Information Science and Statistics), 3rd Edition, Springer, 2016.
4. Raúl Rojas, Neural Networks - A Systematic Introduction, 2nd Edition, Springer-Verlag, Berlin, New-York, 2013.
5. Nikhil Buduma and Nicholas Locascio, Fundamentals of Deep Learning: Designing Next-Generation Machine Intelligence Algorithms, 1st Edition, O'reily, 2017.

B.Tech. IV (CSE) Semester – VIII
ADVANCED COMPILER DESIGN
(CORE ELECTIVE - 6)
CS438

	L	T	P	Credit
Scheme	3	0	0	03

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1. **Course Outcomes (COs):** **At the end of the course, the students will be able to**	
CO1	explain compiler structure and overall compilation process.
CO2	apply code generation and optimization techniques for machine-independent optimization.
CO3	analyse processor architecture, scheduling and pipeling to achieve Instruction Level parallelism and optimize for parallelism and locality.
CO4	evaluate various inter procedural analysis methods to analyze a program with multiple procedures.
CO5	design and develop the mechanism required for compiling advanced language translators.

2. Syllabus

- **INTRODUCTION** **(08 Hours)**

  Overview of the Translation Process, Compiler Structure, and Compilation Process, Difference between Interpreter, Assembler and Compiler, Phases of Compiler, Programming Language Grammars, Lexical Analysis, Syntax Analysis, Intermediate Code Generation and Run Time Environment.

- **CODE GENERATION** **(06 Hours)**

  Issues in the Design of Code Generation, Addresses in Target Code, Basic Blocks and Flow Graphs, Optimization of Basic Blocks, Simple Code Generator, Peephole Optimization, Optimal code Generation for Expression, Dynamic Programming Code Generation.

- **MACHINE-INDEPENDENT OPTIMIZATION** **(06 Hours)**

  Scope for Optimization, Data and Control Flow Analysis, Constant Propagation, Partial Redundancy Elimination, Loops in Flow Graph, Region Based Analysis, Symbolic Analysis.

- **INSTRUCTION LEVEL PARALLELISM** **(06 Hours)**

  Processor Architecture, Code Scheduling Constraints, Basic Block Scheduling, Global Code Scheduling, Software Pipelining.

- **OPTIMIZING FOR PARALLELISM AND LOCALITY** **(06 Hours)**

Parallelization and Multiprocessors, Iteration Spaces, Affine Array Indexes, Data Reuse, Array Data Dependant Analysis, Synchronization Free Parallelism, Synchronization Between Parallel Loops, Pipelining, Locality Optimization, Uses of Affine Transforms.

- **INTERPROCEDURAL ANALYSIS** **(06 Hours)**

  Need for Inter Procedural Analysis, Logical Representation of Data Flow, Pointer Analysis, Context Insensitive Inter Procedural Analysis, Context Sensitive Pointer Analysis, Datalog Implementation.

- **ADVANCED TOPICS** **(04 Hours)**

  Code Profiling, Parallelization and Vectorization, Garbage Collector, Just in Time Compilation and Recent Developments.

(Total Contact Time: 42 Hours)

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3. Books Recommended:

1. Aho, Sethi and Ullman, Compilers, Principles, Techniques, and Tools, 2nd Edition, Addison Wesley, 2011.
2. Nandini Prasad, Principles of Compiler, 3rd Edition, Cengage Publication, 2017.
3. Steven Muchnick, Advanced Compiler Design and Implementation, 1st Edition, M. Kaufmann, 1997.
4. R. Wilhelm and D. Maurer, Compiler Design (International Computer Science Series), 1st Edition, Addison Wesley, 1995.
5. V. Raghavan, Principles of Compiler Design, 1st Edition, TMG publication, 2017.

B.Tech. IV (CSE) Semester – VIII
ADVANCED DATABASE MANAGEMENT SYSTEMS
(CORE ELECTIVE - 6)
CS442

	L	T	P	Credit
Scheme	3	0	0	03

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1. Course Outcomes (COs): **At the end of the course, students will**	
CO1	describe advanced database techniques for storing a variety of data with various database models.
CO2	apply various database techniques/functions with Object Oriented approach to design database for real life scenarios.
CO3	analyse the problem to design database with appropriate database model.
CO4	evaluate methods of storing, managing and interrogating complex data.
CO5	develop web application API's, distributed databases with the integration of various programming languages.

2. Syllabus

- **DISTRIBUTED DATABASE CONCEPTS** **(06 Hours)**

  Overview of Client - Server Architecture and its Relationship to Distributed Databases, Concurrency Control Heterogeneity Issues, Persistent Programming Languages, Object Identity and its Implementation, Clustering, Indexing, Client Server Object Bases, Cache Coherence.

- **PARALLEL DATABASES** **(06 Hours)**

  Parallel Architectures, Performance Measures, Shared Nothing/Shared Disk/Shared Memory Based Architectures, Data Partitioning, Intra-operator Parallelism, Pipelining, Scheduling, Load Balancing.

- **QUERY PROCESSING** **(06 Hours)**

  Index Based, Cost Estimation, Query Optimization: Algorithms, Online Query Processing and Optimization, XML, DTD, XPath, XML Indexing, Adaptive Query Processing.

- **ADVANCED TRANSACTION MODELS** **(06 Hours)**

  Save Points, Sagas, Nested Transactions, Multilevel Transactions, Recovery: Multilevel Recovery, Shared Disk Systems, Distributed Systems 2PC, 3PC, Replication and Hot Spares, Data Storage, Security and Privacy Multidimensional K- Anonymity, Data Stream Management.

- **MODELS OF SPATIAL DATA** **(05 Hours)**

21/7/2022

Conceptual Data Models for Spatial Databases (e.g. Pictogram Enhanced ERDs), Logical Data Models for Spatial Databases: Raster Model (Map Algebra), Vector Model, Spatial Query Languages, Need for Spatial Operators and Relations, SQL3 and ADT, Spatial Operators, OGIS Queries.

- **WEB ENABLED APPLICATIONS** **(05 Hours)**

  Review of 3-Tier Architecture - Typical Middle-ware Products and Their Usage. Architectural Support for 3 -Tier Applications: Technologies Like RPC, CORBA, COM, Web Application Server - WAS Architecture Concept of Data Cartridges - JAVA/HTML Components, WAS.

- **OBJECT ORIENTED DATABASES** **(04 Hours)**

  Notion of Abstract Data Type, Object Oriented Systems, Object Oriented DB Design. Expert Databases: Use of Rules of Deduction in Databases, Recursive Rules.

- **ADVANCED TOPICS** **(04 Hours)**

  No SQL Databases, Unstructured Databases, Couchbase, MangoDB, Cassendra, Redis, Memcached.

(Total Contact Time: 42 Hours)

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3. Books Recommended:

1. R. Elmasri and S. Navathe, Fundamentals of Database Systems, 5th Edition, Benjamin- Cummings Pearson Education India, 2007.
2. Avi Silberschatz, Hank Korth and S. Sudarshan, Database System Concepts, 5th Edition, McGraw Hill, 2005.
3. S. Shekhar and S. Chawla, Title Spatial Databases: A Tour, 1st Edition, Prentice Hall, 2003.
4. Hector Garcia-Molina, Jeff Ullman and Jennifer Widom, Database Systems, 2nd Edition, Pearson, 2008.
5. Carlos Coronel and Steven Morris, Database Systems: Design, Implementation & Management , 11th Edition, Cengage Learning, 2014.

21/12/20

B.Tech. IV (CSE) Semester – VIII
WEB ENGINEERING (CORE ELECTIVE - 6)
CS444

Scheme	L	T	P	Credit
	3	0	0	03

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1. **Course Outcomes (COs):** At the end of the course, the students will be able to	
CO1	acquire knowledge about the web application development methodologies, web application architecture, modelling and testing techniques.
CO2	apply the knowledge of web application development steps to configure the web application project to solve the given problem.
CO3	analyze the given problem statement for which web application is required and debug, troubleshoot the basics issues with web application.
CO4	test the web application, manage web resources and also evaluate quality of web project.
CO5	develop the web project, maintain and manage changes in the web project for given problems.

2. Syllabus

- **INTRODUCTION** **(05 Hours)**

  Web Application, Categories of Web Applications, Characteristics of Web Applications, Product-Related Characteristics, Usage Related Characteristics, Development-Related Characteristic, Concepts And Reference Model Web Engineering: Introduction And Perspectives, Evolution of Web Engineering, Web Engineering Resources Portal (WEP): A Reference Model And Guide.

- **REQUIREMENTS ENGINEERING ACTIVITIES** **(04 Hours)**

  Introduction, Principles for Requirement Engineering of Web Applications, Adapting Requirement Engineering Methods to Web Application Development, Requirement Types, Notations, Tools.

- **WEB APPLICATION DEVELOPMENT** **(04 Hours)**

  Web Application Development Methodologies, Relationship Analysis- A Technique to Enhance Systems Analysis For Web Development, Engineering Location-Based Services in the Web, Tools.

- **WEB APPLICATION ARCHITECTURES & MODELLING** **(06 Hours)**

  Categorizing Architectures, Specifics of Web Application Architectures, Components of a Generic Web Application Architecture, Layered Architectures, 2-Layer Architectures, N-Layer Architectures, Data-Aspect Architectures, Database-Centric Architectures, Architectures for Web Document Management, Architectures for Multimedia Data, Modelling Specifics in Web Engineering, Levels, Aspects, Phases Customization, Modelling Requirements, Hypertext Modelling, Hypertext

21/9/2020

Structure Modelling Concepts, Access Modelling Concepts, Relation to Content Modelling, Presentation Modelling, Relation to Hypertext Modelling, Customization Modelling, Relation to Content.

- **TESTING WEB APPLICATIONS** **(07 Hours)**

  Introduction, Fundamentals, Terminology, Quality Characteristics, Test Objectives, Test Levels, Role of the Tester, Test Specifics in Web Engineering, Test Approaches, Conventional Approaches, Agile Approaches, Test Scheme, Three Test Dimensions, Applying the Scheme to Web Applications, Test Methods and Techniques, Link Testing, Browser Testing, Usability Testing, Load, Stress, and Continuous Testing, Testing Security, Test-driven Development, Test Automation, Benefits and Drawbacks of Automated Test, Test Tools.

- **WEB METRICS AND QUALITY** **(03 Hours)**

  Models and Methods, Architectural Metrics for Web Application: A Balance Between Rigor and Relevance, The Equal Approach to the Assessment of Web Application Quality, Web Cost Estimation.

- **WEB RESOURCE MANAGEMENT** **(03 Hours)**

  Models and Techniques, Ontology-Supported Web Content Management, Design Principles And Applications of XML.

- **WEB MAINTENANCE AND EVOLUTION** **(04 Hours)**

  Techniques and Methodologies, Program Transformations for Web Application Restructuring, The Requirements of Methodologies for Developing Web Applications, A Customer Analysis-Based Methodology for Improving Web Business Systems.

- **WEB PROJECT MANAGEMENT** **(06 Hours)**

  Understanding Scope, Refining Framework Activities, Building a Web Team, Managing Risk, Developing a Schedule, Managing Quality, Managing Change, Tracking the Project.

(Total Contact Time: 42 Hours)

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3. **Books Recommended:**

1. Achyut Godbole and Atul Kahate, Web Technologies, 3rd Edition, Tata McGraw Hill, India, 2017, ISBN: 978-1259062681.
2. Peter Smith, Professional Website Performance, 1st Edition, Wiley India Pvt. Ltd, 2012, ISBN: 9781118487525.
3. Roger Pressman and David Lowe, Web Engineering: A Practitioner's Approach, 1st Edition, McGraw-Hill, 2009, ISBN:0073523291, 9780073523293.

21/7/2020

4. J. Governor, D. Hinchcliffe and D. Nickull, Web 2.0 Architectures: What Entrepreneurs and Information Architects Need to Know, 1st Edition, O'Reilly, 2009, ISBN: 9780596514433.
5. Andrew King, Website Optimization, 1st Edition, Shroff Publishers, India, 2009, ISBN: 9788184045628.

ADDITIONAL REFERENCE BOOKS

1. Guy W. Lecky Thompson, Just Enough Web Programming with XHTML, PHP, and Mysql, 1st Edition, Cengage Learning, 2008, ISBN 9781598634815.

21/7/2020

B.Tech. IV (CSE) Semester – VIII

FOUNDATIONS OF AUTOMATIC VERIFICATION
(CORE ELECTIVE - 7)
CS446

	L	T	P	Credit
Scheme	3	0	0	03

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1. Course Outcomes (COs): **At the end of the course, the students will be able to**	
CO1	explain automatic verification of programs using different techniques like, propositional logic and predicate logic.
CO2	apply methods of program verification for the given problem and represent system using Binary Decision Diagrams.
CO3	analyse the programs for correctness and complexity.
CO4	evaluate different programs using model checking methods.
CO5	design and develop a framework for software verification.

2. Syllabus

- **PROPOSITIONAL LOGIC** **(02 Hours)**

  Declarative Sentences, Natural Deduction, Rules for Natural Deduction, Derived Rules, Natural Deduction in Summary, Provable Equivalence, An Aside: Proof by Contradiction, Propositional Logic as a Formal Language, Semantics of Propositional Logic, The Meaning of Logical Connectives, Mathematical Induction, Soundness of Propositional Logic, Completeness of Propositional Logic, Normal Forms, Semantic Equivalence, Satisfiability and Validity, Conjunctive Normal Forms and Validity, Horn Clauses and Satisfiability, SAT Solvers, A Linear Solver, A Cubic Solver.

- **PREDICATE LOGIC** **(02 Hours)**

  The Need for a Richer Language, Predicate Logic as a Formal Language, Free and Bound Variables, Substitution, Proof Theory of Predicate Logic, Natural Deduction Rules, Quantifier Equivalences, Semantics of Predicate Logic, Models, Semantic Entailment, The Semantics of Equality, Undecidability of Predicate Logic, Expressiveness of Predicate Logic, Existential Second-Order Logic, Universal Second-Order Logic, Micromodels of Software, State Machines, Software Micromodel.

- **VERIFICATION BY MODEL CHECKING** **(06 Hours)**

  Motivation for Verification, Linear-Time Temporal Logic, Syntax of LTL, Semantics of LTL, Practical Patterns of Specifications, Important Equivalences Between LTL Formulas, Adequate Sets of Connectives for LTL, Model Checking: Systems, Tools, Properties, Example: Mutual Exclusion, The NuSMV Model Checker, Running NuSMV, Mutual Exclusion Revisited, The Ferryman, The Alternating Bit Protocol, Branching-Time Logic, Syntax of CTL, Semantics of CTL, Practical Patterns of Specifications, Important Equivalences Between CTL Formulas, Adequate Sets of CTL Connectives. CTL* and The Expressive Powers of LTL and CTL, Boolean Combinations of Temporal Formulas in CTL, Past Operators in LTL, Model-Checking Algorithms, The CTL Model-Checking Algorithm, CTL Model Checking With Fairness, The LTL Model-Checking Algorithm, The Fixed-Point Characterisation of CTL, Monotone Functions.

- **PROGRAM VERIFICATION** **(04 Hours)**

  Need for Specification and Verification of Code, A Framework for Software Verification, Hoare Triples, Partial and Total Correctness, Program Variables and Logical Variables, Proof Calculus for Partial Correctness, Proof Rules, Proof Tableaux, Proof Calculus for Total Correctness, Programming by Contract.

- **BINARY DECISION DIAGRAMS** **(06 Hours)**

  Representing Boolean Functions, Propositional Formulas and Truth Tables, Binary Decision Diagrams, Ordered BDDs, Algorithms for Reduced OBDDs, The Algorithm Reduce, The Algorithm Apply, The Algorithm Restrict, The Algorithm Exists, Assessment of OBDDs, Symbolic Model Checking, Representing Subsets of the Set of States, Representing the Transition Relation, Implementing the Functions pre∃ and pre∀, Synthesising OBDDs, A Relational Mu-Calculus, Syntax and Semantics, Coding CTL Models and Specifications, BDD-Based Symbolic Model Checking.

- **SAT SOLVING** **(04 Hours)**

  CDCL SAT Solvers: Organization, CDCL SAT Solvers, SAT-Based Problem Solving, Armin Biere and Daniel Kröning, Bounded Model Checking on Kripke Structures, Bounded Model Checking for Hardware Designs, Bounded Model Checking for Software, Encodings into Propositional SAT.

- **SATISFIABILITY MODULO THEORIES** **(04 Hours)**

  SMT in Model Checking, The Lazy Approach to SMT, Theory Solvers for Specific Theories, Combining Theory Solvers, SMT Solving Extensions and Enhancements, Eager Encodings to SAT, Additional Functionalities of SMT Solvers.

- **COMPOSITIONAL REASONING** **(02 Hours)**

  Reasoning with Assertions, Automata-Based Assume-Guarantee Reasoning.

- **ABSTRACTION AND ABSTRACTION REFINEMENT** **(06 Hours)**

  Simulation and Bisimulation Relations, Abstraction Based on Simulation, Counter Example-Guided Abstraction Refinement (CEGAR), Abstraction Based on Modal Simulation, Completeness, Predicate Abstraction for Program Verification, Characterizing Correctness via Reachability, Characterizing Correctness via Inductiveness , Solving Refinement Constraints for Predicate Abstraction.

- **MODEL CHECKING CASE STUDIES** **(06 Hours)**

Equational Logic Frameworks, Real-time Frameworks, Reactive Frameworks, Pi-calculus, Tree Automata and Weak Second-Order Logic with k Successors (WSkS), Automatic Verification of Finite State Systems: Case Study of Languages and Systems like Z, B, Spin, PVS, Step.

(Total Contact Time: 42 Hours)

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3. Books Recommended:

1. Bloem Roderick, Clarke Edmund, M. Henzinger, Thomas A. Veith and Helmut, Handbook of Model Checking, Springer International Publishing, 2018, ISBN: 978-3-319-10575-8,3319105752, 978-3-319-10574-1.
2. Michael Huth and Mark Ryan, Logic in Computer Science: Modelling and Reasoning about Systems, 2nd Edition, Cambridge University Press New York, NY, USA, 2004, ISBN:052154310X.
3. P. Cousot and Jan Van Leeuwen, Methods and Logics for Proving Programs in Handbook of Theoretical Computer Science, The MIT Press, 1994.
4. Robinson, J. A. Alan and Andrei Voronkov, Handbook of Automated Reasoning, 2nd Edition, Gulf Professional Publishing, 2001.
5. Antoni Ligeza, Logical Foundations for Rule-Based Systems (Studies in Computational Intelligence), 2nd Edition, Springer, 2006.

ADDITIONAL REFERENCE BOOKS

1. Uwe Schöning, Logic for Computer Scientists (Modern Birkhauser Classics), 1st Edition, Birkhauser, 2008.

21/7/2023

B.Tech. IV (CSE) Semester – VIII
SECURE SOFTWARE ENGINEERING (CORE ELECTIVE - 7)
CS448

	L	T	P	Credit
Scheme	3	0	0	03

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1. Course Outcomes (COs):	
At the end of the course, the students will be able to	
CO1	explain the security field and its key concept.
CO2	illustrate attack patterns.
CO3	analyse the risk behind any system/code.
CO4	evaluate the attack as well as cybercrimes.
CO5	design a system with minimal risk and attack possibilities.

2. Syllabus

- **INTRODUCTION** **(04 Hours)**

  Software Security, Security in SDLC, Review of Software Engineering Concepts, SDLC, Software Qualities, Interdependence of Software Qualities, Security as a Software Quality, Review of Information Security Concepts, Software Security vs. Information Security vs. Application Security, Terminologies, The Trinity of Trouble viz. Connectivity, Extensibility and Complexity, Studies of Various Catastrophes Due to Insecure software, Model Based Security Engineering, Three Pillars of Software Security, Security in Software Lifecycle.

- **ATTACKS AND TYPES OF ATTACKERS** **(06 Hours)**

  Attacks-Types, Methods, Attacks in Each Phase of Software Life Cycle, Motivation for Attackers, Methods for Attacks: Malicious Code, Hidden Software Mechanisms, Social Engineering Attacks, Physical Attacks, Non-malicious Dangers to Software, Attacks in Each Phase of Software Life Cycle, Security Vulnerabilities and Attack Taxonomy in Internet of Things and Cyber Physical Systems, Attack Trees, Attack Trees for BGP, PGP, PGP Probable Vulnerabilities.

- **SECURITY VULNERABILITIES-I** **(06 Hours)**

  Introduction to Stack Analysis, Hands on Stack Analysis using gcc Compiler and sdb Debugger Tool, Methods of Attack, Taxonomy of Security Vulnerabilities, Introduction to Code Reviews and Static Informal Reviews, Formal Inspections. Code Coverage and Code Coverage Criteria viz. Statement Coverage, Branch Coverage, Condition Coverage, Path Coverage, Illustrations.

- **SECURITY VULNERABILITIES-II** **(04 Hours)**

  Format String Vulnerabilities, Race Conditions Vulnerability, Examples of TOCTOU Race Conditions in Linux Environment, Code Injection and its Types, SQL Injection, Interpreter Injection; Weak Session Cookies, Buffer Over flows, Hidden Form Fields, Fail Open Authentication, Cross-site Scripting.

- **INTRODUCTION TO PETRINETS** **(04 Hours)**

  Petrinet as a Modelling Tool, Graphical Notations, Modelling Deadlocks and Starvation, Coloured Petrinets, Simulations of Real time Applications using Petrinets

- **INTEGRATING SECURITY INTO SDLC.** **(02 Hours)**

  Risk Management and Threat Modelling Methodologies, Software Risk Assessment and Threat Modelling Methodologies, Secure Development Cycle Activities and Practices.

- **USECASE MODELLING** **(04 Hours)**

  Usecases, Sequence Diagram, Collaboration Diagram, Illustrations of Kerberos and SET Through Sequence Diagram.

- **ATTACK PATTERNS** **(04 Hours)**

  The Attack Patterns, Illustrations, Review of Design Patterns in SE and Multi-tier architecture, Attack Proles, Attack Proles from Attack Patterns, Usage of Attack Proles, Using Attack Patterns in Attack Proles, Generating Attack Patterns, Case Studies, Abuse Cases, Misuse Cases, Using Attack Patterns to Generate an Abuse Case Model and Anti-Requirements, Finite State Machines for Security Requirements, Case Studies, Security Patterns.

- **ARCHITECTURAL RISK ANALYSIS** **(04 Hours)**

  Introduction to UMLSEC AND SECUREUML, Risk Analysis using Z for Secure Specifications, Introduction To Penetration Testing.

- **SECURE PROGRAMMING** **(04 Hours)**

  Common Software Security Bugs and Coding Errors.

(Total Contact Time: 42 Hours)

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3. Books Recommended:

1. Gary McGraw, Software Security: Building Security, 2nd Edition, Addison Wesley Software Security Series, 2006.
2. Theodor Richardson and Charles Thies, Secure Software Design, 2nd Edition, Jones and Bartlet Learning, 2013.
3. Ghezzi, Jazayeri and Mandrioli, Fundamentals of Software Engineering, 2nd Edition, Pearson EDU, 2003.
4. Mark Merkow, Secure, Resilient and Agile Software Development, 1st Edition, Auerbach Publications, 2019.
5. Jason Grembi, Secure Software Development: A Security Programmer's Guide, 1st Edition, Cengage Learning, 2008.

B.Tech. IV (CSE) Semester – VIII
ANIMATION & RENDERING (CORE ELECTIVE - 7)
CS452

Scheme	L	T	P	Credit
	3	0	0	03

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1. **Course Outcomes (COs):** **At the end of the course, the students will be able to**	
CO1	acquire knowledge about the fundamentals of animation, drawings, images and lighting.
CO2	apply the knowledge of mathematics, graphics, rendering in making of animation and rendering.
CO3	analyse the different light and sound sources, its effects and characterizing the animated character with different visual effects.
CO4	evaluate the different scenario generated using sound and light for animation and rendering.
CO5	create 2D-3D animated movies, advertisement, children educational tool kits, and developing tools for awareness among the society.

2. Syllabus

- **INTRODUCTION** **(08 Hours)**

  History, Fundamentals of Images, Video, Sound and Audio, Traditional Art, 2D Animation, Lighting, Texture, Rendering, Colour, Key Frames, Video Composition, Graphics Principles, Affine Transformation, Projection, Rotation, Illumination, Reflection, Refraction, Shadow, Focusing, 3D Model, Media Technology, Basic Mathematics: Polynomials, Graphs, Trigonometry, Vector, Differentiation.

- **VISUAL EFFECTS AND RENDERING** **(06 Hours)**

  Concepts of Light, Material Property, Spotlight, Free Lights, Directional Light, Ray Tracing, Radiosity Computation, Surface Property, Surfacing, Volume Rendering, Light Fields, Procedural and Image-based Texturing and Shading, Non-photorealistic Rendering, Creation and Management of Layers, Parallel Rendering, Rigging and Animation, 3D Lighting, Editing, Colour Grading, Special Effects.

- **ANIMATION DESIGN** **(06 Hours)**

  Observational Drawing, Characters, Shapes, Verbal Articulation, Storytelling, Translating Sequential Images Into Action, Frame Creation, Scripting, Gestures, Expression, Nonverbal Communication, Motion, Attitude and Body Language of Characters, 2D and 3D Composition, Lip Syncing, Morphology, 3D Animation, Shadow Effects, Mesh Representation, Recoil Effects, Stretching, Squash, Overlapping Action, Object Behaviour and Time Synchronization, Humour, Deformers, Blend Shaping, Action and Reaction, Scene Timing and Invisible Activity, Polygon Modelling, Nurbs Modelling.

21.11.2020

- **VIDEO PROCESSING** **(06 Hours)**

  Fundamentals of Video Production, Still Images, Blurring and Focusing, Camera Functioning, Framing, Photography, Cinematography, Morphology, Visual Design, Filming, Sound and Audio Processing, Filters, Tracking, Image Sequences and Object Layers, Video Codecs, Video Streaming, Video Editing.

- **AUDIO PROCESSING** **(04 Hours)**

  Basic of Signals, Fundamentals of Sound, Audio Features, Transforms, Recording, Analysis and Synthesis, Dynamics of Sound, Sound Tracks, Digital Filters, Spectrum, Formats, Recording and Effects, Equalizer, Mixer, Post Processing of Recorded Sound, Musical Instruments and Spectrum Analysis.

- **ADVANCED TOPICS** **(12 Hours)**

  Creating a Walkthrough, Dynamic FX, Dynamic Simulations of Collision, Rigid Bodies, Fire and Fluid Simulation, VFX Technology, MAYA Basic Workflow and Interface, Objects Hierarchy and Animation Design, Crowd Control, Advanced Modelling Methods, Highlights of Constitutional Rule and Laws, Copyright Act, IT Act, etc.

(Total Contact Time: 42 Hours)

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3. Books Recommended:

1. A. Watt and M. Watt, Advanced Animation and Rendering Techniques: Theory and Practice, 2nd Edition, Addison-Wesley, 1992.
2. Mascelli Joseph V, The Five C's of Cinematography: Motion Pictures Filming Techniques, 1st Edition, Silman-James Press, 1998.
3. Preston Blair, Cartoon Animation, 1st Edition, Walter Foster Publishing Inc., CA, 1995.
4. Richard Taylor, Encyclopedia of Animation Techniques, 2nd Edition, Book Sales, 2004.
5. David Lewis Yewdall, Practical Art of Motion Picture Sound, 2nd Edition, Focal Press, 2003.

ADDITIONAL REFERENCE BOOKS

1. Ed Hooks, Acting for Animators, 2nd Edition, Routledge, 2013.
2. Peter Hames and Dark Alchemy, The Films of Jan Svankmajer, 2nd Edition, Wallflower Press, 2008.
3. David Sonnensch, Sound Design: The Expressive Power of Music, Voice and Sound Effects in Cinema, 2nd Edition, Michael Wiese Productions, 2013.
4. Tomlinson Holman, Sound for Film and Television, 2nd Edition, Focal Press, 2001.

21/7/2020

B.Tech. IV (CSE) Semester – VIII
RESEARCH METHODOLOGY
(CORE ELECTIVE - 7)
CS454

	L	T	P	Credit
Scheme	3	0	0	03

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1. Course Outcomes (COs): **At the end of the course, the students will be able to**	
CO1	describe different research techniques to perform the research in academic as well as real life.
CO2	apply sampling techniques and develop the models for the real world problems.
CO3	perform, evaluate, analyse and interpret the research design through project development and case study analysis using appropriate tools.
CO4	evaluate the outcomes of the developed models.
CO5	design, develop and innovate a research strategy for complex engineering problems.

2. Syllabus

- **INTRODUCTION** **(04 Hours)**

  Research: Definition, Characteristics, Motivation and Objectives, Research Methods vs Methodology, Types of Research – Descriptive vs Analytical, Applied vs Fundamental, Quantitative vs Qualitative, Conceptual vs Empirical.

- **RESEARCH METHODOLOGY** **(04 Hours)**

  Research Process, Formulating the Research Problem, Defining the Research Problem, Research Questions, Research Methods vs. Research Methodology.

- **RESEARCH DESIGN** **(04 Hours)**

  Concept and Importance in Research, Features of a Good Research Design, Exploratory Research Design, Concept, Types and Uses, Descriptive Research Designs, Concept, Types and Uses, Experimental Design: Concept of Independent & Dependent variables.

- **LITERATURE REVIEW** **(04 Hours)**

  Review Concepts and Theories, Identifying and Analyzing the Limitations of different Approaches.

- **DATA MODELING AND SIMULATIONS** **(08 Hours)**

  Mathematical Modeling, Experimental Skills, Simulation Skills , Data Analysis and Interpretation.

- **TECHNICAL WRITING AND TECHNICAL PRESENTATIONS** **(04 Hours)**
- **CREATIVITY AND ETHICS IN RESEARCH, INTELLECTUAL PROPERY RIGHTS** **(04 Hours)**
- **TOOLS AND TECHNIQUES FOR RESEARCH** **(06 Hours)**

  Methods to Search Required Information Effectively, Reference Management Software, Software for Paper Formatting, Software for Detection of Plagiarism.
- **DISCUSSION AND DEMONSTRATION OF BEST PRACTICES** **(04 Hours)**

(Total Contact Time: 42 Hours)

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3. **Books Recommended:**

1. John W. Creswell, Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, 2nd Edition, SAGE Publications, 2002.
2. C.R. Kothari, Research Methodology: Methods and Techniques, 4th Edition, New Age International, 2019.
3. David Silverman, Qualitative Research, 4th Edition, SAGE Publications Ltd, 2016.
4. Norman K. Denzin and Yvonna Sessions Lincoln, Handbook of Qualitative Research, 2nd Edition, SAGE Publications Ltd, 2011.
5. Michael Quinn Patton, Qualitative Research and Evaluation Methods, 3rd Edition, SAGE Publications Ltd, 2002.

7/10/2020

B.Tech. IV (CSE) Semester – VIII
ETHICAL HACKING (CORE ELECTIVE - 7)
CS456

Scheme

L	T	P	Credit
3	0	0	03

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1. Course Outcomes (COs): **At the end of the course, the students will be able to**	
CO1	acquire knowledge of core concepts related to information security and ethical hacking.
CO2	install, configure, and use different state of the art hacking software on a closed network environment.
CO3	analyze the vulnerabilities related to computer system and networks using state of the art tools and technologies.
CO4	evaluate best practices in information security to maintain confidentiality, integrity and availability.
CO5	implement effective solutions for ethical hacking in different environments.

2. Syllabus

- **INTRODUCTION** **(09 Hours)**

  Ethical Hacking: Introduction, Networking & Basics, Foot Printing, Google Hacking, Scanning, Windows Hacking, Linux Hacking, Trojans & Backdoors, Virus & Worms.

- **INFORMATION AND NETWORK SECURITY** **(09 Hours)**

  Proxy & Packet Filtering, Denial of Service, Sniffer, Social Engineering System and Network Vulnerability and Threats to Security, Various Types of Attack and the Various Types of Attackers in the Context of the Vulnerabilities Associated with Computer and Information Systems and Networks Physical Security, Steganography.

- **ETHICAL HACKING – 1** **(12 Hours)**

  Cryptography, Wireless Hacking, Firewall & Honeypots, IDS & IPS, Vulnerability, Penetration Testing, Session Hijacking, Hacking Web Servers, SQL Injection, Cross Site Scripting, Exploit Writing, Buffer Overflow.

- **ETHICAL HACKING – 2** **(12 Hours)**

  Reverse Engineering, Email Hacking, Incident Handling & Response, Bluetooth Hacking, Mobile Phone Hacking Basic Ethical Hacking Tools and Usage of These Tools in a Professional Environment. Legal, Professional and Ethical Issues Likely to Face the Domain of Ethical Hacking. Ethical

Responsibilities, Professional Integrity and Making Appropriate Use of the Tools and Techniques Associated With Ethical Hacking.

(Total Contact Time: 42 Hours)

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3. Books Recommended:

1. Dominic Chell, Tyrone Erasmus, Shaun Colley, Oflie Whitehouse, The Mobile Application Hacker's Handbook , 2nd Edition, Wiley, 2015.
2. Michael Gregg, Certified Ethical Hacker (CEH) Cert Guide , 2nd Edition, Pearson India, 2014.
3. Rafay Baloch, Ethical Hacking and Penetration Testing Guide , 2nd Edition, CRC Press, 2017.
4. Allen Harper, Shome Harris, Jonathan Ness,Chris Eagle, Gideon Lenkey, TerronVilliams Gray Hat Hacking The Ethical Hakers Handbook , 3rd Edition, TMH, 2011.
5. Patrick Engebretson, The Basics of Hacking and Penetration Testing: Ethical Hacking and Penetration Testing Made Easy , 2nd Edition, Elsevier, 2013.

ADDITIONAL REFERENCE BOOKS

1. Jon Erickson HACKING: The art of Exploitation , 2nd Edition, William Pollock No Starch Press, 2008.

B.Tech. IV (CSE) Semester – VIII
CYBER LAW AND FORENSICS (CORE-16)
CS402

Scheme	L	T	P	Credit
	3	0	2	04

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1. Course Outcomes (COs): **At the end of the course, the students will be able to**	
CO1	explain the basics of cyber law and cyber forensics with respect to Indian IT Act.
CO2	apply knowledge of cyber law to provide solutions to cyber security.
CO3	analyze various computer forensics technologies and systems.
CO4	evaluate and assess the methods for data recovery and digital evidence collection.
CO5	give solutions to real life problems using state of the art cyber forensics tools and techniques.

2. Syllabus

- **INTRODUCTION** **(08 Hours)**

  Cyber Security and its Problem-Intervention Strategies: Redundancy, Diversity and Autarchy, Cyber-Crime and The Legal Landscape Around the World, Why Do We Need Cyber Laws, Cyber Forensics Fundamentals, Benefits of Forensics, Cyber Forensics Evidence and Courts, Legal Concerns and Private Issues.

- **CYBER LAWS -1** **(08 Hours)**

  The Indian IT Act, Challenges to Indian Law and Cybercrime Scenario in India, Consequences of Not Addressing the Weakness in Information Technology Act, Digital Signatures and the Indian IT Act, Cybercrime and Punishment, Cyber Law, Technology and Students: Indian Scenario.

- **CYBER LAWS -2** **(08 Hours)**

  Private Ordering Solutions, Regulation and Jurisdiction For Global Cyber Security, Copyright Source of Risks, Pirates, Internet Infringement, Fair Use, Postings, Criminal Liability, First Amendments, Data Losing, Cyber Ethics - Legal Developments, Cyber Security in Society, Security in Cyber Laws Case Studies, General Law and Cyber Law-A Swift Analysis.

- **CYBER FORENSICS -1** **(09 Hours)**

  Cyber Investigation - Procedure for Corporate High-Tech Investigations, Understanding Data Recovery Workstation and Software, Conducting and Investigations, Data Acquisition - Understanding Storage Formats and Digital Evidence, Determining the Best Acquisition Method, Acquisition Tools, Validating Data Acquisitions, Performing RAID Data Acquisitions, Remote Network Acquisition Tools, Other Forensics Acquisitions Tools.

7/10/20

- **CYBER FORENSICS -2** **(09 Hours)**

  Current Cyber Forensics Tools- Software and Hardware Tools, Validating and Testing Forensic Software, Addressing Data-Hiding Techniques, Performing Remote Acquisitions, E-Mail Investigations- Investigating Email Crime and Violations, Understanding E-Mail Servers, Specialized E-Mail Forensics Tool.

- **Practicals will be based on the coverage of the above topics.** **(28 Hours)**

(Total Contact Time: 42 Hours + 28 Hours = 70 Hours)

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3. Practicals:

1 Introduction to various software tools related to cyber law and cyber forensics.

2 Practical based on disk forensics.

3 Practical based on network forensics.

4 Practical based on device forensics.

5 Practical based on email security.

6 Practical using forensic tools for image and video fraud.

7 Practical using on e-commerce related cyber-attacks.

8 Practical based on social network and online transactions related cyber threats.

4. Books Recommended:

1. Sunit Belapure and Nina Godbole, Cyber Security: Understanding Cyber Crimes, Computer Forensics and Legal Perspectives, 1st Edition, Wiley India Pvt. Ltd, 2011.
2. Mark F Grady, Fransesco Parisi, The Law and Economics of Cyber Security , 1st Edition, Cambridge University Press, 2006.
3. Jonathan Rosenoer, Cyber Law: The law of the Internet , 1st Edition, Springer-Verlag, 1997.
4. Warren G. Kruse II and Jay G. Heiser, Computer Forensics: Incident Response Essentials , 1st Edition, Addison Wesley, 2002.
5. B. Nelson, A. Phillips, F. Enfinger, C. Stuart, Guide to Computer Forensics and Investigations, 2nd Edition, Thomson Course Technology, 2006, ISBN: 0-619-21706-5.

ADDITIONAL REFERENCE BOOKS

1. J. Vacca, Computer Forensics: Computer Crime Scene Investigation , 2nd Edition, Charles River Media, 2005, ISBN: 1-58450-389.

Revised Syllabus for B. Tech. IInd to B. Tech. IVth year
Electrical Engineering Department

Teaching Scheme of B. Tech.-I (Semester I & II)
DIVISION – XXXX(Electrical Engineering)

SEMESTER – I

Sr. No.	Subject	Code	Scheme	Credit
1	Mathematics-I	MA 101 S1	3-1-0	04
2	Physics-I	PH 102 S1	3-0-2	04
3	Branch Specific Course -I (Basic Electrical Engineering)	EE 103 S1	3-0-2	04
4	Chemistry	CY 104 S1/S2	3-0-2	04
5	Engineering Drawing	CIME 105 S1/S2	2-0-4	04
6	Energy and Environmental Engineering	CIME 106 S1/S2	3-0-2	04
7	Holistic Empowerment and Human Values*	HU 107 S1/S2	3-0-0	00
		Total	**20-1-12=33**	**24**

* Audit Course (attendance would be compulsory as per institute norms)

SEMESTER – II

Sr. No.	Subject	Code	Scheme	Credit
1	Mathematics-II	MA 112 S2	3-1-0	04
2	Physics-II	PH 113 S2	4-0-0	04
3	Branch Specific Course -II (Electronics Devices & Circuits)	EC 114 S2	3-0-2	04
4	Engineering Mechanics	AM 108 S2/S1	3-0-2	04
5	Fundamentals of Computers & Programming	CO 109 S2/S1	3-0-2	04
6	English & Professional Communications	HU 110 S2/S1	3-0-0	03
7	Workshop Practice	ME 111 S2/S1	0-0-4	02
		Total	**19-1-10=30**	**25**

S1 = Semester-1, S2 = Semester-2
AM = Applied Mechanics, CH = Chemical, CI = Civil, CO = Computer,
ME = Mechanical, EE = Electrical, EC = Electronics,
PH = Physics, CY = Chemistry, MA = Mathematics, HU = Humanities, MG = Management

Teaching Scheme of B. Tech.-I (Semester I & II)

DIVISION-YYYY(Electrical Engineering)

SEMESTER – I

Sr. No.	Subject	Code	Scheme	Credit
1	Mathematics-I	MA 101 S1	3-1-0	04
2	Physics-I	PH 102 S1	3-0-2	04
3	Branch Specific Course -II (Electronics Devices & Circuits)	EC 114 S1	3-0-2	04
4	Engineering Mechanics	AM 108 S2/S1	3-0-2	04
5	Fundamentals of Computers & Programming	CO 109 S2/S1	3-0-2	04
6	English & Professional Communications	HU 110 S2/S1	3-0-0	03
7	Workshop Practice	ME 111 S2/S1	0-0-4	02
		Total	**18-1-12=31**	**25**

Semester – II

Sr. No.	Subject	Code	Scheme	Credit
1	Mathematics-II	MA 112 S2	3-1-0	04
2	Physics-II	PH 113 S2	4-0-0	04
3	Branch Specific Course -I (Basic Electrical Engineering)	EE 103 S2	3-0-2	04
4	Chemistry	CY 104 S1/S2	3-0-2	04
5	Engineering Drawing	CIME 105 S1/S2	2-0-4	04
6	Energy and Environmental Engineering	CIME 106 S1/S2	3-0-2	04
7	Holistic Empowerment and Human Values*	HU 107 S1/S2	3-0-0	00
		Total	**21-1-10=32**	**24**

* Audit Course (attendance would be compulsory as per institute norms

S1 = Semester-1, S2 = Semester-2

AM = Applied Mechanics, CH = Chemical, CI = Civil, CO = Computer,

ME = Mechanical, EE = Electrical, EC = Electronics,

PH = Physics, CY = Chemistry, MA = Mathematics, HU = Humanities, MG = Management

SEMESTER – III

Sr. No.	Subject	Code	Scheme	Credit
1	Mathematics-III	MA217	3-1-0	04
2	Electric Circuits	EE201	4-1-0	05
3	Electrical Machines I	EE203	3-1-2	05
4	Digital Circuits	EC211	3-1-2	05
5	Introduction to Data Structure	CS207	3-0-2	04
		Total	**16-4-6=26**	**23**

SEMESTER – IV

Sr. No.	Subject	Code	Scheme	Credit
1	Engineering Mathematics (to be taught by the concerned Department)	EE202	3-1-2	05
2	Electrical Machines II	EE204	3-1-2	05
3	Elements of Power Systems	EE206	3-1-2	05
4	Electromagnetic Field Theory	EE208	3-1-0	04
5	Signals & Systems	EE212	3-1-0	04
		Total	**15-5-6=26**	**23**

SEMESTER –V

Sr. No.	Subject	Code	Scheme	Credit
1	Power System Analysis	EE301	3-1-2	05
2	Control Systems	EE303	3-1-2	05
3	Power Electronic Converters	EE305	3-1-2	05
4	EIS-I	--	3-0-0	03
5	Electrical and Electronic Measurements	EE307	3-1-2	05
6	Seminar	EE309	0-0-2	01
		Total	**15-4 -10=29**	**24**

SEMESTER –VI

Sr. No.	Subject	Code	Scheme	Credit
1	Professional Ethics, Economics and Management#	HU353	4-0-0	04
2	Power Electronics System and Electric Drives	EE304	3-1-2	05
3	Microprocessor & Microcontrollers	EE306	3-1-2	05
4	Instrumentation	EE308	3-1-2	05
5	EIS-II	--	3-0-0	03
6	ES-I	EE3AA	3-0-0	03
		Total	**19-3-6=28**	**25**

 # One hour will be engaged by the core department.

SEMESTER –VII

Sr. No.	Subject	Code	Scheme	Credit
1	Microcontroller and Embedded 'C' Programming	EE401	3-0-2	04
2	Electrical Machine Design	EE403	3-1-0	04
3	ES-II	EE4AA	3-0-0	03
4	ES-III	EE4BB	3-0-0	03
5	Summer Training*	EE405	0-0-0	02
6	Project Preliminaries	EE407	0-0-6	03
		Total	**12-1-8=21**	**19**

***Summer Training is to be organized during the summer vacation after 6th Semester.**

SEMESTER –VIII

Sr. No.	Subject	Code	Scheme	Credit
1	ES-IV	EE4XX	3-0-0	03
2	ES-V	EE4YY	3-0-0	03
3	ES-VI	EE4ZZ	3-0-0	03
4	Innovation, Incubation & Entrepreneurship	HU410	3-0-0	03
5	Project	EE402	0-0-12	06
		Total	**12-0-12=24**	**18**

Total credits= 181

ELECTIVE INTERDISCIPLINARY SUBJECTS - EIS-I (EE3XX) (INSTITUTE LEVEL)

Course Code	Subject Name
EE361	Renewable Energy Sources
EE363	Optimization Methods
EE365	Forecasting and Planning Methods
EE367	Fundamental of Electrical Power Systems (Non-Electrical Students)
EE369	Modern Electrical Drives (Non-Electrical Students)
EE371	Introduction to Power Electronic Converters (Non-Electrical Students)
EE373	Control Systems (Non-Electrical Students)

ELECTIVE INTERDISCIPLINARY SUBJECTS - EIS-II (EE3YY) (INSTITUTE LEVEL)

Course Code	Subject Name
EE362	Industrial Automation and Process Control
EE364	State Variable Analyses
EE366	Energy Audit and Management
EE368	Special Electrical Machines
EE372	Advanced Materials for Energy Applications
EE374	Distributed Power Generation and Micro-Grids

CORE ELECTIVE SUBJECTS – ES – I (EE3AA) (DEPARTMENTAL)

Course Code	Subject Name
EE322	Power Plant Engineering
EE324	Adaptive Control and Soft Computing
EE326	Utilization of Electrical Energy
EE328	Modelling and Simulation of Electrical Machines
EE332	Random Processes
EE334	Artificial Intelligence Techniques
EE336	Switchgear and Protection

CORE ELECTIVE SUBJECTS – ES – II (EE4AA) (DEPARTMENTAL)

Course Code	Subject Name
EE421	Power Quality Disturbances and Mitigations
EE423	High Voltage Engineering
EE425	FACTS Devices
EE427	Discrete-Time Control Systems
EE429	Restructuring and Deregulation of Power Systems
EE431	Renewable Energy Systems

CORE ELECTIVE SUBJECTS – ES – III (EE4BB) (DEPARTMENTAL)

Course Code	Subject Name
EE433	Advanced Electrical Drives
EE435	Electronic Instrumentation and Control
EE437	Power System Transients
EE439	Advanced Industrial Automation
EE441	Reliability Evaluation of Electrical Systems
EE443	Wind and Solar Energy

CORE ELECTIVE SUBJECTS – ES – IV (EE4XX) (DEPARTMENTAL)

Course Code	Subject Name
EE422	Electric Traction and Linear Machines
EE424	EHV AC Transmission
EE426	Advanced Power Electronics
EE428	Nonlinear and Optimal Control
EE432	Advanced Microcontroller (Digital Signal Controller)
EE434	Industrial Instrumentation
EE436	Power System Operation and Control

CORE ELECTIVE SUBJECTS – ES – V (EE4YY) (DEPARTMENTAL)

Course Code	Subject Name
EE438	Power Filter Technology
EE442	Smart Grid Technology
EE444	HVDC Transmission
EE446	Electric Vehicles
EE448	Digital Signal Processing
EE452	Modern Materials for Electrical Engineering
EE454	Special Electrical Machines and Drives

CORE ELECTIVE SUBJECTS – ES – VI (EE4ZZ) (DEPARTMENTAL)

Course Code	Subject Name
EE456	Switched Mode Power Supply
EE458	Computer Methods for Power Systems
EE462	Robotics
EE464	Communication Engineering
EE466	VLSI Technology
EE468	Antenna and Wave Propagations
EE472	Cryptography and Cyber Security for Smart Grid

SARDAR VALLABHBHAI NATIONAL INSTITUTE OF TECHNOLOGY, SURAT
DEPARTMENT OF ELECTRICAL ENGINEERING

B. Tech. Programme

B. Tech. II

Semester III

Sr. No.	Course Code	Course	L	T	P	Credits	Examination Scheme				
			Hrs	Hrs	Hrs		Theory Marks	Tutorial Marks	Term work Marks	Practical Marks	Total Marks
1.	MA217	Mathematics-III	3	1	0	04	100	25	-	-	125
2.	EE201	Electric Circuits	4	1	0	05	100	25	-	-	125
3.	EE203	Electrical Machines I	3	1	2	05	100	25	25	25	175
4.	EC211	Digital Circuits	3	1	2	05	100	25	25	25	175
5.	CS207	Introduction to Data Structure	3	0	2	04	100	00	25	25	150
Total(L-T-P)			**16**	**04**	**06**	**23**	**500**	**100**	**75**	**75**	**750**
Total			**26**			**23**					

Semester IV

Sr. No.	Course Code	Course	L	T	P	Credits	Examination Scheme				
			Hrs	Hrs	Hrs		Theory Marks	Tutorial Marks	Term work Marks	Practical Marks	Total Marks
1.	EE202	Engineering Mathematics	3	1	2	05	100	25	25	25	175
2.	EE204	Electrical Machines II	3	1	2	05	100	25	25	25	175
3.	EE206	Elements of Power Systems	3	1	2	05	100	25	25	25	175
4.	EE208	Electromagnetic Field Theory	3	1	0	04	100	25	-	-	125
5.	EE212	Signals & Systems	3	1	0	04	100	25	-	-	125
Total(L-T-P)			**15**	**05**	**06**	**23**	**500**	**125**	**75**	**75**	**775**
Total			**26**			**23**					

B. Tech. II year, Semester III

Mathematics-III

L	T	P	Credit
3	1	0	04

MA 217 **Scheme**

1. Course Outcomes (Cos):

At the end of the course, the students will be able to:

CO1	explain the concept of convergence and divergence of infinite series
CO2	express the periodic functions in the form of Fourier series along with different cases.
CO3	compute Fourier Integral from Fourier series
CO4	explain the concept of Fourier transform with their applications
CO5	apply basic concept of the Linear Algebra to Electrical Engineering Problems

2. Syllabus

- **INFINITE SERIES** **(07 Hours)**
  Introduction, Positive term series, Comparison test, Cauchy's root test, D'Alembert's test, Raabe's test, Logarithmic test, Integral test, Gauss's test, Series with arbitrary terms, Rearrangement of terms.
- **FOURIER SERIES** **(07 Hours)**
  Definition, Fourier series with arbitrary period, in particular periodic function with period 2π. Fourier series of even and odd function, Half range Fourier series.
- **FOURIER INTEGRAL AND FOURIER TRANSFORMS** **(07 Hours)**
  Fourier Integral theorem, Fourier sine and cosine integral complex form of integral, Inversion formula for Fourier transforms, Fourier transforms of the derivative of a function.
- **MATRICES** **(07 Hours)**
  Properties of matrices, Non-singular Matrices, Reduced Row-Echelon form, Systems of linear equations, Solution of system of linear equations, LU Decomposition Method
- **EIGENVALUES AND EIGENVECTORS** **(07 Hours)**
  Eigenvalues and eigenvectors, Characteristic polynomials, Minimal polynomials, Diagonalizability, Triangularization, Rational canonical form, Jordon canonical form, Positive Define Matrices, Singular Value Decomposition.
- **VECTOR SPACE AND SUBSPACES** **(07 Hours)**
  Fields, Vector spaces over a field, subspaces, Linear independence and dependence, coordinates, Bases and dimension, Gram-Schmidt ortho-normalization, Orthonormal basis, Orthogonal projection.

Tutorials will be based on the coverage of the above topics separately **(14 Hours)**

Total Hours: 42

Tutorials will be conducted separately for 14 hours

3. Books Recommended:

1. E. Kreyszig, Advanced Engineering Mathematics, 10th Edition, John Wiley, 2015.
2. C. R. Wiely, Advanced Engineering Mathematics, 6th Edition, McGraw-Hill, 1995.
3. O'Neil Peter, Advanced Engineering mathematics, 8th Edition, Thompson, 2017.
4. D. Greenbar Michael, Advanced Engineering Mathematics, Pearson Singapore Indian Edition, 2007.
5. Sheldon Axler, Linear Algebra Done Right, 3rd Edition, Springer. 2015.

RJ

RJ

B. Tech. II year, Semester III

L	T	P	Credit
4	1	0	05

Electrical Circuits

EE 201

Scheme

1. Course Outcomes (Cos):

At the end of the course the students will be able to:

CO1	apply concept of graph theory for solution of AC and DC circuits.
CO2	develop a mathematical model (differential equations) of a given electric circuit and solve it using technique of domain transformation.
CO3	construct a given waveform by using set of standard functions.
CO4	calculate various parameters of two port network and inter relationship between them.
CO5	design filter circuits for given specifications.

2. Syllabus

- **GRAPH THEORY AND ITS APPLICATIONS** **(10 Hours)**
  Fundamental concepts, definitions of a graph and various related terms, cut sets and tie sets, matrices of oriented graphs, properties and inter relationships of incidence, tie set and cut set matrices, complete circuit analysis using tie set and cut set techniques
- **LAPLACE TRANSFORMATION** **(09 Hours)**
  Laplace transform properties and theorems, Laplace transform of standard functions, Laplace transforms for periodic functions, initial and final value theorems, Inverse Laplace transform using partial fraction expansion and convolution integral methods. Waveform synthesis.
- **NETWORK FUNCTIONS AND TWO PORT PARAMETERS** **(16Hours)**
  Poles and zeros of a function, physical and analytical concepts, terminals and terminal pairs, driving point immittances, transfer functions, restrictions on locations of poles and zeros in S-plane. time domain behavior from pole zero locations in the S plane, procedure for finding network functions for general two terminal pair network, transfer immittances, two port and N-port networks, Ladder, Lattice, Pie, and Tee networks. Definitions, calculations and interrelationships of impedance, admittance, hybrid, and transmission line parameters for two port networks and their interrelations
- **ONE TERMINAL PAIR NETWORKS** **(05 Hours)**
  Reactive networks and their properties, external and internal critical frequencies, separation property for reactive functions and its proof
- **TWO TERMINAL PAIR REACTIVE NETWORKS (FILTERS)** **(08Hours)**
  Ladder network and its decomposition into tee, pie, and L sections, image impedance, image transfer function and applications to LC networks, attenuation and phase shift in symmetrical Tee and Pie networks, constant K-filters, m-derived filters, composite filters, lattice filters, Bartlett's bisection theorem. Introduction to the active filters
- **AC AND DC TRANSIENTS** **(08 Hours)**
  Initial and final conditions of networks and their S-domain equivalent circuits , R-L, R-C and R-L-C DC transients, two mesh transients, R-L, R-C and R-L-C sinusoidal transient analysis using Laplace transform methods, two mesh AC transients, complete response of RL, RC and RLC circuits to step, sinusoidal, exponential, ramp, impulse and the combinations of these excitations.

Total Hours: 56

Tutorials will be conducted separately for 14 hours

3. **Books Recommended**:

1. W. H. Hayt, J. E. Kemmerly, and Durbin S. M., Engineering Circuit Analysis, Tata McGraw Hill, 6th Edition, 2006.
2. M.E. Van Valkenburg, Network Analysis, Prentice Hall, India, 3rd Edition, 2002.
3. A. Chakrabarti, Circuit Theory, Dhanpat Rai & Co., 6th Edition, 2012.
4. A. Edminister Joseph, Electrical circuits, Schaum's outline series, McGraw hill, 2nd Edition, 1983.
5. Charles K. Alaxander and Matthew N.O. Sadiku, Fundamentals of electric circuits, Tata McGraw Hill, 5th Edition, 2013.

B. Tech. II year, Semester III

Electrical Machines – I

L	T	P	Credit
3	1	2	05

EE203 **Scheme**

1. Course Outcomes (Cos):

At the end of the course the students will be able to:

CO1	explain the construction and principle of operation of the transformers and induction motors.
CO2	perform tests on the transformers and induction motors
CO3	analyze the performance of the transformers and induction motors
CO4	compare the performance of different types of transformers and induction motors
CO5	select the machines for different real world applications
CO6	communicate effectively through laboratory report writing, presentation and perform task as an efficient team member

2. Syllabus

- **TRANSFORMERS** **(06 Hours)**
  Review of equivalent circuits and vector diagram, circuit parameter determination, per unit impedance, regulation, losses, efficiency, magnetic inrush and effect of saturation, parallel operation.
- **POLYPHASE TRANSFORMERS** **(09 Hours)**
  Standard connections phase angle difference, harmonic analysis, open delta connection, Scott connections, three-phase to six-phase conversion, three winding transforms and parallel operation.
- **AUTO TRANSFORMERS** **(02 Hours)**
  Construction, voltage and current ratios, phasor diagram and equivalent circuit.
- **TESTS ON TRANSFORMERS** **(04 Hours)**
  OC- SC tests, Polarity test, Back to back Sumpner's test.
- **THREE-PHASE INDUCTION MOTORS** **(07 Hours)**
  Review of equivalent circuit and vector diagram, performance analysis, torque-speed characteristics, no load and blocked rotor tests, circle diagram.
- **STARTING, BRAKING AND SPEED CONTROL** **(07 Hours)**
  Double cage motors, starting problems, methods of starting, speed control methods, cascade connections, cogging and crawling, regenerative braking, plugging, ac and dc dynamic (rheostatic) braking.
- **INDUCTION GENERATORS AND REGULATOR** **(03 Hours)**
  Principle of operation, performance analysis, application.
- **SINGLE PHASE INDUCTION MOTORS** **(04 Hours)**
  Principle of operation, revolving field theory, cross field theory, equivalent circuit and performance analysis, determination of circuit parameters by no- load and blocked rotor test, starting methods, unbalanced operation of three phase induction motor.

Total Hours:42

Tutorials will be conducted separately for 14 hours

3. List of Experiments:

1. Determination of efficiency & regulation of single- phase transformer from Open circuit and short circuit test.
2. Determination of efficiency & regulation of single- phase transformer from Sumpner's test.
3. Scott connection of 1-phase transformers.
4. Open delta connection of three single-phase transformers.
5. Standard connections for three-phase transformer.
6. Load test on three-phase Induction Motor.
7. Load test on three-phase Induction Generator.
8. Determination of the equivalent circuit parameters from No-Load and Blocked rotor tests of three-phase Induction Motor.
9. Determination of the equivalent circuit parameters from No-Load and Blocked rotor tests of 1-phase Induction Motor.
10. Determination of the performance parameters of three-phase induction motor from circle diagram.
11. Induction regulator.
12. Unbalanced operation of three-phase Induction Motor.

4. Books Recommended:

1. I. J. Nagrath and D. P. Kothari, Electric Machines, Tata McGraw Hill, New Delhi, 2005.
2. M. G. Say, The performance and design of alternating current machines, CBS Publishers and Distributors, Delhi, 1983.
3. Fitzgerald, Kingsley and Umans, Electric Machinery, Tata McGraw Hill, New Delhi, 2003
4. S. K. Sen, Electrical Machinery, Khanna Pub., Delhi, 2012.
5. Mukherjee and Chakravorty, Electrical Machines, Dhanpat Rai Pub., New Delhi, 2005.

B. Tech. II year, Semester III

L	T	P	Credit
3	1	2	05

Digital Circuits

EC211 **Scheme**

1. Course Outcomes (Cos):

At the end of the course the students will be able to:

CO1	apply Boolean algebra to understand binary logic and logic circuits.
CO2	formulate combinational logic problems and solve using truth table. Optimize using K-map and other equivalent techniques
CO3	investigate and realize various options for implementing sequential synchronous logic
CO4	explain operation of synchronous sequential circuit, counters, registers and memory
CO5	formulate RTL (register transfer language) statements to describe complex digital hardware and derive or infer logic circuit from RTL Description
CO6	design and analyze circuits for ALU and Shifter. Design and investigate various Control unit architecture (Hardwired, Micro-program, PLA etc.) to control and sequence hardware operations

2. Syllabus:

- **BOOLEAN ALGEBRA AND SIMPLIFICATION** **(08 Hours)**
  Basic Logic Operation and Logic Gates, Truth Table, Basic Postulates and Fundamental Theorems of Boolean Algebra, Standard Representations of Logic Functions- SOP and POS Forms, Simplification of Switching Functions-K-Map and Quine-McCluskey Tabular Methods, Synthesis of Combinational Logic Circuits
- **COMBINATIONAL LOGIC CIRCUITS** **(08 Hours)**
  Binary Parallel Adder, BCD Adder, Encoder Priority Encoder, Decoder, Multiplexer and De-multiplexer Circuits, Implementation of Boolean Functions using Decoder and Multiplexer, Arithmetic and Logic Units, BCD-To-Segment Decoder, Common Anode and Common Cathode, 7-Segment Displays, Random Access Memory, Read Only Memory and Erasable Programmable ROMs, Programmable Logic Arrays(PLA) and Programmable Array Logic(PAL)
- **LATCHES AND FLIP-FLOPS** **(06 Hours)**
  Cross Coupled SR Flip-Flop Using NAND or NOR Gates, Clocked Flip-flops, D-Types and Toggle Flip-flops, Truth Tables and Excitation Tables for Flip-flop. Master Slave Configuration, Edge Triggered and Level Triggered Flip-flop, Flip-flop with Preset and Clear
- **SEQUENTIAL LOGIC CIRCUIT** **(06 Hours)**
  Introduction to State Machine, Mealy and Moore Model, State Machine Notation, State Diagram, State Table, Transition Table, Table Excitation, Table and Equation, Basic Concepts of Counters and Register, Shift Left and Right Register, Registers with Parallel Load, Serial-in-Parallel-Out(SIPO) and Parallel-In-Serial-Out(PISO), Register Using Different Types of Flip-flop, Binary Counters, BCD Counters, Up Down Counter, Johnson Counter, Module-N Counter, Design of Counter using State Diagrams and Tables, Sequence Generators
- **REGISTER TRANSFER LOGIC** **(04 Hours)**
  Arithmetic Logic and Shift Micro-Operation, Conditional Control Statements, Fixed-Point and Floating-Point Data, Arithmetic Shifts, Instruction code and Design of Simple Computer
- **PROCESSOR DATA PATH AND CONTROL UNIT** **(06 Hours)**
  Processor Organization, Design of Arithmetic Logic Unit (ALU), Design of Accumulator, Control Organization, Hard-Wired Control, Micro Program Control, Control of Processor Unit, PLA Control

- **INTRODUCTION TO VHDL** **(04 Hours)**
  Introduction, Gate-Level Modeling, Data Type, Operators, Operands, Process and Behavioral Modeling, Timing Controls, Structural modeling, Registers, Flip-flop, Counter, Multiplexer, Adder/Subtractors, Tri-State Buffers
- **TUTORIALS** **(14 Hours)**

Total Hours:42

Tutorials will be conducted separately for 14 hours

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3. List of Experiments:

(Following experiments are to be performed using discrete components)

1. Introduction to variety of logic gates and digital ICs
2. Flip-flops using NAND/ NOR Gate.
3. Half-Adder/ Half-subtarctor Circuits using a serial Input.
4. Full-Adder/ Full-subtarctor Circuits using a serial Input.
5. Parity checker and parity generator circuit
6. 4-Bit Gray to Binary, Binary to Gray Code convertor using Select input.

(Following experiments are to be performed on CPLD kit using VHDL)

7. Logic expression with the Help of MUX IC 74153.
8. (a) Modulo-7 Ripple Counter with synchronous reset.
   (b) 4-bit up/down ripper counter with asynchronous reset
9. 4-Bit Shift Left/Right Register.
10. Sequence Generator using LFSR method.
11. Excess-3 BCD Adder/ Subtractor with Select Input.

4. Books Recommended:

1. Mano Morris, Digital Logic and Computer Design, Pearson Education, 4th Edition, 2006.
2. Anand Kumar, Fundamentals of Digital Circuits, PHI, 4th Edition, 2016.
3. R. P. Jain and M. H. S. Anand, Digital Electronics Practices using Integrated Circuits, Tata McGraw Hill, 1st Edition, 2004.
4. Lee Samual, Digital Circuits and Logic Design, PHI, 1st Edition, 1998.
5. Floyed Thomas L. and R. P. Jain, Digital Fundamentals, Pearson Education, 8th Edition, 2006.
   Brown S. and Zvonko Vranesic, Fundamental of Logic with Verilog Design, Tata McGraw Hill, 1st Edition, 2003.

B. Tech. II year, Semester III

L	T	P	Credit
3	0	2	04

Introduction to Data Structures

CS207 **Scheme**

1. Course Outcomes (Cos):

At the end of the course the students will be able to:

CO1	recognize the need of different data structures and understand its characteristics.
CO2	apply different data structures for given problems.
CO3	design and analyze different data structures, sorting and searching techniques.
CO4	evaluate data structure operations theoretically and experimentally.
CO5	solve for complex engineering problems.

2. Syllabus

- **BASICS OF DATA STRUCTURES** **(02 Hours)**
  Review of Concepts: Information and Meaning, Abstract Data Types, Internal Representation of Primitive Data Structures, Arrays, Strings, Structures, Pointers.

- **LINEAR LISTS** **(06 Hours)**
  Sequential and Linked Representations of Linear Lists, Comparison of Insertion, Deletion and Search Operations for Sequential and Linked Lists, Doubly Linked Lists, Circular Lists, Lists in Standard Template Library (STL), Applications Of Lists.

- **STACKS** **(06 Hours)**
  Sequential and Linked Implementations, Representative Applications such as Recursion, Expression Evaluation Viz., Infix, Prefix and Postfix, Parenthesis Matching, Towers of Hanoi, Wire Routing in a Circuit, Finding Path in a Maze.

- **QUEUES** **(06 Hours)**
  Operations of Queues, Circular Queue, Priority Queue, Dequeue, Applications of Queues, Simulation of Time Sharing Operating Systems, Continuous Network Monitoring System Etc.

- **SORTING AND SEARCHING** **(04 Hours)**
  Sorting Methods, Bubble Sort, Selection Sort, Quick Sort, Radix Sort, Bucket Sort, Dictionaries, Hashing, Analysis of Collision Resolution Techniques, Searching Methods, Linear Search, Binary Search, Character Strings and Different String Operations.

- **TREES** **(08 Hours)**
  Binary Trees and Their Properties, Terminology, Sequential and Linked Implementations, Tree Traversal Methods and Algorithms, Complete Binary Trees, General Trees, AVL Trees, Threaded Trees, Arithmetic Expression Evaluation, Infix-Prefix-Postfix Notation Conversion, Heaps as Priority Queues, Heap Implementation, Insertion and Deletion Operations, Heapsort, Heaps in Huffman Coding, Tournament Trees, Bin Packing.

- **MULTIWAY TREES** **(04 Hours)**
  Issues in Large Dictionaries, M-Way Search Trees, B Trees, Search, Insert and Delete Operations, Height of B-Tree, 2-3 Trees, Sets and Multisets in STL.

- **GRAPHS** **(06 Hours)**
  Definition, Terminology, Directed and Undirected Graphs, Properties, Connectivity in Graphs, Applications, Adjacency Matrix and Linked Adjacency Chains, Graph Traversal, Breadth First and

Depth First Traversal, Spanning Trees, Shortest Path and Transitive Closure, Activity Networks, Topological Sort and Critical Paths.

Total Hours: 42

3. List of Experiments:

(Problem statements will be changed every year and will be notified on website.):

1 Implementation of Array and its applications
2 Implementation of Stack and its applications
3 Implementation of Queue and its applications
4 Implementation of Link List and its applications
5 Implementation of Trees and its applications
6 Implementation of Graph and its applications
7 Implementation of Hashing functions and collision resolution techniques
8 Mini Project (Implementation using above Data Structure)

4. Books Recommended:

1. Trembley and Sorenson, An Introduction to Data Structures with Applications, 2nd Edition, Tata McGraw Hill, 1991.
2. Tanenbaum and Augenstein, Data Structures using C and C++, 2nd Edition, Pearson, 2007.
3. Horowitz and Sahani, Fundamentals of Data Structures in C, 2nd Edition, Silicon Press, 2007.
4. T. H. Cormen, C. E. Leiserson, and R. L. Rivest, Introduction to Algorithms, 3rd Edition, MIT Press, 2009.
5. Robert L. Kruse, C. L. Tondo and Brence Leung, Data Structures and Program Design in C, 2nd Edition, Pearson Education, 2001.

B. Tech. II year, Semester IV

Engineering Mathematics

L	T	P	Credit
3	1	2	05

EE202 **Scheme**

1. Course Outcomes (Cos):

At the end of the course the students will be able to:

CO1	Explain various numerical methods.
CO2	Compare their convergence rate, errors and propagation of error.
CO3	Implement the algorithms through software like on C/C++/MATLAB.
CO4	Apply the numerical methods for solving problems related to electrical engineering.
CO5	Modeling various systems and perform regression analysis.

2. Syllabus:

- **ERRORS IN NUMERICAL COMPUTATION AND THEIR ESTIMATION (04 Hours)**
  Introduction, Taylor Theorem Revisit, Measuring Errors, Sources of Error, Binary Representation, Floating Point Representation, Propagation of Errors.
  Application: errors in electrical measurements and instrumentations

- **SOLUTION OF TRANSCENDENTAL AND POLYNOMIAL EQUATIONS (07 Hours)**
  Bisection method, Secant Method, False position method, Newton Raphson method for Polynomial and transcendental equations, system of nonlinear equations, rate of convergence, conditions for convergence

- **SOLUTION TO SYSTEM OF LINEAR ALGEBRAIC EQUATIONS (08 Hours)**
  Gauss elimination method, Gauss Jordon Method, LU decomposition, Jacobi and Gauss Seidel Iteration methods, conditions for convergence
  Applications: solution to mesh and nodal analysis of electrical networks, solution to power load flow, operation of different electrical applications

- **INTERPOLATION AND REGRESSION (11 Hours)**
  Direct method of interpolation, Linear interpolation and higher order interpolation using Lagrange's and Newton's forward, backward and divided difference formulae, linear, quadratic, exponential and logarithmic regression, adequacy of regression models.
  Applications: prediction of the performance of electrical motors and generators from their practical data, application to load forecasting and generation scheduling, prediction of solar intensity and wind velocity.

- **NUMERICAL INTEGRATION (03 Hours)**
  Trapezoidal rule, Simpson's 1/3 and 3/8 rules and Errors
  Applications: average, RMS quantity determination of electrical measuring quantities, load demand calculations.

- **SOLUTION TO ORDINARY DIFFERENTIAL EQUATIONS (09 Hours)**
  Taylor series, Euler's method, Euler's predictor corrector method, Runge-Kutta method of Second and Fourth Order, higher order/coupled ordinary differential equation
  Applications: DC and AC transients of electrical networks, solution for generators oscillations

Total Hours: 42

Tutorials will be conducted separately for 14 hours

3. List of Experiments:

The programmes are to be executed in C++/MATLAB

1. To find the roots of the polynomial using bisection, false position, Newton-Raphson, secant methods
2. To find the solution of set of nonlinear equations using Newton-Raphson method
3. To find the numerical integration suing trapezoidal, Simpson's 1/3 and Simpson's 3/8 method
4. To find the interpolating polynomial using Linear, Lagrangian, Newton's forward, backward and divided difference methods
5. To find the solution to set of linear simultaneous equations using Gauss elimination, Gauss-Jordan, Jacobi and Gauss-Seidel methods
6. To find the solution to ordinary differential equations using Euler's, modified Euler's, Runge-Kutta 2nd order and 4th order methods
7. To regress a given set of data using polynomial, exponential and logarithmic regression formulae

4. Books Recommended:

1. S. S. Shastri, Introductory Methods of Numerical Analysis, Prentice Hall Ltd., 4th Edition, 2005.
2. M. K. Jain, M. K. Iyengar and S.R.K., Jain, Numerical Methods for Scientific and Engineering Computation, 4th Edition, 2003, New Age international Publishers, Pvt. Ltd.
3. S. A. Teukolsky W. T. Vetterling, W. H. Press and B. P. Flannery, Numerical recipes in 'C', 2nd Edition, Foundation Books Pvt. Ltd., 2001.
4. R. S. Salaria, Numerical methods: A computer oriented approach, BPB Publications, 1996.
5. S. D. Conte and Carl de Boor, Elementary Numerical Analysis- An Algorithmic Approach, 3rd Edition, McGraw-Hill, 1980.

B. Tech. II year, Semester IV

Electrical Machines – II

L	T	P	Credit
3	1	2	05

EE204

Scheme

1. COURSE OUTCOMES (COs):

At the end of the course the students will be able to:

CO1	explain the construction and principle of operation of the DC machines and synchronous machines
CO2	perform tests on the DC machines and synchronous machines
CO3	analyze the performance of the DC machines and synchronous machines
CO4	compare the performance of different types of DC machines and synchronous machines
CO5	select the machines for different real world applications
CO6	communicate effectively through laboratory report writing, presentation and perform task as an efficient team member

2. SYLLABUS

- **DIRECT CURRENT MACHINES** **(09 Hours)**
  Construction, armature windings, simple lap and wave windings, armature reaction, demagnetizing and cross magnetizing ampere-turns, compensating winding, commutation, commutation time and type, reactance voltage, inter-poles, ampere-turns for inter-poles, self and separate excitations, shunt, series and compound motors and generators, magnetization characteristics, performance characteristics of DC generators and motors.

- **STARTING, SPEED CONTROL AND BRAKING OF DC MACHINES** **(06 Hours)**
  Starting problems, methods of starting, starters, methods of speed control, methods of braking.

- **TESTING OF DC MACHINES** **(05 Hours)**
  Swinburne's test, Hopkinson's test, separation of core losses, retardation test, series field test.

- **BRUSHLESS D.C. MACHINES** **(03 Hours)**
  Construction, equivalent circuit, performance analysis.

- **SYNCHRONOUS MACHINES**
  Construction, cylindrical and salient pole type, basic principles, armature windings, distributed winding, full pitched windings, chording, EMF equation, distribution and pitch factors, excitation system, **(04Hours)**
  armature reaction, synchronous machine impedance, SCR, equivalent circuit, phasor diagram, voltage regulations, synchronous impedance method, MMF method, ZPF method, operating characteristics **(05Hours)**
  'V' and inverted 'V' curves, power angle characteristics, power flow equation for salient and non-salient pole type synchronous machines, salient pole synchronous machine - two reaction model, phasor diagram, **(05 Hours)**
  power angle characteristic, hunting, damper winding, parallel operation of alternators, starting methods of synchronous motors, synchronous condenser, synduction machines **(05Hours)**

Total Hours: 42

Tutorials will be conducted separately for 14 hours

3. LIST OF EXPERIMENTS:

1. Speed control of dc shunt motor.
2. Swinburne's test
3. Speed torque characteristic of a D. C. Shunt motor.
4. D. C. Series motor, Speed -torque characteristic.
5. External & Internal characteristics of D. C. separately excited and Shunt generator.
6. Regulation of an alternator by synchronous impedance method
7. 'V' and 'inverted V' curves of a synchronous motor.
8. Regulation of an alternator by zero power factor method
9. Regulation of an alternator by MMF method.
10. Synchronization of an alternator with infinite bus bar.
11. Power factor improvement using synchronous motor.
12. Hopkinson's Test on DC machines.
13. Retardation Test on DC Shunt motor.
14. Separation of core losses of DC machines.

4. BOOKS RECOMMENDED:

1. Nagrath and Kothari, "Electric Machines", TMH, New Delhi, 2005.
2. M. G. Say, The performance and design of alternating current machines, CBS Publishers and Distributors, Delhi, 1983.
3. A. E. Clayton and N. M. Hancock, The Performance and Design of Direct Current Machines, CBS Publishers, 2004.
4. P. K. Mukherjee and S. Chakravorty, Electrical Machines, Dhanpat Rai Pub., New Delhi, 2005.
5. Fitzgerald, Kingsley and Umans, Electric Machinery, Tata McGraw Hill, New Delhi, 2003.

RJ

B. Tech. II year, Semester IV

Elements of Power Systems

L	T	P	Credit
3	1	2	05

EE206 **Scheme**

1. Course Outcomes (Cos):

At the end of the course the students will be able to:

CO1	classify and analyze the electrical power transmission and distribution.
CO2	compute the cost of power generation and the cost of electricity.
CO3	design the transmission line and analyze the performance of transmission lines.
CO4	analyze the performance of the underground cable.
CO5	Simulate/model the power system components in MATLAB/ETAP platforms and analyze the numerical results.

2. SYLLABUS:

- **SUPPLY SYSTEMS** **(04 Hours)**
  AC and DC power supply systems, comparison of ac and dc transmission, advantages of high transmission voltage, various systems of power supply, comparison of conductor materials in overhead system and underground cable system, economic choice of conductor size and economic choice of voltage.

- **D.C. AND A. C. DISTRIBUTION** **(06 Hours)**
  Types of dc distributors, dc distribution calculations, ac distributor, fed at one and fed at both the ends with concentrated loads and uniformly distributed loads, ring distributors with inter connectors, current distribution in three wire and four wire ac systems, overview of distribution automation.

- **ECONOMIC ASPECTS OF POWER SYSTEM** **(06 Hours)**
  Power factor improvement, Tariff structure, ABT, Economic aspects of power generation.

- **UNDERGROUND CABLES** **(05 Hours)**
  Underground cables, construction of cables, classification of cables, cables for three phase services, insulation resistance of a single core cable, capacitance of a single core cable, dielectric stresses in a single core cable, most economical conductor size in a cable, grading of cables, capacitance grading and inter-sheath grading, capacitance of three core cable and measurements of capacitances, dielectric loss and tan(δ) measurement.

- **CALCULATION OF LINE PARAMETERS** **(09 Hours)**
  Conductors, types of conductors in use, bundled conductor, spacing of conductors, symmetrical and unsymmetrical spacing, equivalent spacing, transposition, transmission line constants, calculation of resistance, inductance and capacitance for simple arrangements and multi-circuit lines, symmetrical and unsymmetrical spacing, concept of self GMD, mutual GMD and their uses in calculations of parameters of overhead lines, skin and proximity effects.

- **CHARACTERISTICS AND PERFORMANCE OF POWER TRANSMISSION LINES** **(12 Hours)**
  Short and medium transmission lines, Line performance, effect of capacitance, charging currents, short and medium lines, calculation by nominal-T, nominal-π and end-condenser method, regulation and efficiency, Concept of ABCD constants, the long transmission line- rigorous solution, evaluation of ABCD constants, interpretation of long line equation, surge impedance and surge impedance loading,

the equivalent circuit of a long transmission line, power flow through a transmission line, circle diagrams, Ferranti effect. Reactive power compensation, transmission line transients, concept of travelling waves, reflection and refraction coefficients.

Total hours: 42

Tutorials will be conducted separately for 14 hours

3. List of Experiments:

The experiments are based on the MATLAB/ETAP simulations of power system components and hardware experiments and a substation/power plant visit.

1. Demonstration visit of 66 kV/22 kV SVNIT sub-station.
2. Study of single line diagram of Power System.
3. Power factor improvement of load.
4. Performance calculation of short and medium transmission lines.
5. Performance calculation of long transmission lines.
6. String efficiency calculation of suspension type insulator.

4. Books Recommended:

1. W. D. Stevenson, Element of Power System Analysis, McGraw Hill, 4th Edition 1982.
2. I. J. Nagrath and D. P. Kothari, Power System Engineering, 4th edition, Tata McGraw Hill publishing Company Ltd, 2014.
3. A. Chakrabarti, M. L. Soni, P. V. Gupta and U. S. Bhatnagar, A Text Book on Power System Engineering, Dhanpat Rai & Co., 2nd Edition 2001.
4. Hadi Saadat, Power System Analysis. 5th reprint, TMH publishing Company Ltd, 2004.
5. Arthur R. Bergen, Vijay Vittal, Power Systems Analysis, Prentice-Hall, Inc., 2nd Edition 2000.

B. Tech. II year, Semester IV

L	T	P	Credit
3	1	0	04

Electromagnetic Field Theory

EE208 **Scheme**

Course Outcomes (Cos):

At the end of the course the students will be able to:

CO1	describe various theorems related to vector analysis
CO2	differentiate different types of coordinate systems and use them for solving the problems of electromagnetic field theory
CO3	explain concepts, theories and laws of electrostatics, magnetics, electromagnetics, electromagnetic wave propagation and transmission lines
CO4	analyze problems of electrostatics, magnetics, electromagnetics and electromagnetic wave propagation
CO5	apply theories and laws of electrostatics, magnetics and electromagnetics to solve electrical engineering problems
CO6	deduce the electromagnetic wave propagation from Maxwell's equations

1. Syllabus:

- **VECTOR ANALYSIS:** **(08 Hours)**
  General Treatment on Cartesian, cylindrical, spherical and general curvilinear co-ordinate systems with reference to vectors, operation of gradient, divergence, curl, Laplacian., Gauss's Divergence theorem, Stoke's theorem.

- **ELECTROSTATICS:** **(09 Hours)**
  Review of electric field quantities and their definitions. Gauss's flux theorem, Poisson's Equation and Laplace Equation, uniqueness theorem, Green's theorem, Coulomb's law, dipole moment. Electrostatic Field in Dielectric: Polarization, electric flux density, boundary conditions, capacitor and capacitance, electrostatic shielding, energy stored in electric fields.

- **MAGNETIC FIELDS AND ELECTROMAGNETIC INDUCTION:** **(10 Hours)**
  Magnetic flux and flux density, static currents in conducting media, Ampere's law, Biot-Savart law, boundary between magnetic media, forces between currents, magnetic potentials, magnetic torque and moment, Dipole, Energy stored in magnetic field. Faraday's law of induction (transformer and motion), Inductor and Inductances (self and mutual).

- **MAXWELL'S EQUATIONS & ELECTROMAGNETIC WAVES:** **(09 Hours)**
  Maxwell's equations - Equation of continuity - Displacement current - Maxwell's equation in point and integral forms ,Time-varying potentials, wave equations, plane waves in Losses Dielectrics, Free space & Good conductors, Poynting vector and Theorem.

- **TRANSMISSION LINES:** **(06 Hours)**
  Line equations, input impedance, SWR and power, smith chart, some applications of Transmission lines.

Total hours: 42

Tutorials will be conducted separately for 14 hours

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2. Books Recommended:

1. W. H. Hayt, J. A. Buck, and M. Jaleel Akhtar, "Engineering Electromagnetics", 8th Edition, McGraw Hill Publication
2. David J. Griffiths, Introduction to Electrodynamics, 4th Edition, PHI, 2013.
3. S. P. Seth, Elements of Electromagnetic Fields, Dhanpat Rai & Co., 4th Edition, 2012.
4. C. L. Wadhwa, Engineering Electromagnetics, New Age International Publishers, 3rd Edition, 2012.
5. Fawwaz T. Ulaby, Electromagnetics for engineers, Pearson education, first Indian reprint,2005.

B. Tech. II year, Semester IV

Signal and Systems

L	T	P	Credit
3	1	0	04

EE212 **Scheme**

1. Course Outcomes (Cos):

At the end of the course students will be able to:

CO1	classify various signals and their mathematical representation
CO2	develop insights into discrete-time systems and their realization
CO3	analyze the characteristics of LTI systems with the help of impulse response and convolution
CO4	design the system properties in frequency domain
CO5	analyze random signals and justify their usefulness in engineering systems

2. Syllabus:

- **SIGNALS AND THEIR PROPERTIES** **(08 Hours)**
  Classification of Signals, continuous-time and discrete-time signals, deterministic and random signals, periodic signals, even and odd signals, exponential and sinusoidal signals, unit step and unit impulse signals, systems with and without memory, time-varying, time-invariant, stationarity, causality, homogeneity, linearity, stability of systems
- **LINEAR TIME INVARIANT SYSTEMS** **(08 Hours)**
  Properties of linear time-variant systems, continuous-time LTI systems, relationship between linear differential equations with constant coefficients, transfer function, state space models, convolution integrals from transfer function and state space models, discrete-time LTI systems, relationship between linear difference equations with constant coefficients, pulse transfer function, discrete-time state space models, convolution sum from transfer function and state space models, connections between time-invariance, causality, stationarity.
- **FOURIER SERIES REPRESENTATION AND FOURIER TRANSFORM** **(05 Hours)**
  Fourier series representation of continuous-time periodic signals, Parseval formula for continuous-time periodic signals, continuous time Fourier transform, discrete-time Fourier transforms, connection between the Fourier transform and Laplace transform, connection between the z-transform and discrete-time Fourier transform.
- **THE LAPLACE TRANSFORMATION TECHNIQUE** **(06 Hours)**
  Definition of the Laplace transformation, the need of the Laplace transformation, region of the convergence of the Laplace transform of signals, properties of the Laplace transform, the Laplace transforms of test signals and practically useful signals, unilateral Laplace transform and bilateral Laplace transforms.
- **THE Z-TRANSFORMATION TECHNIQUE** **(06 Hours)**
  Definition of the z- transformation, the need of the z- transformation, region of the convergence of the z- transform of signals, pulse transfer function, stability of systems using the z-transform. The z-transforms of test signals and practically useful signals, unilateral z transform and bilateral z transforms
- **FEEDBACK CONCEPTS** **(09 Hours)**
  Physical representation of network, general restrictions on physical network characteristics Feedback, mathematical definition of feedback, stability and feedback realizability, contour integration and Nyquist criterion for stability, physical representation of network, general restrictions on physical network characteristics

Total Lectures: 42

Tutorials will be conducted separately for 14 hours

3. Books Recommended:

1. A. V. Oppenheim, A. S. Wilsky and S. H. Nawab, Signals and Systems, Pearson India Education Services Private limited India, 2nd Edition, 2016.
2. R. A. Gabel and R. A. Robert, Signals and Linear Systems, John Wiley and Sons, 3rd Edition, 1987.
3. B. P. Lathi, Principles of Linear Systems and Signals, Oxford University Press, 2nd Edition, 2009.
4. C. T. Chen, Systems and Signal Analysis - A Fresh Look, Oxford University Press India, 3rd Edition, 2004.
5. S. T. Alan, Introduction to Signals and Systems, Thomson India Edition, 1st Edition, 2007.

SARDAR VALLABHBHAI NATIONAL INSTITUTE OF TECHNOLOGY, SURAT

DEPARTMENT OF ELECTRICAL ENGINEERING

B. Tech. Programme

B. Tech. III

Semester V

Sr. No.	Course Code	Course	L	T	P	Credits	Examination Scheme				
			Hrs	Hrs	Hrs		Theory Marks	Tutorial Marks	Term work Marks	Practical Marks	Total Marks
1.	EE301	Power System Analysis	3	1	2	05	100	25	25	25	175
2.	EE303	Control Systems	3	1	2	05	100	25	25	25	175
3.	EE305	Power Electronic Converters	3	1	2	05	100	25	25	25	175
4.	--	EIS-I	3	0	0	03	100	-	-	-	100
5.	EE307	Electrical and Electronic Measurements	3	1	2	05	100	25	25	25	175
6.	EE309	Seminar	0	0	2	01	-	-	20	30	50
Total (L-T-P)			**15**	**04**	**10**	**24**	**500**	**100**	**120**	**130**	**850**
Total			**29**			**24**					

ELECTIVE INTERDISCIPLINARY SUBJECTS -EIS-I (EE3XX)

(INSTITUTE LEVEL)

Course Code	Subject Name
EE361	Renewable Energy Sources
EE363	Optimization Methods
EE365	Forecasting and Planning Methods
EE367	Fundamental of Electrical Power Systems (Non-Electrical Students)
EE369	Modern Electrical Drives (Non-Electrical Students)
EE371	Introduction to Power Electronic Converters (Non-Electrical Students)
EE373	Control Systems (Non-Electrical Students)

Semester VI

Sr. No.	Course Code	Course	L	T	P	Credits	Examination Scheme				
			Hrs	Hrs	Hrs		Theory Marks	Tutorial Marks	Term work Marks	Practical Marks	Total Marks
1.	HU306	Professional Ethics, Economics and Management#	4	0	0	04	100	-	-	-	100
2.	EE304	Power Electronics System and Electric Drives	3	1	2	05	100	25	25	25	175
3.	EE306	Microprocessor and Microcontrollers	3	1	2	05	100	25	25	25	175
4.	EE308	Instrumentation	3	1	2	05	100	25	25	25	175
5.	--	EIS-II	3	0	0	03	100	-	-	-	100
6.	EE3AA	ES-I	3	0	0	03	100	-	-	-	100
		Total (L-T-P)	**19**	**03**	**06**	**25**	**600**	**75**	**75**	**75**	**825**
		Total	**28**			**25**					

 # One hour will be engaged by the core department.

ELECTIVE INTERDISCIPLINARY SUBJECTS -EIS-II (EE3YY) (INSTITUTE LEVEL)

Course Code	Subject Name
EE362	Industrial Automation and Process Control
EE364	State Variable Analyses
EE366	Energy Audit and Management
EE368	Special Electrical Machines
EE372	Advanced Materials for Energy Applications
EE374	Distributed Power Generation and Micro-Grids

CORE ELECTIVE SUBJECTS – ES – I (EE3AA) (Departmental Electives)

Course Code	Subject Name
EE322	Power Plant engineering
EE324	Adaptive Control and Soft Computing
EE326	Utilization of Electrical Energy
EE328	Modeling and Simulation of Electrical Machines
EE333	Random Processes
EE334	Artificial Intelligence Techniques
EE336	Switchgear and Protection

B. Tech. III year, Semester V

Power System Analysis

L	T	P	Credit
3	1	2	05

EE301 **Scheme**

1. Course Outcomes (Cos):

At the end of the course students will be able to:

CO1	explain the concept of per unit system and its application in power
CO2	analyze symmetrical and unsymmetrical fault conditions in electrical power systems.
CO3	discuss, analyze and compare different methods of power flow analysis in power system and estimate economic load dispatch.
CO4	classify power system stability, and its importance in power system operation
CO5	illustrate using software tools (MATLAB, ETAP etc.) to examine system performance with reference to fault, load flow and stability and analyze the results

2. Syllabus:

- **REPRESENTATION OF POWER SYSTEM COMPONENTS** **(04 Hours)**
  Introduction, single phase solution of balanced three phase networks, the one line diagram and the impedance or reactance diagram, per-unit (pu) system, complex power, synchronous machine, representation of loads.
- **LOAD FLOW STUDIES** **(08 Hours)**
  Network model formulation, formation of Y bus, power flow problem, different types of buses, approximate power flow, Gauss Seidel method, Newton-Raphson method, Decoupled Power flow studies, Fast Decoupled power flow studies, comparison of power flow methods.
- **ECONOMIC LOAD DISPATCH** **(04 Hours)**
  Economic dispatch of thermal units and methods of solution, Transmission losses, B matrix loss formula, Composite generation production cost function-solution by gradient search techniques, Nonlinear function optimization
- **SYMMETRICAL FAULT ANALYSIS** **(08 Hours)**
  Introduction, transient on a transmission line, short circuit of a synchronous machine on no load, short circuit of a loaded synchronous machine, balanced three phase fault, short circuit capacity, fault analysis using bus impedance matrix, selection of protective equipment.
- **UNSYMMETRICAL FAULT ANALYSIS** **(08 Hours)**
  Symmetrical component analysis of unsymmetrical faults, single line to ground (LG) fault, line to line (LL) fault, double line to ground (LLG) fault, open conductor faults, bus impedance matrix method for analysis of unsymmetrical faults.
- **POWER SYSTEM STABILITY** **(10 Hours)**
  Importance of stability analysis in power system planning and operation - classification of power system stability - angle and voltage stability – simple treatment of angle stability into small-signal and large-signal (transient) stability Single Machine Infinite Bus (SMIB) system: Development of swing equation - equal area criterion - determination of critical clearing angle and time by using modified Euler method and Runge-Kutta second order method. Algorithm and flow chart.

Total Hours:42

Tutorials will be conducted separately for 14 hours

3. List of Experiments:

Simulations based on different types of faults, stability and transients using MATLAB and ETAP.

1. To study mathematical modeling of R-L, R-L-C and complex electrical circuit using MATLAB.
2. To study mathematical modeling of 3rd order differential equation.
3. To solve differential equations using Euler's and trapezoidal rule.
4. To observe variable of rotor angle and to find critical clearing time when fault occurs at:
    - (i) Sending end of the line
    - (ii) Mid-point of the line
    - (iii) When the fault at mid-point is cleared by removing the faulty line of SMIB system.
5. To study short circuit analysis of overhead transmission line using MATLAB.
6. To study and obtain sub-transient current for symmetrical fault using ETAP software.
7. To perform load flow analysis using ETAP software.
8. To study and determine fault current for short circuit analysis using ETAP software.

4. Books Recommended:

1. J. J. Grainger and W. D. Stevenson, Power System Analysis, McGraw Hill, New Delhi, 1st Edition, 1994.
2. Hadi Saadat, Power System Analysis, 5th reprint, Tata McGraw Hill publishing Company Ltd, New Delhi, 2004.
3. I. J. Nagrath and D. P. Kothari, Power System Engineering, Tata McGraw Hill publishing Company Ltd., New Delhi, 3rd Edition, 2014.
4. J. Duncan Glover, S. Mulkutla Sarma and Thomas Overby, Power System Analysis and Design, 5th Edition Cengage Learning 2012.
5. Arthur R. Bergen, Vijay Vittal, Power Systems Analysis, Prentice Hall of India, Inc., 2nd Edition, 2000.

B. Tech. III year, Semester V

L	T	P	Credit
3	1	2	05

Control Systems

EE303 **Scheme**

1. Course Outcomes (Cos):

At the end of the course students will be able to:

CO1	classify various types of control systems and to develop mathematical modeling of physical systems
CO2	analyze the response of various control systems in the time domain
CO3	analyze the stability of control systems using a variety of methods
CO4	evaluate the response and stability of control systems using frequency domain techniques
CO5	design various control schemes for linear systems

2. Syllabus:

- **INTRODUCTION TO CONTROL SYSTEMS:** **(02 Hours)**
  Open loop control and close loop control; Illustrative examples of control systems.

- **MATHEMATICAL MODELS OF PHYSICAL SYSTEMS:** **(10 Hours)**
  Linear and non-linear systems; equations and transfer functions for linear mechanical translational systems and linear electrical network; Force-Voltage and Force-Current analogy; Block diagram representation of control systems; Block diagram reduction; Transfer functions of armature-controlled and field-controlled DC servomotors and 2-phase AC servomotors; Signal flow graph and Mason's gain formula.

- **TIME DOMAIN ANALYSIS OF CONTROL SYSTEMS:** **(06 Hours)**
  Typical test signals; Response of first-order systems; Transient response of a second order system due to step input; Time domain specifications of a second order system; Impulse and ramp response of second order system; Steady-state errors; Static error coefficients; Error series and dynamic error coefficients.

- **CONCEPTS OF STABILITY:** **(08 Hours)**
  Introduction to stability, definition through impulse response function, asymptotic stability and relative stability, Routh-Hurwitz stability criterion. Basic Properties of Root Loci, Construction of Root Loci, Effects of Adding Poles and Zeros.

- **FREQUENCY DOMAIN ANALYSIS OF CONTROL SYSTEMS:** **(08 Hours)**
  Steady state response of a system due to sinusoidal input; Frequency response; Logarithmic plots or Bode diagrams; Log-magnitude versus phase plots; Resonant peak and resonant frequency of a second order system; Polar plots; conformal mapping, principal of argument, Nyquist stability criterion, Stability analysis; Relative stability; Gain margin and phase margin; Closed loop frequency response.

- **DESIGN OF CONTROL SYSTEMS:** **(08 Hours)**
  Introduction to phase lag, phase lead and phase lag-lead networks and their applications. P, PI, PID Controllers.

Total Hours: 42

Tutorials will be conducted separately for 14 hours

3. List of Experiments:

1. To obtain open loop and close loop transfer function for an oven.
2. To control the speed of two-phase AC Servo motor using auto tunable PI controller.
3. To understand the practical Air blower control system and to control the speed Of Blower using Programmable Logic Controller (PLC) and VFD from SCADA.
4. a) To obtain no load speed Vs control voltage curve for the two phase servo motor
   b) To obtain speed –torque curves for the various control voltages of servo motor.
5. To obtain Close Loop Response of an OVEN.
6. To understand the about the transient behavior on practical Air blower control system.
7. To understand the PID controller tuning using MATLAB.
8. To obtain the frequency response of phase lead network
9. a) To obtain step response and to find transient time domain specification for Second order system using MATLAB.
   b) To obtain Bode plot and Root locus using MATLAB.

4. Books Recommended:

1. I. J. Nagrath and M. Gopal, Control system engineering, New Age International Publishers, 3rd Edition, 2001.
2. K. Ogata, Modern control system engineering, Pearson Education Asia, 4th Edition, 2002.
3. B. C. Kuo, Automatic control system, Prentice Hall of India, 7th Edition, 1995.
4. Richard C. Dorf and Robert H Bishop, Modern control system, Pearson Education Asia. 8th Edition, 2004.
5. N. S. Nise, Control System Engineering, John Wiley & sons, 4th Edition, 2004.

B. Tech. III year, Semester V

Power Electronic Converters

L	T	P	Credit
3	1	2	05

EE305 **Scheme**

1. Course Outcomes (Cos):

At the end of the course, the students will be able to:

CO1	explain the basic principle of operation of semiconductor devices and list their applications.
CO2	analyze and compare the performance of various phase-controlled rectifier
CO3	analyze and design the various choppers.
CO4	design inverters and AC voltage controllers for various application.
CO5	develop laboratory prototype of power electronic systems.

2. Syllabus:

- **POWER SEMICONDUCTOR DEVICES** **(12 Hours)**
  Introduction to Power Electronics Scope and Applications, Interdisciplinary Nature of Power Electronics, Types of power electronics circuits, Thyristor Characteristics, Two transistor analogy, Gate Characteristics, Methods of triggering and commutation, series and parallel operation of thyristors, Ratings and protection of devices, Introduction to power electronic devices like Power BJT, MOSFET, GTO, IGBT, MCT etc.

- **PHASE CONTROLLED RECTIFIERS** **(12 Hours)**
  Principle of phase control, half wave controlled rectifiers, half wave controlled rectifiers with R, R-L, R-L-E load, single phase full wave controlled converters, 2-pulse mid-point converters, 2-pulse half and fully controlled bridge converters with R, R-L, R-L-E load, Three phase converter system with diodes, 3 phase half and fully controlled bridge converters, triggering scheme, Effect of source impedance on the performance or the converters, Dual converters.

- **CHOPPERS** **(06 Hours)**
  Basic principle of chopper operation, Control strategies – Duty Ration Control and Frequency Control, Types of idealized chopper circuits, Steady state time domain analysis of Type A choppers, Step up chopper.

- **INVERTERS** **(08 Hours)**
  Single phase voltage source inverters, half bridge inverters, full bridge inverters, Steady state analysis, Voltage control in single phase inverters, 3-phase bridge inverters, Pulse width modulated inverters, Reduction of harmonics in Inverter.

- **AC VOLTAGE CONTROLLERS** **(04 Hours)**
  Principle of AC Voltage Controllers – Integral Cycle Control and Phase Control, Types of AC voltage controllers, Analysis of 1-phase Integral Cycle Control AC controllers with R load, Analysis of 1-phase Phase Control AC controllers with R and R-L load, Thyristor controlled reactors (TCR).

Total Hours: 42

Tutorials will be conducted separately for 14 hours

3. List of Experiments:

1. Study of IGBT, MOSFET, SCR, Triac, Diac Characteristics.
2. Study of Different SCR Triggering Circuit Trainer – DC, R, R-C, UJT.
3. Study of Single Phase Half Controlled Bridge Converter with R, R-L Load.
4. Study of Single Phase Fully Controlled Bridge Converter with R, R-L Load.
5. Study of Single Phase SCR Full Bridge Inverter Circuit.
6. Study of High Voltage Thyristorised Chopper.
7. Study of Single Phase AC Voltage Controller Using SCR.
8. Study of Single Phase AC Voltage Controller Using Triac.
9. Study of Single Phase Dual Converter Circuit.
10. Study of SCR dc Circuit Breaker Circuit.
11. Study of Three Phase SCR Triggering Circuit Using Tca785 IC.
12. Study of Ac Solid State Relay Using IC 555, Opto Coupler & Triac.
13. Simulation of Power EC circuits in PSIM and SIMULINK.

4. Books Recommended:

1. P. S. Bimbhra, Power electronics, Khanna Publishers, New Delhi, 5th Edition, 2014.
2. M. H. Rashid, Power Electronics Circuits, Devices, and Applications, Prentice-Hall of India Pvt. Ltd., New Delhi, 2nd Edition, 1999.
3. M. D. Singh and K. B. Khanchandani, Power electronics, Tata McGraw-Hill Publishing Co. Ltd., New Delhi, 2nd Edition, 2006.
4. Ned Mohan, Tore M. Undeland and William P. Robbins, Power Electronics Converters, Applications, and Design, John Willey & Sons, Inc., 2nd Edition, 1995.
5. J. P. Agrawal, Power electronic systems: Theory and design, Addison Wesley Longman (Singapore) Pte. Ltd. New Delhi, 2nd Edition, 2001.

B. Tech. III year, Semester V

Electrical and Electronic Measurements

L	T	P	Credit
3	1	2	05

EE307 **Scheme**

1. Course Outcomes (Cos):

At the end of the course students will be able to:

CO1	identify different standards and explain measurement techniques of resistance, inductance and capacitance.
CO2	explain magnetic measurement techniques, discuss and analyze utilization of CT and PT.
CO3	classify different indicating instrument.
CO4	Operate electronic meters and oscilloscope
CO5	Illustrate calibration and traceability of test equipment

2. Syllabus:

- **STANDARDS** **(03 Hours)**
  Standards and their classification. Electrical Standards: EMF, current, resistance and capacitance standards
- **MEASUREMENT of RESISTANCE, INDUCTANCE AND CAPACITANCE** **(07 Hours)**
  Concept of four arm bridge network, Kelvin's double bridge, Anderson bridge, Schering bridge, Wagner earthling device, Localization of cable fault using loop methods
- **MAGNETIC MEASUREMENTS** **(05 Hours)**
  Measurement of flux: ballistic galvanometer, Grassot flux meter, Hall effect devices for measurement of flux, measurement of iron loss by wattmeter method, Hibbert magnetic standard.
- **INSTRUMENT TRANSFORMERS** **(06 Hours)**
  Theory of current and voltage transformer, ratio error and phase angle, burden, turns compensation performance characteristics, testing of CT and PT and applications of CT and PT in measurement of power.
- **INDICATING INSTRUMENTS** **(07 Hours)**
  Classification, operating principles, general construction details of indicating instruments, balancing, control and damping method, theory and construction of PMMC, moving iron and electrostatic instruments, electrodynamics wattmeter.
- **ELECTRONIC METERS AND OSCILLOSCOPE** **(08 Hours)**
  DC amplifier voltmeter, AC voltmeter using rectifiers, true RMS responding voltmeter, Oscilloscope block diagram, CRT and its circuits, vertical deflection systems, delay line, multiple trace, horizontal deflection system, oscilloscope probes, Function generator.
- **CALIBRATION AND MEASUREMENT** **(06 Hours)**
  calibration and traceability of instruments, Calibration of indicating instruments using DC potentiometer, High voltage oil testing equipment, H.V. breakdown tester, Insulation resistance measurement techniques, calibration of energy meter

Total hours:42

Tutorials will be conducted separately for 14 hours

3. List of Experiments:

1. To measure unknown resistance using Kelvin's Double Bridge.
2. To measure unknown inductance using Anderson Bridge
3. To calibrate voltmeter using Potentiometer.
4. To measure unknown capacitance using Schering Bridge
5. Calibration of single phase energy meter.
6. Testing of Current Transformer using Biffi's method.
7. To find out iron loss and flux density in a given sample of laminated steel core. (Lloyd fisher square)
8. To perform the operation of HV oil testing.
9. To study operation of oscilloscope and function generator.

4. Books Recommended:

1. Golding and Widdis, Electrical measurements and Measuring instruments, Wheeler books, 5th Edition.
2. A. K. Sawhney, Electrical and electronic Measurements and Instrumentation, Dhanpat Rai & Co., 17th Edition.
3. A. D. Helfrick and W. D. Cooper, Modern electronic Instrumentation and Measurement techniques, PHI, 2nd Edition, 2009.
4. D. A. Bell, Electronic Instrumentation and Measurement, Oxford Uni. Press, 3rd Edition, 2013.
5. P. Purkait, B. Biswas, S. Das and C. Koley Electrical and Electronics Measurement and Instrumentation, McGraw Hill Education, 1st Edition, 2013.

B. Tech. III year, Semester V

Renewable Energy Sources (EIS-I)

L	T	P	Credit
3	0	0	03

EE361 **Scheme**

1. Course Outcomes (Cos):

At the end of the course the students will be able to:

CO1	recognize the limits of the conventional energy sources and discuss the potential of present scenario of renewable energy conversion.
CO2	explain solar thermal energy conversion and list their associated applications.
CO3	explain working of wind and solar energy conversions, associated performance characteristics and their applications.
CO4	describe the basic operation of the other renewable energy sources.
CO5	predict the impacts of the renewable energy sources on the environment and from the aspect of economy

2. Syllabus:

- **INTRODUCTION TO RENEWABLE ENERGY** **(03 Hours)**
  Man and energy, world's production and reserves of commercial energy sources, India's production and reserves, energy alternatives, fossil fuels and climate change.
- **SOLAR THERMAL ENERGY** **(06 Hours)**
  Introduction, the rooftop solar water heating system, the nature and availability of solar radiation, low-temperature solar energy applications, active and passive solar heating, day lighting, solar thermal engines and electricity generation, solar energy storage system, sensible and latent heat storage, solar pond, economics-potential and environmental impact.
- **SOLAR PHOTOVOLTAICS** **(12 Hours)**
  Introduction, brief on semi-conductor physics, basic principle, electrical characteristic of PV cell and module, crystalline silicon and thin film PV technologies, other innovative PV technologies, PV for remote power and grid-connected PV systems, cost of energy from PV, environmental impacts and safety, PV integration, resources and further process.
- **WIND ENERGY** **(10 Hours)**
  Introduction, classifications and descriptions of wind turbines, wind data in form of wind speed, speed-frequency distribution curve, speed-duration curve, power density-duration curve, performance calculations, and environmental impacts.
- **BIO-ENERGY** **(03 Hours)**
  Introduction, biomass as a fuel, bio-energy from crops and wastes, combustion of solid biomass, production of gaseous fuels and liquid fuels from biomass, environmental impacts, economics and future prospects.
- **HYDRO ELECTRICITY** **(04 Hours)**
  Introduction, the resources, stored energy and available potential, different turbines for hydro power, types of hydro-electric plants, small scale hydroelectricity, system integration and environmental considerations and economics.
- **OTHER SOURCES OF ENERGY AND THEIR UTILIZATIONS** **(04 Hours)**
  Wave energy, tidal power, ocean thermal energy (OTEC), geothermal energy, fuel cells.

Total hours:42

3. **Books Recommended:**

1. Godfred Boyle, Renewable energy: Power for a sustainable future, 2nd Edition, Oxford University Press Inc., New York, 2012.
2. S. P. Sukhatme and J. K. Nayak, Solar energy: Principles of thermal collection and storage, 3rd Edition, Tata McGraw Hill, New Delhi, 2010.
3. Chetan Singh Solanki, Solar Photovoltaics: Fundamentals, technologies and applications, 2nd Edition, PHI Learning Private Limited, New Delhi, 2011.
4. John Twidell and Tony Weir, Renewable energy resources, 2nd Edition, Taylor & Francis, London, 2006.
5. J. W. Tester, E. M. Drake, M. J. Driscoll, M. W. Golay and W. A. Peters, Sustainable energy: Choosing among options, PHI Learning Private Limited, New Delhi, 2009.

B. Tech. III year, Semester V

Optimization Methods (EIS-I)

L	T	P	Credit
3	0	0	03

EE363 **Scheme**

1. Course Outcomes (Cos):

At the end of the course the students will be able to:

CO1	explain basic concepts and theoretical principles in optimization.
CO2	convert the a real-world problem, described in words, into a mathematical formulation and solve them.
CO3	apply efficient computational procedures to solve optimization problems.
CO4	compare different optimization methods to solve single variable Optimization problems to find maxima/minima.
CO5	analyze and apply various optimization methods for getting optimum solution of multi variable optimization problems with different constraints.

2. Syllabus:

- **MATHEMATICAL PRELIMINARIES** **(04 Hours)**
  convex sets, intersection of convex sets, vertices or extreme points of a convex set, convex polyhedron, hyper-planes, closed and open half space, convex functions, Local & Global Maxima and Minima. Saddle point, Unconstrained optimization- First and second order necessary and sufficient conditions.

- **LINEAR PROGRAMMING** **(10 Hours)**
  Standard form, Geometry of LP problems, Definitions and theorems, formulation of LP problems, graphical representation and solution of LP in two-dimensional space. Feasible, Basic Feasible and Optimal solutions, pivotal reduction of a set of linear equations, slack and surplus variables, Simplex method and algorithm, two phase method, degeneracy, Big M method. Duality in linear programming, duality theorems. Integer Linear programming graphical representation, Gomory's cutting plane method for all Integers programming problem.

- **TRANSPORTATION AND ASSIGNMENT PROBLEM** **(05 Hours)**
  Description, finding initial basic feasible solution, test for optimality, new Basic solution. Assignment Problem and its solution.

- **SINGLE VARIABLE OPTIMIZATION ALGORITHMS** **(05 Hours)**
  Optimality Criteria- Uni-modal function-Bracketing Methods-Region-Elimination Methods-Fibonacci & Golden section search –Gradient Based Methods:-Newton-Raphson method, Bisection Method, Secant Method.

- **MULTIVARIABLE OPTIMIZATION ALGORITHMS:** **(07 Hours)**
  Optimality Criteria-Unidirectional Search- Direct Search Methods- Hooke-Jeeves pattern method-Powell's conjugate direction method.
  Gradient Based Methods: Steepest Descent Method-Newton's Method-Conjugate Gradient Method-Quasi-Newton method.

- **CONSTRAINED OPTIMIZATION ALGORITHMS:** **(07 Hours)**
  Direct Substitution-Lagrange Multiplier Method-Kuhn-Tucker Conditions- Frank and Wolfe method. Cutting plane method.

- **ADVANCED OPTIMIZATION TECHNIQUES:** **(04 Hours)**
  Introduction to Multi objective Optimization, Genetic Algorithm, Swarm base Optimization techniques and other Nontraditional Optimization Algorithms

Total Hours: 42

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3. Books Recommended:

1. S. S. Rao, Engineering Optimization, 3rd Edition, New Age International (P) Ltd, New Delhi, 2004.
2. David G. Luenberger, Linear and Non Linear Programming, 2nd Edition, Addison-Wesley Pub. Co., Massachusetts, 1973.
3. W. L. Winston, Operation Research-Applications & Algorithms, Thomson publications, 2003.
4. Kalyanmoy Deb, Optimization for Engineering Design, Algorithms and Examples, Prentice Hall of India, 2nd Edition, 2013.
5. G. B. Dantzig, Linear Programming and Extensions, Princeton University Press, 1998.

B. Tech. III year, Semester V

Forecasting and Planning Methods (EIS-I)

L	T	P	Credit
3	0	0	03

EE365 **Scheme**

1. Course Outcomes (Cos):

At the end of the course students will be able to:

CO 1	explain the basics of forecasting and planning for engineering.
CO 2	apply methods of time series decomposition and its smoothing for better forecasting and planning.
CO 3	learn various simple and multiple regression models for forecasting.
CO 4	learn the BOX-Jenkins and ARIMA for forecasting.
CO 5	Discuss the basics of planning for engineering applications
CO 6	classify various methods of planning and their applications.

2. Syllabus:

- **FUNDAMENTALS OF FORECASTING** **(04 Hours)**
  The forecasting perspective and Time Series Forecasting, overview of forecasting techniques and tools, time series, and cross-sectional data, and plots, univariate and bivariate statistics, autocorrelation, measuring forecast accuracy, ACF of forecast error, prediction intervals, least square estimates, transformation and adjustments.

- **TIME-SERIES DECOMPOSITION AND EXPONENTIAL SMOOTHING METHODS** **(06 Hours)**
  Principle of decomposition, seasonal adjustment, moving averages, local regression smoothing, classical decomposition, additive and multiplicative decomposition, extensions to X-12 ARIMA, STL decomposition, inner loop, outer loop, choosing the STL parameters, Exponential smoothing methods: Exponential smoothing methods, single exponential smoothing and its adaptive approach, Holt's linear and Holt-Winter's method: Pegel's classification.

- **SIMPLE AND MULTIPLE REGRESSION** **(08 Hours)**
  Least squares estimation, the correlation coefficient, residuals, The F-test for overall significance, confidence intervals for individual coefficients, t-tests for individual coefficients, forecasting using the simple regression model, non-linear relationship, non-linearity in the parameters, using logarithms to form linear models, local regression.

- **BOX-JENKINS METHODOLOGY FOR ARIMA MODELS** **(06 Hours)**
  Examining correlation in time series data, the autocorrelation function, white noise model autocorrelation coefficient, Random walk model, tests for stationarity, ARIMA models of time series, autoregressive, moving average model, Mixtures ARIMA models, identification and estimation of parameters.

- **FORECASTING AND PLANNING** **(10 Hours)**
  The role of forecasting in planning, Comparison and selection of forecasting methods, Introduction to Planning, multidisciplinary nature, role of a planner, definitions and Basics of Planning, Goals and objectives of planning; Components of planning; Benefits of planning; Arguments for and against planning. Planning Process, Levels of Planning in India.

- **PLANNING METHODS** **(08 Hours)**
  Definition of development plan; Types of development plans, Comprehensive planning, requirements for planning; sources of primary and secondary data; questionnaire design, measurement scale and their application, sampling techniques, types of socio-economic surveys; self-surveys, interviews, questionnaires and observer participation, Data requirement for various types of regional plans; Techniques for conducting surveys.

Total Hours: 42

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3. Books Recommended:

1. Makridakis, Spyros, Forecasting methods and application, John Wiley, 3rd Edition, 1993.
2. X. Wang & J. R. Mc Donald, Modern Power system planning, McGraw. Hill, 2nd Edition, 2003.
3. A. S. Pabla, Electrical Power system planning, Mac Millan, Delhi, 4th Edition, 1998.
4. Sullivan, Power system planning, McGraw. Hill, 1977.
5. E. Lakervi and E. J. Holmes, Electricity distribution network design, IEE, 2nd Edition, 2003.

B. Tech. III year, Semester V

Fundamentals of Electrical Power Systems (Non-electrical students) (EIS-I)

L	T	P	Credit
3	0	0	03

EE367 **Scheme**

1. Course Outcomes (Cos):

At the end of the course the students will be able to:

CO1	classify and compare the electrical power transmission and distribution.
CO2	estimate the cost of power generation and the cost of electricity.
CO3	discuss various protective devices and compare them.
CO4	analyze the performance of the underground cable.
CO5	illustrate and the concept of lighting system and various components associated.

2. Syllabus:

- **SUPPLY SYSTEMS** **(04 Hours)**
  AC and DC power supply systems, comparison of ac and dc transmission, advantages of high transmission voltage, various systems of power supply, comparison of conductor materials in overhead system and underground cable system.

- **UNDERGROUND CABLES** **(05 Hours)**
  Underground cables, construction of cables, classification of cables, cables for three phase services, insulation resistance of a single core cable, capacitance of a single core cable, dielectric stresses in a single core cable, most economical conductor size in a cable, grading of cables, capacitance grading and inter-sheath grading, capacitance of three core cable and measurements of capacitances.

- **CHARACTERISTICS AND PERFORMANCE OF POWER TRANSMISSION LINES** **(08 Hours)**
  Conductors, types of conductors in use, bundled conductor, spacing of conductors, symmetrical and unsymmetrical spacing, equivalent spacing, transposition, types of transmission line towers and insulator string Short and medium transmission lines, Line performance, effect of capacitance, charging currents, short and medium lines, calculation by nominal-T, nominal-π and end-condenser method, regulation and efficiency, Concept of ABCD constants, evaluation of ABCD constants for short and medium line.

- **ECONOMIC ASPECTS OF POWER SYSTEM** **(07 Hours)**
  Cost of Generation and Tariff, Power factor and its effect on system economy, Power factor improvement.

- **PROTECTION OF POWER SYSTEM** **(10 Hours)**
  Rewirable fuses, HRC fuses, isolators and earthing switches, selection of fuses. Effectively grounded and ungrounded systems, resonant grounding Methods of neutral grounding, Bulk oil circuit breaker, arc controlled devices, MOCB, ACB, ABCB, SF_6 circuit breaker, vacuum circuit breaker and DC circuit breakers, circuit breaker ratings, auto-recloser, Fundamental characteristics of relays, standard definition of relay terminologies, relay classifications, operating principles of single and double actuating quantity type electromechanical relays, directional relay, differential relay, numerical relay.

- **ILLUMINATION AND LIGHTING SYSTEM** **(08 Hours)**

  Nature of light, visibility spectrum curve of relative sensitivity of human eye and wave length of light. Definition: Luminous flux, solid angle, luminous intensity, illumination, luminous efficiency, depreciation factor, coefficient of utilization, space to height ratio, reflection factor, glare, shadow, lux. Laws of illumination. Different type of lamps, construction and working of incandescent and discharge lamps – their characteristics, fittings required for filament lamp, mercury vapour lamp, fluorescent lamp, metal halide lamp, neon lamp. Calculation of number of light points for interior illumination, calculation of illumination at different points, considerations involved in simple design problems. Illumination schemes; indoor and outdoor. Illumination levels. Main requirements of proper lighting; absence of glare, contrast and shadow. General ideas about street lighting, flood lighting, monument lighting and decorative lighting, LED lighting

Total Hours: 42

3. Books Recommended:

1. I. J. Nagrath and D. P. Kothari, Modern Power System analysis, Tata McGraw Hill Publishing Company Ltd, New Delhi, 4th Edition, 2011.
2. W. D. Stevenson, Element of Power System Analysis, McGraw Hill, 4th Edition, 1982.
3. A. Chakrabarti, M. L. Soni, P. V. Gupta, and U. S. Bhatnagar, A Text Book on Power System Engineering, Dhanpat Rai & Co., 2012.
4. C. L. Wadhwa, Electric Power System, New Age International Ltd, 3rd Edition, 2010.
5. V. K. Mehta, Rohit Mehta, Principles of Power System, S. Chand & Co. 2003.

B. Tech. III year, Semester V

Modern Electrical Drives (Non-electrical students) (EIS-I)

L	T	P	Credit
3	0	0	03

EE369 **Scheme**

1. Course Outcomes (Cos):

At the end of the course students will be able to:

CO1	explain the basic concept of electric drives, their components and principle of operation
CO2	distinguish the characteristics of open loop and closed loop control of drives
CO3	apply various power electronic converters to electric drives
CO4	apply various control strategies to modern AC DRIVES
CO5	analyze qualitatively the multi-quadrant operations drives

2. Syllabus:

- **FUNDAMENTALS OF ELECTRIC DRIVES** **(07 Hours)**
  Electric drives, advantages of electrical drives, parts of electrical drives, choice of electrical drives, status of ac and dc drives, types of load, fundamental of torque equation, speed-torque convention and multi quadrant operation, selection of power rating.

- **ELECTRICAL MOTORS** **(11 Hours)**

  DC Motors – permanent magnet, filed would, series, shunt compound - constructional features, principle of operation, torque equation, speed torque characteristics
  AC Motors – Induction Motor, Synchronous Motor, Brushless DC Motor, Permanent Magnet Synchronous Motor, Switched Reluctance Motor, Stepper Motor, Universal Motor, Hysteresis Motor, Servo Motor - constructional features, principle of operation, torque equation, speed torque characteristics.

- **POWER ELECTRONICS CONTROL OF ELECTRICAL MOTORS** **(14 Hours)**
  Power electronics control - scope and applications, Types of power electronics circuits and their applications in drives, Speed and current sensors, open-loop and closed-loop control, position control, practical applications.

- **VARIOUS CONTROL TECHNIQUES FOR AC DRIVES** **(10 Hours)**
  Scalar control, Concept of Space vector, field oriented control and direct torque control, soft computing techniques and adaptive controllers.

Total Hours: 42

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3. Books Recommended:

1. B. K. Bose, Modern Power Electronics & AC Drives, 1st Edition, Pearson.
2. G. K. Dubey, Fundamentals of Electrical Drives, Narosa Publishing House, 2nd Edition, 2001.
3. R. Krishnan, Switched Reluctance Motor Drives, Modelling, Simulation, Analysis, Design and applications, CRC press, 2006.
4. T. J. E. Miller, Brushless Permanent Magnet and Reluctance Motor Drives, Clarendon Press, Oxford, 1989.
5. M. H. Rashid, Power Electronics Circuits, Devices, and Applications, Prentice-Hall of India Pvt. Ltd., New Delhi, 2nd edition, 1999.

B. Tech. III year, Semester V

Introduction to Power Electronic Converters (Non-electrical students) (EIS-I)

L	T	P	Credit
3	0	0	03

EE371 **Scheme**

1. Course Outcomes (Cos):

At the end of the course the students will be able to:

CO1:	explain the basic principle of operation of semiconductors devices
CO2:	explain the various triggering schemes different converters
CO3:	classify and explain the functions of phase controlled rectifiers, DC-DC converters, Inverters and AC voltage regulators
CO4:	analyze the steady state performance of converters
CO5:	compare the performance of the converters based on topologies, control techniques and types of load

2. Syllabus:

- **POWER SEMICONDUCTOR DEVICES** **(10 Hours)**
  Introduction to Power Electronics Scope and Applications, Interdisciplinary Nature of Power Electronics, power electronic devices like Power SCR, BJT, MOSFET, IGBT, triggering scheme.

- **PHASE CONTROLLED RECTIFIERS** **(12 Hours)**
  Principle of phase control, half wave controlled rectifiers, half wave controlled rectifiers with R, R-L, single phase full wave controlled converters, 2-pulse mid-point converters, 2-pulse half and fully controlled bridge converters with R, R-L, Three phase converter system with diodes, 3 phase half and fully controlled bridge converters, Effect of source impedance on the performance or the converters, Dual converters.

- **DC-DC CONVERTERS** **(10 Hours)**
  Introduction, Step-Down (Buck) Converter, Step-Up (Boost) Converter, Buck-Boost Converter, Converter, Control Principles, Applications of DC-DC Converters.

- **INVERTERS** **(06 Hours)**
  Single phase voltage source inverters, Half bridge inverters, full bridge inverters, Voltage control in single phase inverters, 3-phase bridge inverters, Pulse width modulated inverters, Reduction of harmonics in Inverter.

- **AC VOLTAGE CONTROLLERS** **(04 Hours)**
  Principle of AC Voltage Controllers – Integral Cycle Control and Phase Control, Types of AC voltage controllers, Analysis of 1-phase Integral Cycle Control AC controllers with R load, Analysis of 1-phase Phase Control AC controllers with R and R-L load, Thyristor controlled reactors (TCR).

Total Hours: 42

3. Books Recommended:

1. P. S. Bimbhra, Power electronics, Khanna Publishers, New Delhi, 5th Edition, 2012.
2. M. H. Rashid, Power Electronics Circuits, Devices, and Applications, Prentice-Hall of India Pvt. Ltd., New Delhi, 2nd edition, 1999.
3. Ned Mohan, Tore M. Undeland and William P. Robbins, Power Electronics Converters, Applications, and Design, John Willey & Sons, Inc., 2nd Edition, 1995.
4. M. D. Singh and K. B. Khanchandani, Power electronics, Tata McGraw-Hill Publishing Co. Ltd., New Delhi, 2nd Edition, 2017.
5. J. P. Agrawal, Power electronic systems: Theory and design, Addison Wesley Longman (Singapore) Pte. Ltd. New Delhi, 2nd Edition, 1995.

B. Tech. III year, Semester V

Control Systems (EIS-I)
(Non-Electrical Students)

L	T	P	Credit
3	0	0	03

EE373 **Scheme**

1. Course Outcomes (Cos):

At the end of the course students will be able to:

CO1	classify various types of control systems and to impart knowledge of mathematical modeling of physical systems
CO2	analyze the response of various control systems in the time domain
CO3	analyze the stability of control systems using a variety of methods
CO4	evaluate the response and stability of control systems using frequency domain techniques
CO5	design various control schemes for linear systems

2. Syllabus:

- **BASIC CONCEPTS** **(02 Hours)**
  Scope Of Control, Parts Of a Control system, Multidisciplinary Nature, Notion of Feedback, Open and Closed Loop systems
- **MODELLING AND REPRESENTATION OF CONTROL SYSTEM** **(05 Hours)**
  Ordinary Differential Equations, Transfer Functions, Block Diagrams, Signal Flow Graphs, State-Space Representation.
- **LINEAR SYSTEM REPRESENTATION** **(05 Hours)**
  Transfer Function and Its Interpretation in terms of Impulse and Frequency Responses, Block Diagram and Signal Flow Graph Manipulations.
- **PERFOMANCE AND STABILITY** **(05 Hours)**
  Concept and Definition, Poles, Time Domain Response, Damping Coefficient, Natural Frequency, Overshoot, Setting Time, Rise Time, Second order Systems, Characteristics Equations and Roots, Routh-Hurwitz Criteria.
- **FREQUENCY DOMAIN TECHNIQUES** **(06 Hours)**
  Bandwidth and Cut-Off Rate, Link Between Time and Frequency Domain Response Feature, Stability and Relative Stability, Root-Locus Methods, Frequency Responses, Bode-Plots, Gain-Margin and Phase Margin, Nyquist Rate.
- **COMPENSATOR CONCEPTS** **(05 Hours)**
  Proportional, PI and PID Controllers, Lead-Lag Compensators.
- **STATE-SPACE CONCEPTS** **(05 Hours)**
  Controllability, Observability, Poles Placement Result.
- **INTRODUCTION TO FUZZY CONTROL** **(04 Hours)**
  Fuzzy Sets and Linguistics Variables, The Fuzzy Control Scheme, Fuzzification and Defuzzification Methods, Examples, Comparison Between Conventional and Fuzzy Control.
- **SAMPLED-DATA SYSTEMS** **(05 Hours)**
  Necessity Of Sample And Hold Operations For Computer Control Sampling Theorems, Z-transform, Stability and Response of Sampled-Data Systems, Controller Design, Special Feature of Digital Control Systems.

Total hours: 42

3. **Books Recommended:**

1. K. Ogata, Modern control system engineering, PHI, 4th Edition, 2003 (UNIT I-IV).
2. I. J. Nagrath and M. Gopal, Control system engineering, New Age International Ltd, 3rd Edition, 2002.
3. B. C. Kuo, Automatic control system, Prentice Hall of India, 7th Edition, 2002.
4. M. Gopal, Control System, Tata McGraw-Hill Publishing Co. Ltd., New Delhi, 1st Edition, 1997.
5. Dorf Richard and Bishop Robert, Modern Control System Engineering, Pearson Education, 8th Edition, 2004.

B. Tech. III year, Semester VI

Professional Ethics, Economics and Business Management

L	T	P	Credit
4	0	0	04

HU306 Scheme

1. Course Outcomes (Cos):

At the end of the course students will be able to:

CO1	identify application of ethics in society and development of understanding regarding professional ethical issues related to Electrical engineering
CO2	develop managerial skills to become future engineering managers
CO3	develop skills related to various functional areas of management (Marketing Management, Financial Management, Operations Management, Personnel Management etc.)
CO4	build knowledge about modern management concepts (ERP, SCM, e-CRM, etc.)
CO5	develop experiential learning through Management games, Case study discussion, Group discussion etc.
CO6	apply knowledge of Economics and Business management aspects in Electrical engineering

2. Syllabus:

- **PROFESSIONAL ETHICS** **(14 Hours)**
  Introduction, Approaches to Ethics, Meaning of Ethics, Major attributes of Ethics, Business Ethics, Factors influencing Ethics, Importance of Ethics, Ethics in Management, Organizational Ethics, Ethical aspects in Marketing, Mass communication and Ethics - Television, Whistle blowing, Education – Ethics and New Professional, Intellectual Properties and Ethics, Introduction to Professional Ethics, Engineering Ethics, Ethical issues related to Electrical Engineering

- **ECONOMICS** **(08 Hours)**
  Introduction To Economics, Micro & Macro Economics, Applications & Scopes Of Economics, Demand Analysis, Demand Forecasting, Factors Of Production, Types Of Cost, Market Structures, Break Even Analysis

- **MANAGEMENT** **(12 Hours)**
  Introduction to Management, Features Of Management, Nature Of Management, Development of Management Thoughts – Scientific Management By Taylor & Contribution of Henry Fayol, Coordination & Functions Of Management, Centralization & Decentralization, Decision Making; Fundamentals of Planning; Objectives & MBO; Types of Business Organizations: Private Sector, Public Sector & Joint Sector; Organizational Behavior: Theories of Motivation, Individual & Group Behavior, Perception, Value, Attitude, Leadership

- **FUNCTIONAL MANAGEMENT** **(18 Hours)**
  Marketing Management: Core Concepts Of Marketing, Marketing Mix (4p), Segmentation – Targeting – Positioning, Marketing Research, Marketing Information System, Concept of International Marketing, Difference Between Domestic Marketing & International Marketing; Operations Management: Introduction to Operations Management, Types of Operation Systems, Types of Layouts, Material Handling, Purchasing & Store System, Inventory Management; Personnel Management: Roles & Functions of Personnel Manager, Recruitment, Selection, Training, Industrial Dispute, Collective Bargaining; Financial Management: Goal of Financial Management, Key

Activities In Financial Management, Organization of Financial Management, Financial Institutions, Financial Instruments, Sources of Finance

- **MODERN MANAGEMENT ASPECTS** **(04 Hours)**
  Introduction To ERP, e – CRM, SCM, RE – Engineering, WTO, IPR Etc.

Total Hours: 56

3. Books Recommended:

1. S. K. Mandal, Ethics in Business and Corporate Governance, Tata McGraw Hill, 2011.
2. Prasad L.M., Principles & Practice of Management, Sultan Chand & Sons, 8th Edition, 2015.
3. T. R. Banga and S. C. Sharma, Industrial Organization & Engineering Economics, Khanna Publishers, 25th Edition, 2015.
4. E. Everett E. Adam, Ronald J. Ebert, Production and Operations Management, Prentice Hall of India, 5th Edition, 2012.
5. P. Kotler, K. L. Keller, A. Koshi and M. Jha, Marketing Management – A South Asian Perspective, Pearson, 14th Edition, 2014.

B. Tech. III year, Semester VI

L	T	P	Credit
3	1	2	05

Power Electronics Systems and Electric Drives

EE304 **Scheme**

1. Course Outcomes (Cos):

At the end of the course students will be able to:

CO1	explain the basic concept of electric drives and list their applications for industrial use.
CO2	apply various power electronic converters to DC and AC drives
CO3	devise different control techniques for DC and AC drives
CO4	compare the performance of various methods of drive control
CO5	decide the suitability of electric drive for industrial needs

2. Syllabus:

- **ELECTRICAL DRIVES** **(07 Hours)**
  Review on dc drives, Fundamental torque equation, speed-torque convention and multi quadrant operation, dynamics of motor load combination, nature and classification of load torque, measurement of moment of inertia, calculation of acceleration time in transient operation, acceleration time for specific nature of motor and load torque, load equalization, stability of electrical drives, Selection of Motor Power Rating.

- **POWER ELECTRONICS CONTROL OF DC DRIVES** **(07 Hours)**
  Review of DC Motors and its performance, starting, braking, Speed control, Rectifier fed DC drives with continuous and discontinuous mode of operation, Design of controllers, Supply Harmonics, Power Factor and ripple in motor current, Chopper Controlled DC Drives, Sources current harmonics in chopper, Converter Ratings and closed loop control scheme.

- **THREE PHASE INDUCTION MOTOR DRIVES** **(12 Hours)**
  Review of Three phase Induction Motor and its performance, starting, braking, Static Voltage control, Variable Frequency Control based on VSI, CSI, cyclo-converter etc, static rotor resistance control and slip power recovery control schemes, vector control.

- **THREE PHASE SYNCHRONOUS MOTORS** **(12 Hours)**
  Review of Three phase Synchronous Motor and its performance, Self-controlled schemes, Variable frequency control of multiple synchronous motor, Permanent magnet AC motor drives, Control of Brushless DC Motor Drives and its applications,

- **INDUSTRIAL APPLICATIONS** **(04 Hours)**
  Steel mills, rolling mills, cement mills, tractions, machine tools and coal mining, Petro-chemical industry etc.

Total Hours: 42

Tutorials will be conducted separately for 14 hours

3. List of Experiments:

1. Study of Speed Control of DC Shunt Motor Using Single Phase Fully Controlled Converter.
2. Controlling of DC Motor with Single Phase Dual Converter.
3. Study of Speed Control of Three Phase AC Induction Motor (V/F Control).
4. Experimental investigation of a 5 HP Induction Motor Drive.
5. Study of DSP Controlled Induction Motor Drive.
6. Study of DSP Controlled BLDC Motor Drive.
7. Simulation of V/F control of 3 phase induction motor using MATLAB.
8. Simulation of speed control of three phase induction motor using stator voltage control (AC Voltage controller) in MATLAB.

4. Books Recommended:

1. B. K. Bose, Modern Power Electronics & AC Drives, Pearson, 1st Edition.
2. G. K. Dubey, Fundamentals of Electrical Drives, Narosa Publishing House, 2nd Edition, 2001.
3. R. Krishnan Electric motor drives Modeling, Analysis and Control PHI-India, 1st Edition, 2015.
4. Hughes, Electric Motors & Drives, Newnes, 3rd Edition, 2005.
5. Ned Mohan, Tore M. Undeland and William P. Robbins, Power Electronics Converters, Applications, and Design, John Willey & Sons, Inc., 2nd Edition, 1995.

B. Tech. III year, Semester VI

Microprocessor and Microcontrollers

L	T	P	Credit
3	1	2	05

EE306 **Scheme**

1. Course Outcomes (Cos):

At the end of the course students will be able to:

CO 1	Illustrate with examples basic concepts of digital circuits.
CO 2	explain architecture of 8–bit Microprocessor (8085A), concept of memory and input-output interfacing with timing diagrams.
CO 3	Describe architecture of 8 bit microcontroller (8051) with special function registers (SFR), basic on chip peripherals like Timer0, Timer 1, UART, and External Interrupts and program execution timings (MIPS).
CO 4	Demonstrate interfacing of external peripheral like ADC, DAC, Key board, LCD and seven segment LED display with 8051 Microcontroller.
CO 5	develop assembly language and embedded 'C' programs with the exposure of Kiel µvision IDE.
CO 6	Design and develop using microcontroller, power electronics based electrical systems and provide solution to other real world problems.

2. Syllabus:

- **REVIEW OF DIGITAL LOGIC CONCEPTS** **(02 Hours)**
  Number systems, gates & De-Morgan's equivalents, 3-state logic gates, flip-flops, buffers, decoders, Encoders, multiplexers, de-multiplexers.

- **MICROPROCESSOR SYSTEM ARCHITECTURE** **(03 Hours)**

  Introduction, Registers, concept of address and data buses, system control signals, basic bus timing, memory (RAM, ROM), input output devices, Microcomputer systems

- **INTRODUCTION TO 8085A MICROPROCESSOR ARCHITECTURE** **(03 Hours)**
  Introduction to 8085A, pin diagram and pin description, bus timing and instruction timing, de-multiplexing of buses, generation of control signals, concept of interrupts.

- **MEMORY INTERFACING WITH 8085A** **(04 Hours)**
  Different types of memory, memory map, address decoding scheme for different memory, memory timings.

- **INPUT OUTPUT DEVICES INTERFACING WITH 8085A** **(04 Hours)**
  Basic interfacing concepts, peripheral I/O interfacing and memory mapped I/O interfacing

- **8051 MICROCONTROLLER ARCHITECTURE** **(06 Hours)**
  Introduction, 8051 family microcontrollers, hardware architecture, input/output pins, I/O ports and circuits, on chip ram ,general purpose registers ,special function registers, timers-counters, concepts of interrupts.

- **ASSEMBLY LANGUAGE PROGRAMMING OF 8051** **(10 Hours)**
  Concept of IDE (assembler, compiler, linker, de-bugger), addressing modes, data move instructions, arithmetic and logical instructions, jump, loop and call instructions, concepts of subroutines, interrupt service routine.

- **PERIPHERALS OF 8051 – HARDWARE CONCEPTS AND 'C' PROGRAMMING** **(10 Hours)**

  GPIO port architecture, timers, interfacing with push button keys, interfacing with seven segment LED display, interfacing with ADC

Total hours: 42

Tutorials will be conducted separately for 14 hours

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3. List of Experiments:

(to write and execute assembly language programme for)

1. Arithmetic operations of Signed and Unsigned Numbers
2. Memory Block Movements (Forward, reverse, overlapping)
3. Ascending and descending arrangement of data string.
4. Code conversion. (Hexadecimal, BCD, Binary, ASCII etc.)

(Embedded 'C' programming)

5. Toggling of port pin with time delay
6. Sensing of push button keys
7. Two digit second clock based on seven segment display
8. Interrupt driven clock
9. Programming of ADC and DAC

4. Books Recommended:

1. R. S. Gaonker, Microprocessor Architecture, programming and application, Wiley Eastern Limited, 6th Edition, 2013.
2. Kenneth J. Ayala, The 8051 Microcontroller, Penram International 3rd Edition, 1999.
3. M. Mazidi and others, The 8051 Microcontroller and Embedded Systems, Prentice Hall of India, 2nd Edition, 2007.
4. Michael Slater, Microprocessor based Design, Prentice Hall of India, 3rd Edition, 2016.
5. Badri Ram, Fundamentals of microprocessors and microcomputers, Dhanpat Rai & Sons, 4th Edition, 1993.

B. Tech. III year, Semester VI

L	T	P	Credit
3	1	2	05

Instrumentation

EE308 **Scheme**

1. Course Outcomes (Cos):

At the end of the course students will be able to:

CO1	analyze performance characteristics of measurement systems.
CO2	demonstrate different types of transducers.
CO3	explain different types of recorders and data transmission techniques.
CO4	discuss operational amplifier and its applications.
CO5	Classify various digital displays and digital measuring instruments.

2. Syllabus:

- **PERFORMANCE CHARACTERISTICS OF MEASUREMENT SYSTEMS** **(06 Hours)**
  Input-output configuration of instruments and measurement systems, methods of correction for interfering and modifying inputs, static performance characteristics of instruments, noise, signal to noise ratio, errors in measurement
- **TRANSDUCERS** **(09 Hours)**
  Classification of transducers, passive transducers: resistive, inductive and capacitive transducers, active transducers: thermocouple, piezoelectric transducer, taco-generator, pH cell, basic signal conditioning circuits for transducers.
- **DATA TRANSMISSION ,RECORDERS and DATA LOGGERS** **(05 Hours)**
  Introduction to industrial data transmission techniques, Distinction between recorder and data loggers, strip chart recorder, X-Y recorders, data logger
- **OPERATIONAL AMPLIFIER FUNDAMENTALS** **(04 Hours)**
  Operational Amplifier, Basic Op-Amp Configuration, an Op-Amp with Negative Feedback, Voltage Series and Voltage Shunt Configurations, Difference Amplifiers,
  Specification of An Op-Amp, Offset Voltages and Currents, CMRR, Slew Rate
- **LINEAR APPLICATIONS OF OPERATIONAL AMPLIFIERS** **(06 Hours)**
  Summing, Scaling and Averaging Amplifiers, Voltage to Current Converter with Floating and Grounded Load, Current to Voltage Converter, Integra tor and Differentiator, Instrumentation Amplifier, Isolation amplifier
- **NON-LINEAR APPLICATIONS OF OPERATIONAL AMPLIFIERS** **(06 Hours)**
  Schmitt Trigger, Voltage Comparator, Voltage Limiters And Window Detector, Clippers And Clampers, Peak Detector, Precision Rectifiers, Analog Switches
- **BASICS of DIGITAL INSTRUMENTS** **(06 Hours)**
  Digital meter displays: LED and LCD, Quantization and digitization process, Quantization error, Specifications of digital instruments like digits, resolution and accuracy, Ramp type Digital voltmeter, Dual slope DVM, Digital multi-meter, LCRQ meter, Digital storage oscilloscope

Total hours: 42

Tutorials will be conducted separately for 14 hours

3. List of Experiments:

1. To study input and output characteristics of LVDT.
2. To study strain measurement using Strain Gauge and cantilever assembly.
3. Measurement of liquid level capacitive transducer.
4. To determine the breakdown voltage of transformer oil.
5. To determine the breakdown voltage of different types of paper.
6. To study the characteristics of RTD.
7. To study and perform Inverting & Non-Inverting Configuration Op-amp.
8. To study and perform Summing, Scaling & Averaging Circuits using Op-amp.
9. To study and perform Integrator & Differentiator using Op-amp.
10. To study Peak detector.

4. Books Recommended:

1. A. K. Sawhney, Electrical and electronic Measurements and Instrumentation, Dhanpat Rai & co., 17th Edition.
2. Gayakwad Ramakant, Op-Amps and Linear Integrated Circuits, PHI, 3rd Edition, 1993.
3. A. D. Helfrick and Cooper W. D., Modern electronic Instrumentation and Measurement techniques, Prentice Hall of India, 1997.
4. E. O. Doebelin, Measurement Systems - Application and Design, 4th Edition, McGraw-Hill, New York, 1992.
5. D. A. Bell, Electronic Instrumentation and Measurement, Oxford University press, 3rd Edition, 2013.

B. Tech. III year, Semester VI

Industrial Automation and Process Control (EIS-II)

L	T	P	Credit
3	0	0	03

EE362 **Scheme**

1. Course Outcomes (Cos):

At the end of the course students will be able to:

CO1	classify various types of Industrial process
CO2	explain working principle of various type of sensors and actuators
CO3	discuss various type of controller and various control system configurations
CO4	develop ladder logic program for PLC for various industrial applications
CO5	discuss case study of Industrial automation.

2. Syllabus:

- **INTRODUCTION OF INDUSTRIAL PROCESSES** **(04 Hours)**
  Process with analog variables, discrete state sequential process, hybrid process, overview of automation.
- **SENSORS** **(06 Hours)**
  Mechanical sensors: strain; motion; pressure; flow: Thermal sensors: RTD; thermistors; thermocouple Optical sensors; photo detectors; pyrometers; optical sources.
- **ACTUATORS** **(05 Hours)**
  Final control operation: signal conversions; actuators; control elements, signal conversions: analog electrical signals; digital signals; pneumatic signals, actuators: electrical; pneumatic; hydraulic, fluid valves : control valve principle; types; sizing
- **CONTROL SYSTEM CONFIGURATIONS** **(05 Hours)**
  Feedback control, Feed Forward Control, Ratio Control, cascade Control, over-ride control, optimizing control system
- **CONTROLLER PRINCIPLES** **(06 Hours)**
  Controller modes, electronic controller, pneumatic controller, digital controllers, controller software.
- **PROGRAMMABLE LOGIC CONTROLLERS** **(12 Hours)**
  Advantages & disadvantages of PLC with respect to relay logic, PLC architecture, Input Output modules, PLC interfacing with plant, ladder diagram
- **CASE STUDY OF INDUSTRIAL AUTOMATION** **(04 Hours)**
  Boiler, conveyor belt system, Heat Exchanger

Total Hours:42

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3. Books Recommended:

1. John Webb, Programmable Logic Controllers Principles & applications, Prentice Hall of India, 1st Edition, 2003.
2. C. D. Johnson, Process Control Instrumentation Technology 4th Edition, PHI.
3. Andrews, Applied Instrumentation in Process Industries (Volume-IV).
4. D. Patranabis, Principles of Process Control, Tata McHgraw Hill PublisohingCompany Ltd., New Delhi, 3rd Edition.
5. T. A. Hughes, Programmable Controllers, 4th Edition, 2004, ISA.

B. Tech. III year, Semester VI

State Variable Analysis (EIS-II)

L	T	P	Credit
3	0	0	03

EE364 **Scheme**

1. Course Outcomes (Cos):

At the end of the course students will be able to:

CO1	construct state-space models for the systems from the ubiquitous domains (electrical/mechanical).
CO2	correlate differential equations, transfer function model with the state space models.
CO3	recast linear, nonlinear, multi input multi output, continuous and discrete systems in state space form.
CO4	design control systems using the state space techniques and analyze the properties of state space models which are essential for developing controllers and observers.
CO5	adopt state space technique for the models of real world problems.

2. Syllabus:

- **MATHEMATICAL BACKGROUND-MATRICES:** **(03 Hours)**
  Definition of Matrices; Matrix Algebra; Matrix Multiplication and Inversion; Rank of a Matrix; Differentiation and Integration of Matrix.

- **STATE SPACE ANALYSIS METHODS AND TECHNIQUES:** **(16 Hours)**
  State Variables; State-Space Representation of Electrical and Mechanical and Electromechanical Systems; State Space Representation of Nth Order, Linear Differential Equation; Transformation to Phase Variable Canonical Form; Relationship Between Transfer Functions and State Equations; Characteristic Equation; Eigen Values and Eigen Vectors; Transformation to Diagonal Canonical Form; Jordan Canonical Form.

- **SOLUTION OF THE TIME-INVARIANT SYSTEMS:** **(06 Hours)**
  Solution of the Time-Invariant State Equation; State Transition Matrix and its Properties; Transfer Matrix; Transfer Matrix of Closed Loop Systems, Methods of calculations of the matrix exponentials using algebraic and algorithmic methods.

- **CONTROLLABILTY AND OBSERVABILITY:** **(08 Hours)**
  Concept of Controllability and Observability; Kalman's Theorems on Controllability; and Observability, Alternative Tests (Gilbert's Method) of Controllability and Observability; Principle of Duality; Relationship among Controllability, Observability and Transfer Function, Decomposition of Transfer Function-Direct, Cascade and Parallel Decomposition; State Diagram.

- **LYAPUNOV STABILITY ANALYSIS:** **(09 HOURS)**
  Stability of Equilibrium State in the Sense of Lyapunov; Graphical Representation of Stability; Asymptotic Stability and Instability; Sign-Definiteness of Scalar Function; Second Method of Lyapunov; Stability Analysis of Linear Systems; Krasovskii's Theorem; Lyapunov Function Based on Variable Gradient Method.

Total Hours: 42

3. Books Recommended:

1. I. J. Nagrath and M. Gopal, Control System Engineering, New Age International Publishers, 3rd Edition, 2001.
2. K. Ogata, Modern Control System Engineering, Pearson Education Asia, 4th Edition, 2002.
3. B. C. Kuo, Automatic Control Systems, Prentice Hall of India, 7th Edition, 1995.
4. N. S. Nise, Control System Engineering, John Wiley & sons, 4th Edition, 2004.
5. P. F. Blackman, Introduction to State Variable Analysis, the McMillan Press, 1st Edition, 1977.

B. Tech. III year, Semester VI

Energy Audit and Management (EIS-II)

L	T	P	Credit
3	0	0	03

EE366 **Scheme**

1. Course Outcomes (Cos):

After completion of the course, the students will be able to:

CO1	recognize the significance of energy management and its role in industries
CO2	analysis of Energy conservation and needs of energy audit and management.
CO3	evaluate the energy economics.
CO4	plan and design energy efficient systems
CO5	estimate the economy and judge the environmental concerns.

2. Syllabus:

- **ENERGY MANAGEMENT** **(12 Hours)**
  Energy Scenario – Energy Demand and Ecological Balance –Resource availability and management, Strategies, Tools available, Energy Monitoring and Targeting, Energy Norms, Energy Policy, Demand Side Management–Role of Energy Managers in Industries - maximizing system efficiencies, Optimizing input energy requirements - Principles and Imperatives of Energy Conservation - Energy Consumption pattern, Energy Conservation acts, Energy Conservation Implementation Programme (ECIP), Energy Audit concepts, needs, energy management (audit) approach, energy audit instruments, Energy action planning and Project management.

- **ELECTRICAL ENERGY AUDITING** **(10 Hours)**
  Potential areas of Electrical Energy Conservation in various industries–Energy Management opportunities in Cable selection, Electricity Act, Electric Heating and Lighting systems –Six basic rules of Energy, Efficient Lighting, Energy losses in electric motors and drives, Energy Efficient Motors and Drives, Soft starters with energy saver, Power factor improvement, Energy conservation in domestic gadgets and transport, DG system- factors affecting selection & performance.

- **ENERGY ECONOMICS** **(10 Hours)**
  Economic analysis of investments, Present value criterion, Discount rate, simple payback period, return on investment, net present value(NPV), internal rate of return, life cycle costing, energy performance contracts and role of ESCOs, Energy Management Information Systems.

- **ECONOMICS OF POWER GENERATION** **(10 Hours)**
  Factors affecting the cost of generation – Load factor, Diversity factor, Plant capacity factor, Plant use factor, Load curves, Load duration curves, Reduction of costs by Interconnection of Stations, Choice of size & number of generator units, Tariffs : types and significance.

Total Hours:42

3. Books Recommended:

1. Albert Thumann, Handbook of Energy Engineering, The Fairmont Press Inc., 6th Edition, 2003.
2. Wayne C. Turner, Energy management Handbook, John Wiley and sons, 9th Edition, 2019.
3. Prasanna Chandra, Financial management, Tata McGraw Hill, 10th Edition, 2019.
4. S. Choudhury, Projects: Planning, Analysis, Selection, Implementation and Review, Tata McGraw Hill Publishing Company, New Delhi, 1995.
5. Cleaner Production, Energy Efficiency Manual for GERIAP, UNEP, prepared by National Productivity Council, Bangkock.

B. Tech. III year, Semester VI

Special Electrical Machines (EIS-II)

L	T	P	Credit
3	0	0	03

EE368 **Scheme**

1. Course Outcomes (Cos):

At the end of the course students will be able to:

CO1	list different types of special electrical machines
CO2	describe the basic principles of special Electrical machines
CO3	compare the performance of various special electric machines
CO4	analyze the steady state performance of special Electrical machines
CO5	identify the special constructional and operating features of special electrical machines
CO6	select appropriate special electric machine for given application

2. Syllabus:

- **SERVO MOTORS** **(05 Hours)**
  Symmetrical components applied to two - phase servo motors - equivalent circuit and performance based on symmetrical components - servo motor torque - speed curves.
- **VARIABLE RELUCTANCE MOTORS** **(08 Hours)**
  Construction of VRM, Concepts of co-energy and expression of torque, inductance, current and torque calculation and waveforms, Drive circuit for VRM.
- **STEPPER MOTORS** **(07 Hours)**
  Construction features, half stepping and the required switching sequence, stepper motor ratings, static and dynamic characteristics, application and selection of stepper motor.
- **RELUCTANCE MOTORS** **(02 Hours)**
  Construction – poly-phase and split phase reluctance motors - capacitor type reluctance motors.
- **HYSTERISIS MOTORS** **(02 Hours)**
  Construction – poly-phase: capacitor type and shaded pole hysteresis motors.
- **UNIVERSAL MOTORS** **(03 Hours)**
  Essential parts of universal motor, performance characteristics and application.
- **LINEAR MACHINES** **(08 Hours)**
  Basic difference between LEMS and rotating - machine - classification of LEMS, linear motors and levitation machines - linear induction motors - linear synchronous motors - DC linear motors - linear levitation machines.
- **PMDC MOTORS** **(01 Hour)**
  Construction, principle of operation, performance analysis.
- **BRUSHLESS DC MOTORS** **(06Hours)**
  Construction, principle of operation, phasor diagram, characteristics, performance analysis.

Total Hours: 42

3. **Books Recommended:**

1. V. D. Toro, Electric machines and power systems, Prentice Hall of India, 1985.
2. Veinott, Fractional horse power electric motors, McGraw Hill, 4th Edition, 1987.
3. S. A. Nasar, Boldeal, Linear Motion Electric machine, John Wiley,1976.
4. V. V. Athani, Stepper Motors, New Age International Pvt. Ltd., 1997.
5. I. J. Nagrath and D. P. Kothari, Electric Machines, Tata McGraw Hill Publishing Company, New Delhi, 4th Edition, 2010.

B. Tech. III year, Semester VI

L	T	P	Credit
3	0	0	03

Advanced Materials for Energy Applications (EIS- II)

EE372 **Scheme**

1. Course Outcomes (Cos):

At the end of the course the students will be able to:

CO1	recognize the need for materials and its future for energy needs.
CO2	describe the physics and chemistry of the materials behind the energy conversion.
CO3	categorize the materials for different energy applications.
CO4	discuss the energy conversion process with different materials.
CO5	design a basic device structure using the materials for different energy applications.

2. Syllabus:

- **ENERGY IN TRANSITION** **(02 Hours)**
  Introduction, Materials for Energy, How Far Ahead Is the Future?
- **MATERIALS FOR PHOTOVOLTAIC SOLAR CELLS** **(08 Hours)**
  The Physics of Solar Cells, Types of Solar Cell, Transparent Conductive Materials, Toward Low Cost, Fast and Scalable Processing, Low-Cost Electricity Production from Sunlight: Third-Generation Photovoltaics and the Dye-Sensitized Solar Cell, Basics of Organic Photovoltaics, Dye-Sensitized Solar Cell Principle
- **THERMOELECTRICS** **(03 Hours)**
  Introduction, Definition, Applications of Thermoelectricity, Semi-classical Theory of Thermoelectricity in Solids, Thermoelectric Materials, Conclusion
- **PIEZOELECTRIC CONVERSION** **(03 Hours)**
  Introduction, Principles of Piezoelectric Transduction, Energy Conditioning Circuitry, Applications of Piezoelectric Energy Harvesting, Current Research Thrusts, Summary and Future Visions
- **FUEL CELLS** **(05 Hours)**
  Introduction, History, Types of Fuel Cells, Thermodynamics, Fuel Cell Efficiency, Applications.
- **BATTERIES: FUNDAMENTALS AND MATERIALS ASPECTS** **(06 Hours)**
  Introduction, Rechargeable Battery Systems, Beyond Li-Ion: From Single to Multivalent Ion Chemistriesm, Redox Flow Batteries
- **ENVIRONMENTALLY FRIENDLY SUPERCAPACITORS** **(04 Hours)**
  Introduction, Energy Storage Devices, Super-capacitors Background, Charge Storage Mechanisms, Classification, Designing High-Performance Environmentally Friendly Super-capacitors, Characterization, Future Perspectives
- **HYDROGEN STORAGE** **(03 Hours)**
  Conventional Hydrogen Storages, Hydrogen Physisorption, Metal Hydrides, Complex Hydrides, Amides and Imides, Ammonia-Borane, Conclusions
- **SUPERCONDUCTORS** **(05 Hours)**
  Introduction, Fundamental Phenomenology of Superconductivity, Superconducting Materials for Application, Coated Conductor Fabrication, Superconductors for Energy Applications, Superconductors for Transportation Applications, Paradigm-Shifting Energy Technologies, Other Applications of Superconductors, Cooling, Cost, Summary

- **SOLID-STATE LIGHTING: AN APPROACH TO ENERGY-EFFICIENT ILLUMINATION** **(03 Hours)**
  Properties of Light, Light Sources, LED Physics, Light Emitting Diodes Based on III-V Junctions, Organic Light Emitting Diodes, White Light with LEDs, New Approaches, LED Packaging, LED Drivers, Lighting Control Systems and Applications

Total Hours: 42

3. Books Recommended:

1. Xevier Moya and David Monoz-Rojas, Materials for Sustainable Energy Applications-Conversion, Storage, Transmission and Consumption, Pan Stanford Publishing, Singapore, 2016.
2. O. S. Burheim, Engineering Energy Storage. Academic Press, 1st Edition 2017.
3. S. O. Kasap, Principles of Electrical Engineering Materials and Devices, Irwin Professional Publishing, 1997.
4. S. M. Sze, Physics of Semiconductor Devices, 2nd Edition, Wiley Eastern Publication, New Delhi, 1993.
5. Donald A. Neamen, Semiconductor Physics and Devices, 3rd Edition, Tata McGraw Hill Publishing Company Limited, New Delhi, 2007.

B. Tech. III year, Semester VI

Distributed Power Generation and Micro-Grids (EIS-II)

L	T	P	Credit
3	0	0	03

EE374 **Scheme**

1. Course Outcomes (Cos):

Upon completion of the course, the students will be able to:

CO1	explain the concept of conventional grid and micro-grids
CO2	appraise the need of distributed renewable energy resources
CO3	describe the extraction and conversion of solar and wind energy.
CO4	evaluate the response and protection of micro-grids.
CO5	recognize the need of smart meters, electricity tariff and other smart devices.

2. Syllabus:

- **INTRODUCTION** **(07 Hours)**
  The basic concepts of power grid, the electric grid vs micro-grids: technical and historic perspective, concept of micro-grid, typical configuration of micro-grid, AC and DC micro-grids, interconnection of micro-grids, technical and economic advantages of micro-grid, challenges and disadvantages of micro-grids, Islanding, need and benefits, different methods of islanding detection, modelling a micro-grid system

- **DISTRIBUTED ENERGY RESOURCES:** **(07 Hours)**
  Introduction - Combined heat and power (CHP) systems - Solar photovoltaic (PV) systems – Wind energy conversion systems (WECS) - Small-scale hydroelectric power generation - Storage devices: Batteries: Lead acid, nickel metal hydrate, and lithium ion batteries , ultra-capacitors, flywheels, Advantages and disadvantages of DG.

- **MICRO-GRID SOLAR ENERGY SYSTEM:** **(07 Hours)**
  the solar energy conversion process, photovoltaic power conversion, photovoltaic material, photovoltaic characteristic, photovoltaic efficiency, design of photovoltaic system, MPPT, storage system based on a single cell battery, the energy yield of a photovoltaic module and the angle of incident, Application of power electronics in solar system

- **MICRO-GRID WIND ENERGY SYSTEM:** **(08 Hours)**
  Wind power, wind turbine generators, power flow analysis of an induction machine, the operation of an induction generator, Permanent magnet synchronous generators, reluctance generators and Application of power electronics in wind farms.

- **PROTECTION ISSUES FOR MICROGRIDS:** **(06 Hours)**
  Introduction, Islanding, Different islanding scenarios, Major protection issues of standalone Micro-grid - Impact of DG integration on electricity market, environment, distribution system, communication.

- **INTRODUCTION TO SMART METERS, ELECTRICITY TARIFF:** **(07 Hours)**
  One Part Tariff, Two Part Tariff and Maximum Demand Tariff, Dynamic Pricing - Time of-use (TOU) pricing, critical-peak pricing (CPP) and Real Time, Pricing- Automatic Meter Reading (AMR).

Total Hours: 42

3. Books Recommended:

1. Ali Keyhani, Mohammad Marwali and Min Dai, Integration and Control of Renewable Energy in Electric Power System John Wiley publishing company, 2009.
2. S. Chowdhury, S. P. Chowdhury, P. Crossley, Micro-grids and Active Distribution Networks, IET Power Electronics Series, 2012.
3. Ali Keyhani, Design of Smart Power Grid Renewable Energy Systems, Wiley, 2nd Edition, 2016.
4. James Momoh, Smart Grid: Fundamentals of Design and Analysis, Wiley, 1st Edition, 2012.
5. R. C. Durgan, M. F. Me Granaghen, H. W. Beaty, Electrical Power System Quality, McGraw-Hill, 3rd Edition, 2017.

B. Tech. III year, Semester VI

Power Plant Engineering (ES – I)

L	T	P	Credit
3	0	0	03

EE322 **Scheme**

1. Course Outcomes (Cos):

At the end of the course students will be able to:

CO1	explain the basics of various components of the power station
CO2	describe the working of steam and hydro power stations
CO3	describe the working of nuclear and diesel and gas power stations.
CO4	explain the working of the power stations based on non-conventional resources.
CO5	design the controllers for various power stations.

2. Syllabus:

- **STEAM POWER STATION** **(04 Hours)**
  Main flow circuits of thermal power station, thermodynamic cycles of steam flow, general layout of power stations, power station auxiliaries, cooling system of alternators, flue-gas flow arrangement, circulating water system, cooling tower.
- **HYDROELECTRIC POWER PLANT** **(06 Hours)**
  Selection of site, water power equations, types of dams, arrangement and layouts of hydro-electric station, classification of plants, water turbines, properties of water wheels, specific speed on the basis of discharge, combined steam and hydro-plants, pumped storage hydro station.
- **NUCLEAR POWER STATION** **(07 Hours)**
  Atomic structure, isotopes, energy release by fission, chain reaction, atomic reactor, fuels, moderators and coolants, types of reactors, fast breeder reactor, radio activity and hazards.
- **DIESEL AND GASTURBINE STATION** **(06 Hours)**
  Field of use, general layout and principle of operation.
- **NON CONVENTIONAL METHOD OF POWER GENERATION** **(06 Hours)**
  MHD generation, wind power, tidal power, solar power, solar cell and fuel cell.
- **COMBINATIONS OFDIFFERENT TYPESOF POWER PLANTS** **(10 Hours)**
  Types of power station, advantages of combined working of different types of power station, need for coordination of different types of power station, run-off river plant in combination with steam plant, hydro- electric plants with ample storage in combination with steam plants, pumped storage plant in combination with ordinary hydro-electric plant, co-ordination of hydro-electric and gas turbine plant, co-ordination of hydro-electric and nuclear power station, co-ordination of different types of power plants in power station.
- **POWER STATION CONTROL** **(03 Hours)**
  Excitation systems, excitation control, field protection, commissioning of alternators, power supply for station auxiliaries, power station control.

Total Hours:42

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3. Books Recommended:

1. Arogya swamy, Power Station Practice, Oxford & IBM Publication Co., New Delhi, 1976.
2. Baptidanov L., Power Station & Substation, Moscow Peace Publication.
3. Leznov S. & Taits, Power Station & Substation Maintenance, Moscow Mir Publication, 1983.
4. Leznov S. & Taits, Power Station Electrification, Moscow Mir Publication, 1983.
5. Bruce, John, London, Power Station Efficiency Control, Sir Issac Pitman & Sons Ltd., 1926.

B. Tech. III year, Semester VI

Adaptive Control and Soft Computing (ES – I)

L	T	P	Credit
3	0	0	03

EE324 **Scheme**

1. Course Outcomes (Cos):

At the end of the course students will be able to:

CO1	explain various concepts related to adaptive control and soft computing techniques.
CO2	compare various soft computing techniques like ANN and fuzzy.
CO3	apply ANN, Fuzzy logic for implementing adaptive control strategies
CO4	choose a particular soft computing technique for solving a specific problem
CO5	design fuzzy, ANN based controllers for various applications.

2. Syllabus:

- **ADAPTIVE CONTROL** **(15 Hours)**
  Need for adaptive control, MIT rule, Model reference and self-tuning adaptive control techniques, Auto tuning, Gain scheduling, Design of Gain-Scheduling Controllers, Adaptive Feedback Linearization, Adaptive Back Stepping, Stability, convergence issues in adaptive control. Practical aspects, implementation and applications of adaptive control.

- **ARTIFICIAL NEURAL NETWORK BASED CONTROL:** **(15 Hours)**
  Introduction to ANN, different activation functions, different architectures, different learning methods; Back Propagation and Radial Basis Function networks: Representation and identification, modelling the plant, control structures – supervised control, Model reference control, Indirect and direct adaptive controller design using neural network.

- **FUZZY LOGIC BASED CONTROL:** **(12 Hours)**
  Fuzzy Controllers: Preliminaries: Mamdani and Sugeno inference methods, Fuzzy sets in commercial products: basic construction of fuzzy controller –Indirect and direct adaptive fuzzy control: case studies.

Total Hours: 42

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3. Books Recommended:

1. I. D. Landau, Adaptive Control: Algorithms, Analysis and Applications, Springer, 2nd Edition, 2011.
2. V. V. Chalam, Adaptive Control Systems: Techniques and Applications, Marcel Dekker, New York, 1st Edition, 1987.
3. K. J. Astromand B. Wittenmark, Adaptive Control, Addison Wesley, 1995.
4. Simon O. Haykin, Neural Network and Learning Machines, 3rd Edition, PHI, 2008.
5. Kwang H. Lee, First course on Fuzzy Theory and Applications, Springer, 2005.

B. Tech. III year, Semester VI

Utilization of Electrical Energy (ES – I)

L	T	P	Credit
3	0	0	03

EE326 **Scheme**

1. Course Outcomes (Cos):

At the end of the course students will be able to:

CO1	explain basic principles of illumination, electric heating and welding and refrigeration system
CO2	estimate the lighting requirements for household Lighting and industrial lighting needs and its design
CO3	calculate the heat developed in different electrical furnaces and ovens
CO4	evaluate the performance of various electric welding techniques.
CO5	evaluate the rating of electrical equipment used in refrigeration and air conditioning system.

2. Syllabus:

- **ILLUMINATION** **(10 Hours)**
  Nature of light, visibility spectrum curve of relative sensitivity of human eye and wave length of light. Various definitions related to illumination, Laws of illumination, construction and working of Different type of lamps, characteristics, fittings required for various lamps, Calculation of number of light points for interior illumination, calculation of illumination at different points, considerations involved in simple design problems. Illumination schemes: indoor and outdoor, Illumination levels. Main requirements of proper lighting; absence of glare, contrast and shadow. General ideas about different lighting schemes.
- **HEATING** **(10 Hours)**
  Advantages of electrical heating. Heating methods: Resistance heating – direct and indirect resistance heating, electric ovens, their temperature range, properties of resistance heating elements, domestic water heaters and other heating appliances and thermostat control circuit. Induction heating; principle of core type and coreless induction furnace. Electric arc heating; direct and indirect arc heating, construction, working and applications of arc furnace. Dielectric heating, applications in various industrial fields. Infra-red heating and its applications. Microwave heating, Power electronics application in heating system.
- **WELDING** **(10 Hours)**
  Advantages of electric welding. Principles of resistance welding, types – spot, projection seam and butt welding and welding equipment used. Principle of arc production, electric arc welding, characteristics of arc, carbon arc, metal arc, hydrogen arc welding method of and their applications. Power supply required. Advantages of using coated electrodes, comparison between AC and DC arc welding, welding control circuits, welding of aluminum and copper. Introduction to TIG, MIG Welding, Power electronics application in welding system.
- **REFRIGERATION AND AIR CONDITIONING** **(12 Hours)**
  Introduction, Refrigeration systems, domestic refrigerator, Types of air conditioning systems, central air conditioning system, heating of buildings, calculation of rating of electrical equipment, Modern and efficient refrigeration and air conditioning system.

Total Hours:42

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3. Books Recommended:

1. Gupta, J. B., Utilization of Electrical Energy and Electric Traction, S. K. Kataria and sons, 10th Edition, 1990.
2. R. K. Rajput, Utilization of Electrical Power, Laxmi publications, 1st Edition, 2007.
3. C. L. Wadhwa, Generation Distribution and Utilization of Electrical Energy, New Age International publishers, 4th Edition, 2011.
4. E. O. Taylor, Utilization of Electric Energy, Orient Blackswan, 1971.
5. H. Partab, Art and Science of Utilization of Electrical Energy, Dhanpat Rai & Co, 2017.

B. Tech. III year, Semester VI

Modeling of Electrical Machines (ES – I)

L	T	P	Credit
3	0	0	03

EE328 **Scheme**

1. Course Outcomes (Cos):

At the end of the course, the students will be able to:

CO1	explain the basic principle of electrical machines based on principle of electromagnetic energy conversion
CO2	develop the mathematical model of DC machine
CO3	explain various reference frame theories for modeling electric machines
CO4	deduce the mathematical model of induction, synchronous and permanent magnet synchronous machines based on reference frame theory
CO5	analyze the performance of electric machines based on the derived mathematical machines
CO6	simulate various electric machines based on mathematical models

2. Syllabus:

- **BASIC PRINCIPLE OF ELECTRIC MACHINE** **(03 hours)**
  Review of Magnetic circuit and electromagnetics (Faraday's law, Ampere's law, Bio Savart's law, Kirchhoff law and Maxwell's equation (integral form and point form)), Principle of transformer action, Principle of Electromagnetic Energy Conversion, Elementary electric machine
- **DC MACHINE MODELLING** **(06 hours)**
  Modeling of D.C. Machine (Separately Excited, shunt and series type), Linearization of machine equations, State-Space Modeling of the machine.
- **INDUCTION MACHINE MODELING** **(12 hours)**
  Distributed Winding in AC Machinery, winding function, air gap mmf, rotating mmf, Flux linkage and Inductance, Stator and rotor voltage equation and torque equation in stator reference frame, Reference frame theory: Space phasor description, Derivation of induction motor modelling in rotor flux and stator flux reference frame, Derivation of steady state model.
- **PERMANENT MAGNET MACHINE MODELING** **(11hours)**
  Voltage and torque equation of surface mount permanent magnet machine in stator reference frame, Voltage and torque equation of surface mount permanent magnet machine in rotor reference frame, Derivation of steady state model.
- **SYNCHRONOUS MACHINE MODELING** **(10 hours)**
  Voltage and torque equation of salient pole synchronous machine including damper winding in stator reference frame, Voltage and torque equation of salient pole synchronous machine including damper winding in rotor reference frame.

Total Hours: 42

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3. Books Recommended:

1. P. C. Krause, Oreg Wasynczuk, Scott D. Sudhoff, Analysis of Electric Machinery and drive systems, Wiley Interscience, 2nd Edition, 2010.
2. P. S. Bimbhra, Generalized theory of Electrical M/C, Khanna Publication, 2000.
3. S. K. Sen, Electrical Machinery, Khanna Pub., Delhi, 2012.
4. Mrittunjay Bhattacharya, Electrical Machines: Modelling and Analysis, PHI, 2016.
5. R. Ramanujam, Modelling and Analysis of Electrical Machines, Wiley, 2019.

B. Tech. III year, Semester VI

L	T	P	Credit
3	0	0	03

Random Processes (ES - I)

EE322 **Scheme**

1. Course Outcomes (Cos):

At the end of the course students will be able to:

CO1	Illustrate with examples the concepts of random variables and probability densities
CO2	infer the statistical properties of various random variables and their properties
CO3	develop stochastic models for various real-life problems
CO4	appreciate the importance of Gaussian random variables and Gaussian density in real-life problems
CO5	apply concepts of state estimation for linear and nonlinear systems

2. Syllabus:

- **CONCEPTS OF PROBABILITY** **(06 Hours)**
  Introduction, set theory, probability space, Total and Conditional Probability, Bayes' Theorem, Examples.
- **RANDOM VARIABLES** **(12 Hours)**
  Concept of random variable, Equivalent Events, Classification of Random variables: Continuous and Discrete, Concepts of probability density function (pdf) and probability mass function (pmf), Cumulative distribution function (cdf), Generation of random variables, Vector random variables, Independent random variables, Co-relatedness and Independence.
- **STATISTICAL PROPERTIES OF SCALAR AND VECTOR RANDOM VARIABLES** **(12 Hours)**
  Frequently used random variables: Uniform and Gaussian random variables, Concepts of Expectation and moments, second central moment, variance, covariance, autocorrelation matrix, Cross correlation matrix, Correlation coefficient, cross covariance, Marginal probability density, Conditional probability density, Joint probability density, Properties of Gaussian random variables.
- **STOCHASTIC PROCESSES** **(12 Hours)**
  Difference between stochastic and deterministic system, Concept of random process, stationarity and ergodicity, auto correlation function, cross correlation function and their properties, Gaussian process, Markov process, central limit theorem, white noise-properties. Concepts of modelling: Brownian motion, random walk problem, Linear perturbation models, Models for computer control: Linear and nonlinear discrete dynamic models. Least squares estimate, Kalman and extended Kalman filter.

Total Hours: 42

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3. Books Recommended:

1. A. Papoulis & S. U. Pillai, Probability, Random Variables and Stochastic Process, 4th Edition, McGraw Hill, 2002.
2. X. Rong Li, Probability Random Signal and Statistics, CRC Press, 1999.
3. A. H. Jazwinski, Stochastic Processes and Filtering Theory, Dover publication, 2005.
4. V. K., Rohatgi and Md. Ehsanes Saleh, An introduction to probability and statistics, 2nd Edition, Wiley India, 2009
5. P. S. Maybeck, Stochastic Models, Estimation and Control, Vol. 1, Academic Press, 1979.

B. Tech. III year, Semester VI

Artificial Intelligence Techniques (ES - I)

L	T	P	Credit
3	0	0	03

EE324 **Scheme**

1. Course Outcomes (Cos):

At the end of the course students will be able to:

CO1	recognize the need of artificial intelligence
CO3	classify various artificial neural network based on its topology and processing methods
CO4	design the ANN for various applications
CO5	explain the basics of fuzzy logic
CO6	design the fuzzy logic controller for various applications.

2. Syllabus:

- **INTRODUCTION TO ARTIFICIAL INTELLIGENCE** **(04 Hours)**
  Foundations of AI, History of AI, Agents and environments, The nature of the Environment, Problem solving Agents, Problem Formulation, Search Strategies

- **KNOWLEDGE AND REASONING FOR AI** **(06 Hours)**
  Knowledge-based Agents, Representation, Reasoning and Logic, Prepositional logic, First-order logic, Using First-order logic, Inference in First-order logic, forward and Backward Chaining

- **ARTIFICIAL NEURAL NETWORKS** **(08 Hours)**
  History of Neural Networks, Structure and Functions Of Biological And Artificial Neuron, Neural Network Architectures, Characteristics Of ANN, Basic Learning Laws and Methods. Neural Networks Components and Terminology, Neural Networks Topology, Neural Network Adaption, Comparing Neural Networks and Other information Processing Methods, Preprocessing and Post Processing.

- **ARTIFICIAL NEURAL NETWORKS APPLICATIONS** **(08 Hours)**
  Single Layer Neural Network and architecture, McCulloch-Pitts Neuron Model, Learning Rules, Perceptron Model, Perceptron Convergence Theorem, Delta learning rule, Outstar Learning, Kohenen Self Organization Networks, Learning Vector Quantization

- **FUZZY SYSTEMS CONCEPTS AND PARADIGMS** **(06 Hours)**
  Fuzzy sets and Fuzzy Logic, Theory of Fuzzy sets, Approximate Reasoning, Fuzzy Systems Implementations and Fuzzy Rule-System Implementation.

- **FUZZY APPLICATIONS** **(10 Hours)**
  Automated Methods for Fuzzy System: Definitions, Batch Least Squares Algorithm, Recursive Least Squares Algorithm, Gradient Method, Clustering Method, Learning From Examples, Modified Learning From Examples, Decision Making with Fuzzy Information: Fuzzy Synthetic Evaluation, Fuzzy Ordering, Non transitive Ranking, Preference and Consensus, Multi objective Decision Making, Fuzzy Bayesian Decision Method, Decision Making Under Fuzzy States and Fuzzy Actions.

Total Hours: 42

3. Books Recommended:

1. Simon Hakins, Neural Networks, Pearson Education, 3rd Edition 2016.
2. Timothy J. Ross, Fuzzy Logic with Engineering Applications, 3rd Edition, Willey, 2010
3. Yang Xiao, Security and Privacy in Smart Grids, CRC Press Taylor & Francis Group, 2014.
4. Stuart Russell, Peter Norvig: Artificial Intelligence: A Modern Approach, 2nd Edition, Pearson Education, 2007.
5. Eberhart & Shi, Computational Intelligence - Concepts to Implementations, Morgan Kaufmann, 1st Edition, 2007.

B. Tech. III year, Semester VI

Switchgear and Protection (ES - I)

L	T	P	Credit
3	0	0	03

EE336 **Scheme**

1. Course Outcomes (Cos):

At the end of the course, the students will be able to:

CO1	explain the basic concept of protection of electrical power system
CO2	demonstrate the function of various Circuit Breakers, fuse and related switches with respect to their construction, theory and applications.
CO3	explain use of current transformer and potential transformer in protection.
CO4	identify appropriate relaying schemes to protect Generator, Motor, Transformer and Bus bar based on fault
CO5	distinguish the various protection methods for the protection of Transmission line

2. Syllabus:

- **FUSES, SWITHCHES AND NEUTRAL GROUNDING** **(03 Hours)**
  Rewirable fuses, HRC fuses, isolators and earthing switches, selection of fuses. Effectively grounded and ungrounded systems, resonant grounding Methods of neutral grounding.
- **BASIC PRINCIPLES AND RATINGS OF CIRCUIT BREAKERS** **(04 Hours)**
  Arc phenomenon, arc Interruption theories, arc control devices, recovery and restriking voltages, current chopping, Interruption of capacitive current, resistance switching, circuit breaker operating mechanism and control systems, making current, breaking current symmetrical and unsymmetrical, continuous current rating, MVA capacity.
- **CIRCUIT BREAKERS** **(09 Hours)**
  Bulk oil circuit breaker, arc controlled devices, MOCB, ACB, ABCB, SF_6 circuit breaker, vacuum circuit breaker and DC circuit breakers, circuit breaker ratings, auto recloser. Testing of circuit Breaker.
- **CURRENT TRANSFORMER AND POTENTIAL TRANSFORMER** **(02 Hours)**
  Construction, Operation, Vector Diagram of CTs , PTs and CVTs.
- **FUNCTIONS OF PROTECTIVE RELAYING** **(02 Hours)**
  Fundamental characteristics of relays, standard definition of relay terminologies, relay classifications, operating principles of single and double actuating quantity type electromechanical relays, directional relay, reverse power relay.
- **GENERATOR & MOTOR PROTECTION** **(06 Hours)**
  Modern methods of protecting generators against faults in stator, rotor and prime movers and other abnormal conditions. Abnormal operating conditions, under voltage, phase and earth fault, overload and unbalanced voltage protections for motors.
- **TRANSFORMER PROTECTION** **(03 Hours)**
  Protection of transformers, basic differential over current relays, restricted earth fault protection, gas relays, overall generator-transformer differential protection, magnetizing inrush protection.
- **BUSBAR PROTECTION** **(03 Hours)**
  Protection of outdoor and indoor bus-bar by current differential, voltage differential and directional comparison principles, linear coupler, high impedance schemes.
- **TRANSMISSION LINE PROTECTION** **(05 Hours)**

Operating characteristics of impedance, reactance relays on R-X diagram, overreach and memory action, ohm and mho types relays and their characteristics, relay response under power swings and effect of fault resistance, setting of distance relays. Carrier Current Protection- Phase comparison and directional comparison principles.

- **BASICS OF NUMERICAL RELAYS** **(05 Hours)**
  Numerical relaying fundamentals, sampling theorem, anti-aliasing filters, least square method for estimation of phasors, Fourier algorithms, Fourier analysis and discrete Fourier transform, estimation of phasors from discrete Fourier transform, Applications for implantation of various numerical relays.

Total Hours:42

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3. Books Recommended:

1. B. Oza, N. C. Nair, R. P. Mehta, V. H. Makwana, Power System Protection and Switchgear, Tata McGraw Hill Ltd. 1st Edition, 2011.
2. Y. G. Paithankar, S. R. Bhide, Fundamentals of power system protection, Prentice Hall of India, 2nd Edition, 2010.
3. B. Ravindranath, M. Chander, Power system Protection and Switchgear, New Age International Publisher, 2nd Edition, 2018.
4. J. Lewis Blackburn, Protective Relaying: Principles and Applications, Marcel Dekker Incorporation, 3rd Edition, 2006.
5. Badri Ram, D. N. Vishwakarma, Power System Protection and Switchgear, Tata McGraw Hill Publishing Company, New Delhi, 2nd Edition, 2017.

SARDARVALLABHBHAI NATIONALINSTITUTE OF TECHNOLOGY, SURAT

DEPARTMENT OF ELECTRICAL ENGINEERING

B. Tech. Programme

B. Tech. IV

Semester VII

Sr. No.	Course Code	Course	L	T	P	Credits	Examination Scheme				
			Hrs	Hrs	Hrs		Theory Marks	Tutorial Marks	Term work Marks	Practical Marks	Total Marks
1.	EE401	Microcontroller and Embedded 'C' Programming	3	0	2	04	100	-	25	25	150
2.	EE403	Electrical Machine Design	3	1	0	04	100	25	-	-	125
3.	EE4AA	ES-II	3	0	0	03	100	-	-	-	100
4.	EE4BB	ES-III	3	0	0	03	100	-	-	-	100
5.	EE405	Summer Training*	0	0	0	02	-	-			
6.	EE407	Project Preliminaries	0	0	6	03	-	-	40	60	100
Total (L-T-P)			12	01	08	19	400	25	65	85	575
Total			**21**			**19**					

***Summer Training is to be organized during the summer vacation after 6th Semester.**

CORE ELECTIVE SUBJECTS – ES – II (EE4AA) (DEPARTMENTAL)	
Course Code	Subject Name
EE421	Power Quality Disturbances and Mitigations
EE423	High Voltage Engineering
EE425	FACTS Devices
EE427	Discrete-Time Control Systems
EE429	Restructuring and Deregulation of Power Systems
EE431	Renewable Energy Systems
CORE ELECTIVE SUBJECTS – ES – III (EE4BB) (DEPARTMENTAL)	
Course Code	Subject Name
EE433	Advanced Electrical Drives
EE435	Electronic Instrumentation and Control
EE437	Power System Transients
EE439	Advanced Industrial Automation
EE441	Reliability Evaluation of Electrical Systems
EE443	Wind and Solar Energy

Semester VIII

Sr. No.	Course Code	Course	L	T	P	Credits	Examination Scheme				
			Hrs	Hrs	Hrs		Theory Marks	Tutorial Marks	Term work Marks	Practical Marks	Total Marks
1.	EE4XX	ES-IV	3	0	0	03	100	-	-	-	100
2.	EE4YY	ES-V	3	0	0	03	100	-	-	-	100
3.	EE4ZZ	ES-VI	3	0	0	03	100	-	-	-	100
4.	HU410	Innovation, Incubation & Entrepreneurship	3	0	0	03	100	00	-	-	100
5.	EE402	Project	0	0	12	06	-	-	120	180	300
Total (L-T-P)			**12**	**00**	**12**	**18**	**400**	**00**	**120**	**180**	**700**
Total			**24**			**18**					

CORE ELECTIVE SUBJECTS ES – I (EE4XX) (DEPARTMENTAL)	
Course Code	**Subject Name**
EE422	Electric Traction and Linear Machines
EE424	EHV AC Transmission
EE426	Advanced Power Electronics
EE428	Nonlinear and Optimal Control
EE432	Advanced Microcontroller (Digital Signal Controller)
EE434	Industrial Instrumentation
EE436	Power system operation and control
CORE ELECTIVE SUBJECTS ES – I (EE4YY) (DEPARTMENTAL)	
Course Code	**Subject Name**
EE438	Power Filter Technology
EE442	Smart Grid Technology
EE444	HVDC Transmission
EE446	Electric Vehicles
EE448	Digital Signal Processing
EE452	Modern Materials for Electrical Engineering
EE454	Special Electrical Machines and Drives
CORE ELECTIVE SUBJECTS ES – I (EE4ZZ) (DEPARTMENTAL)	
Course Code	**Subject Name**
EE456	Switched Mode Power Supply
EE458	Computer Methods for Power Systems
EE462	Robotics
EE464	Communication Engineering
EE466	VLSI Technology
EE468	Antenna and Wave Propagations
EE472	Cryptography and Cyber Security for Smart Grids

B. Tech. IV (Electrical), Semester VII

Microcontroller and Embedded C Programming

L	T	P	Credit
3	0	2	04

EE401 **Scheme**

1. Course Outcomes (Cos):

At the end of the course students will be able to:

CO 1	revise basic concepts of 8051 microcontroller and embedded 'C' programming.
CO 2	explain architecture of CIP 51 8 bit microcontroller with the advanced features of the controller.
CO 3	describe the functionality of Programmable internal and external peripherals of CIP 51.
CO 4	write embedded 'C' code for CIP51 with the exposure of SI Lab IDE.
CO 5	develop microcontroller based prototype for automation, power electronics based electrical systems and other real world problems.

2. Syllabus:

- **INTRODUCTION TO CIP-51 CONTROLLER ARCHITECTURE** **(04 Hours)**

  Memory Map, Instruction Pipeline, PLL & Clock System, On Chip Peripherals, concept of Cross-bar and Pin assignment

- **INTRODUCTION TO EMBEDDED 'C' PROGRAMMING** **(04 Hours)**

  Variables and constants, storage classes, enumerations and definitions, I/O operations, control statements, functions, pointers and arrays, structure and unions, interrupt service routines.

- **HARDWARE CONCEPT AND PROGRAMMING OF CIP-51 PERIPHERALS** **(14 Hours)**

  Timer/Counters, GPIO, ADC, DAC, UART, Interfacing of seven-segment LED and LCD display, interfacing of pushbutton keys, interfacing of Matrix key board

  ADVANCED PERIPHERAL OF CIP-51 **(12 Hours)**

  Comparator, SPI & I2C serial Communication interface, MAC unit on CIP-51, On-chip PLL and Its programming

- **CIP-51 BASED DESIGN OF EMBEDDED SYSTEMS** **(08 Hours)**

  Design and implementation of ZCD circuits, Thyristor and triac firing circuit, Non isolated buck and boost converters

Total Hours: 42

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3. List of Experiments:

(to write and execute using 'C' programming to)

1. generate square wave of different frequency using timer T0
2. generate square wave of different frequency using timer T0
3. generate different duty cycle and different switching frequency waveform with timer T0 and T2.
4. interface LCD with cip-51
5. display digital clock on LCD
6. turn on and turn off led with key debounce
7. generate PWM signal using timer T2 and PCA timer

8. generate high frequency square wave using PCA Timer
9. generate sine wave and triangular wave using DAC
10. measure voltage and current using ADC
11. measure frequency of unknown signal using timer T2 and PCA timer
12. transmit following character data string at 9600 baud rate using uart0. Use timer 2 to generate required baud rate data string- _hello svnit"

4. **Books Recommended:**

1. Barnett, O'cull, Cox, Embedded C Programming and the Microchip PIC, Cengage Learning publication.
2. M. Mazidi, J. G. Mazidi and R. D. McKinlay, _The 8051 Microcontroller and Embedded Systems, Prentice Hall of India, 3rd edition, 2007.
3. Mark Siegesmund, Embedded C Programming: Techniques and Applications of C and PIC MCUS, Elsevier Science, 1st Edition 2014.
4. Datasheet of SILABS C8051F12X. (www.silabs.com)
5. Application notes from SILAB C8051F12X.

B. Tech. IV (Electrical), Semester – VII

Electrical Machine Design

L	T	P	Credit
3	1	0	04

EE403 **Scheme**

1. Course Outcomes (Cos):

At the end of the course, the students will be able to:

CO1	demonstrate the basic steps involved in design of electrical machines
CO2	describe the basic equations related to the electric machine design
CO3	calculate the performance indices of electrical machines
CO4	estimate the design parameters as per performance requirements
CO5	analyze the effect of design parameters on the performance of electric machines
CO6	develop the design of transformers, induction machines, dc machines and synchronous machines

2. SYLLABUS:

- **GENERAL ASPECTS OF ELECTRICAL MACHINE DESIGN** **(04 Hours)**
  Electrical engineering materials, magnetic circuit design, thermal design
- **TRANSFORMERS** **(09 Hours)**
  Output equation - single phase and three phase power transformers - main dimensions - choice of specific electric and magnetic loadings- design of core, LV winding, HV winding, tank and cooling tubes - prediction of no load current, forces on winding during short circuit, leakage reactance and equivalent circuit based on design data – computer aided design examples.
- **GENERAL CONCEPTS AND CONSTRAINTS IN DESIGN OF ROTATING MACHINES** **(03 Hours)**
  Specific loadings and output equations of AC and DC machines.
- **DC MACHINES** **(08 Hours)**
  Main dimensions - choice of speed and number of poles - design of armature conductors, slots and winding - design of air-gap, field system, commutator, interpoles, compensating winding and brushes – Carter's coefficient - real and apparent flux density – Computer aided design examples.
- **ALTERNATORS** **(08 Hours)**
  Salient pole and turbo alternators - main dimensions - choice of speed and number of poles - design of armature conductors, slots and winding - design of air-gap, field system and damper winding - prediction of open circuit characteristics and regulation of the alternator based on design data – computer aided design examples.
- **INDUCTION MACHINES** **(10 Hours)**
  Main dimensions - design of stator and rotor windings, stator and rotor slots and air-gap of slip ring and squirrel cage motors – calculation of rotor bar and end ring currents in cage rotor - calculation of equivalent circuit parameters and prediction of magnetizing current based on design data – computer aided design examples.

Total Hours:42

Tutorials will be conducted separately for 14 hours

3. Books Recommended:

1. A. K. Sawhney, Chakrabarti, A Course in Electrical Machine Design, Dhanpat Rai & Co., 2016.
2. Clayton & Hancock, Performance & Design of DC Machines, CBS, 3rd Edition, 2001.
3. M. G. Say, Performance & Design of AC Machines, Pitman, ELBS.3rd Edition, 1983.
4. S.K.Sen, Principles of Electrical Machine Design, Oxford & IBH Pub., 2nd Edition, 2006
5. R. K. Agarwal, Principles of Electrical Machine Design, S. K. Kataria & Co., 2nd Edition, 2012.

B. Tech. IV (Electrical), Semester – VII

L	T	P	Credit
3	0	0	03

Power Quality Disturbances and Mitigations (ES – II)

EE403 **Scheme**

1. Course Outcomes (Cos):

At the end of the course the students will be able to:

CO1	identify the power quality events and problems
CO2	analyze of stationary/Non-stationary signals
CO3	assess the power quality events.
CO4	design and analyze of power filters
CO5	design the controllers for power filters

2. Syllabus:

- **POWER QUALITY** **(08 Hours)**
  Signal processing and power quality, Origin of power quality variation and events, power quality indices, causes and effects of power quality disturbances, Power quality standards, Power quality measuring instruments, Analysis of Power outages, unbalance, distortions, voltage sag, flickers and load balancing.
- **PROCESSING OF STATIONARY & NON-STATIONARY SIGNALS** **(09 Hours)**
  Stationary signals: Overview of analysis methods, frequency domain analysis and signal transformation, estimation of harmonics and inter-harmonics.
  Non –stationary signals: Power quality data analysis methods, discrete STFT for analyzing time – evolving signal components, discrete wavelet transform for time scale analysis disturbances, block–based modeling.
- **CHARACTERIZATION OF POWER QUALITY EVENTS** **(09 Hours)**
  Voltage magnitude, phase angle and three characteristics versus time, event indices, transient.
- **EVENT CLASSIFICATION** **(08 Hours)**
  Overview of event classification method, step used for event classification, learning and classification using artificial neural network.
- **POWER FACTOR CORRECTION & MITIGATION OF POWER QUALITY PROBLEMS** **(08 Hours)**
  Power factor improvement techniques, Passive Compensation, Passive filter: Design and operation, Active filter: Design of shunt and series active filter and Control algorithms.

Total Hours:42

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3. Books Recommended:

1. Hirofumi Akagi, Edson Hirokazu Watanabe and Mauricio Aredes, Instantaneous Power Theory and Applications to Power Conditioning, Wiley Interscience, New Jersey, 2007.
2. Bollen Math, H. J. GU and Y. H. Irene, Signal Processing of Power Quality Disturbances, Wiley Interscience Publication (IEEE Press), 2006.
3. J. Wakileh George, Power System Harmonics: Fundamentals, analysis and filter Design, Springer, (first Indian reprint) 2007.
4. E. F. Fuchs, A. S. Masoum Mohammad, Power Quality in Power Systems and Electrical Machines, Elsevier Academic Press, 2008.
5. A. Ghosh and G. Ledwich, Power Quality Enhancement Using Custom Power Devices, Springer International Edition, Delhi, 2009.

B. Tech. IV (Electrical), Semester – VII

High Voltage Engineering (ES – II)

L	T	P	Credit
3	0	0	03

EE423 **Scheme**

1. Course Outcomes (Cos):

At the end of the course students will be able to:

CO1	illustrate different methods of generating various high voltages and currents
CO2	explain various methods of measuring various high voltages and currents
CO3	analyze various breakdown phenomena occurring in gaseous, liquid and solid dielectrics
CO4	apply appropriate testing method(s) for various high voltage apparatus
CO5	estimate the testing source requirement for any high voltage testing
CO6	plan the high voltage laboratory

2. Syllabus:

- **GENERATION OF VARIOUS TYPES OF HIGH VOLTAGES** **(12 Hours)**
  Generation of High DC Voltages: Half Wave and full wave circuits –Ripple voltages in HW and FW rectifiers. Voltage doubler circuits – Simple voltage doubler, cascade voltage doubler. Voltage multiplier circuits – Crockroft Walton voltage multiplier circuits. Ripple and regulation. Electrostatic machines – principles – Van de Graff generator.

  Generation of high AC voltages: Cascade transformers, resonant transformers – parallel and series resonant test systems. Generation of high frequency high voltages – Tesla coil.

  Generation of impulse voltages – Standard impulse wave shape Basic circuits for producing impulse waves – Analysis of commercial impulse generator circuits – Wave shape control, multi-stage impulse generators – Marx circuit – modified Marx impulse generator circuit – Components of multi stage impulse generator. Generation of Switching surges. Generation of impulse current. Definition of impulse current waveform – Circuit for producing impulse current waves.

- **MEASUREMENTS OF HIGH VOLTAGES & CURRENTS** **(06 Hours)**
  Measurement of high voltages and currents-DC,AC and impulse voltages and currents-DSO, electrostatic and peak voltmeters, sphere gaps-factors affecting measurements, potential dividers(capacitive and resistive)-series impedance ammeters, Rogowski coils, hall effect generators.

- **ELECTRICAL BREAKDOWN IN GASES, LIQUIDS & SOLID DIELECTRICS** **(10 Hours)**
  Introduction to Insulation materials. Breakdown in gas and gas mixtures-breakdown in uniform and non-uniform fields, Paschen's law, Townsends criterion, streamer mechanism, corona discharge, breakdown in electro negative gases, Breakdown in liquid dielectrics-suspended particle mechanism, Breakdown in solid dielectrics-intrinsic, streamer, thermal breakdown.

- **DESIGN, PLANNING AND LAYOUT OF HV LABORATORY** **(04 Hours)**
  Test Facilities, Activities & Studies in HV lab, Classification of HV lab, Size & rating of HV lab, grounding of impulse testing laboratories.

- **HV TESTING OF ELECTRICAL APPRATUS** **(10Hours)**
  Non-destructive testing of dielectric materials – measurement dielectric constant and loss factor. Testing of Insulators, Bushings, Isolators, Circuit breakers, Cables, Transformers, Surge diverters, RI Measurement.

Total Hours:42

3. Books Recommended:

1. E. Kuffel, W. S. Zaengl and J. Kuffel, _High voltage Engineering Fundamentals,_Newnes, 2nd Edition, 2002.
2. M. S. Naidu, V. Kamaraju, High Voltage Engineering,_Tata Mcgraw Hill, 2nd Edition, 2001.
3. L. L. Alston, High voltage Technology,_BS Publications, 2008.
4. Nils Hylten-Cacallius, High voltage Laboratory Planning, High voltage test system, Asea Haefely.
5. Standard Techniques for High Voltage Testing,_IEEE Publication, 1978.
6. Relevant IS standards and IEC standards.

B. Tech. IV (Electrical), Semester – VII

FACTS Devices (ES – II)

L	T	P	Credit
3	0	0	03

EE423 **Scheme**

1. Course Outcomes (Cos):

At the end of the course students will be able to:

CO1	explain the basic principle of power transmission and reactive power control.
CO2	analyze shunt compensation and its requirement.
CO3	evaluate series compensation and its requirement
CO4	analyze of shunt-series compensation and its requirement.
CO5	design of controllers for FACTS devices.

2. Syllabus:

- **LOAD COMPENSATION** **(07 Hours)**
  Requirement and objectives of load compensations, Practical considerations, power factor and voltage regulations, balancing of unsymmetrical loads, Active filters: : Principle of operation, Analysis, Configurations, Control system, Applications.
- **REACTIVE POWER COMPENSATION** **(08 Hours)**
  Analysis of uncompensated AC line, Passive reactive power compensation, Compensation by a series capacitor connected at the mid-point of the line, Effect on Power Transfer capacity, Compensation by STATCOM and SSSC
- **STATIC SHUNT COMPENSATORS** **(10 Hours)**
  Static Var Compensators (TCR, FC-TCR, TSC-TCR): Principle of operation, Analysis, Configurations, Control system, Applications, protection aspect. STATCOM: Principle of operation, Analysis of six pulse and multi-pulse converters, Control systems, Applications.
- **STATIC SERIES COMPENSATORS** **(10 Hours)**
  Concept of controlled series compensation, (TCSC, GCSC): Principle of operation, Analysis, Configurations, Control system, Applications. SSSC: Principle of operation, Analysis, Configurations, Control system, Applications.
- **COMBINED COMPENSATORS** **(07Hours)**
  (UPFC,IPFC) Principle of operation, Analysis, Configurations, Control system, Applications.

Total Hours: 42

3. Books Recommended:

1. K. R. Padiyar, FACTS Controller in Power Transmission and Distribution, New Age international, 1st Edition, 2007.
2. N.G. Hingorani, Understanding FACTS, IEEE Press, Standard Publishers Distributor, 2001.
3. T. J. E. Miller, Reactive Power Control in Electric Systems, John Wiley, 2010.
4. R. Mathur, N. Mohan and R. K. Varma, Thyristor–based FACTS Controllers for Electrical Transmission System, Wiley Inter-Science, 2011.
5. Acha E., Agelidis V. G., Anaya-Lara O., T.J.E. Miller, Power Electronics Control in Electrical System, Newnes Power Engineering Series, 2002.

B. Tech. IV (Electrical), Semester – VII

Discrete-time Control Systems (ES – II)

L	T	P	Credit
3	0	0	03

EE427 **Scheme**

1. Course Outcomes (Cos):

At the end of the course, the students will be able to

CO1	classify various Discrete-Time control systems
CO2	analyze the Discrete-Time control systems with Z transformation
CO3	design Discrete-Time control systems and to assess the stability of DTCS
CO4	obtain and analyze State-space representations of discrete-time systems
CO5	design various discrete-time systems control schemes

2. Syllabus:

- **INTRODUCTION TO DISCRETE-TIME CONTROL SYSTEMS** **(03 Hours)**
  Introduction, digital control systems, quantizing and quantization error, data acquisition, conversion, and distribution systems.
- **THE Z TRANSFORMATION** **(08 Hours)**
  The z transform, transforms of elementary functions, important properties and theorems of the z transform, the inverse z transform, z transform method for solving difference equations.
- **Z-PLANE ANALYSIS OF DISCRETE-TIME CONTROL SYSTEMS** **(08 Hours)**
  Impulse sampling and data hold, obtaining the z transform by the convolution integral method, reconstructing original signals from sampled signals, the pulse transfer function, realization of digital controllers and digital filters.
- **DESIGN OF DISCRETE-TIME CONTROL SYSTEMS** **(10 Hours)**
  Introduction, mapping between the S plane and the z plane, stability analysis of closed-loop systems in the z plane, transient and steady-state response analysis, design based on the root-locus method, design based on the frequency-response method, analytical design method.
- **STATE-SPACE ANALYSIS** **(08 Hours)**
  State-space representations of discrete-time systems, solving discrete-time state-space equations, pulse-transfer-function matrix, discretization of continuous-time state-space equations, Lyapunov stability analysis.
- **POLE PLACEMENT AND OBSERVER DESIGN** **(05 Hours)**
  Controllability, observability, useful transformations in state-space analysis and design, via pole placement, state observers, servo systems.

Total Hours:42

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3. Books Recommended:

1. K. Ogata, Discrete Time Control System, Pearson Education, Inc., 2nd Edition, 2015.
2. B. C. Kuo, Discrete Data Control System, Prentice-Hall, 2nd Edition, 1992.
3. I. J. Nagrath and M. Gopal, Control System Engineering" New Age International Publishers, 3rd Edition, 2001.
4. M. Gopal, Digital control System, McGraw-Hill Education, 4th Edition, 2017.
5. B. C. Kuo, Automatic Control System, Prentice Hall of India, 7th Edition, 1995.

B. Tech. IV (Electrical), Semester VII

Restructuring and Deregulation of Power Systems (ES – II)

L	T	P	Credit
3	0	0	03

EE429 Scheme

1. Course Outcomes (Cos):

At the end of the course, the students will be able to:

CO1	explain the basics and benefits of restructuring and deregulations
CO2	evaluate the market scenario and completion in deregulated environment
CO3	judge the pricing and agreements associated with deregulation policies.
CO4	explore the contingency and ancillary service management restructured and deregulated system.
CO5	explore the impact of availability and unavailability in terms of reliability indices

2. Syllabus:

- **DEREGULATION OF THE ELECTRICITY SUPPLY INDUSTRY (06 Hours)**
  Deregulation, Reconfiguring Power systems, unbundling of electric utilities, Background to deregulation and the current situation around the world, benefits from a competitive electricity market, after-effects of deregulation.
- **POWER SYSTEM OPERATION IN COMPETITIVE ENVIRONMENT (10 Hours)**
  Role of the independent system operator, Operational planning activities of ISO: ISO in Pool markets, ISO in Bilateral markets, Operational planning activities of a GENCO: Genco in Pool and Bilateral markets, market participation issues, competitive bidding.
- **TRANSMISSION OPEN ACCESS AND PRICING ISSUES (08 Hours)**
  Power wheeling, Transmission open access, pricing of power transactions, security management in deregulated environment, congestion management in deregulation.
- **ANCILLARY SERVICES MANAGEMENT (08 Hours)**
  General description of some ancillary services, ancillary services management in various countries, reactive power management in deregulated electricity markets
- **RELIABILITY AND DEREGULATION (10 Hours)**
  Reliability analysis: interruption criterion, stochastic components, component models, calculation methods, Network model: stochastic networks, series and parallel connections, minimum cut sets, reliability costs, Generation, transmission and distribution reliability, Reliability and deregulation: conflict, reliability analysis, effects on the actual reliability, regulation of the market.

Total Hours: 42

3. **Books Recommended:**

1. K. Bhattacharya, MHT Bollen and J.C Doolder, Operation of Restructured Power Systems, Kluwer Academic Publishers, USA, 2001.
2. Lei Lee Lai, Power System Restructuring and Deregulation, John Wiley and Sons, UK. 1st Edition, 2001.
3. Fred I Denny and David E. Dismukes, Power System Operations and Electricity Markets, CRC Press, LLC, 1st Edition, 2002.
4. Mohammad Shaidehpur, Muwaffaq Alomoush, Restrctured electrical Power Systems, Operation, Trading and Volatility, Marcel Dekker Publications.
5. Xiao Ping Zhang, Restructured electrical Power Systems with equilibrium Models, John Wiley & Sons, 1st Edition, 2010.

B. Tech. IV (Electrical), Semester – VII

Renewable Energy Systems (ES – II)

L	T	P	Credit
3	0	0	03

EE431 **Scheme**

1. Course Outcomes (Cos):

At the end of the course the students will be able to:

CO1	identify the limits of the conventional energy sources and recognize the importance of renewable energy conversion.
CO2	explain the working principle of wind energy conversion and choose the suitable turbine and power electronic interfaces.
CO3	describe the process of solar thermal energy conversion and list its applications.
CO4	illustrate the working principle of solar photovoltaic conversion, maximum power tracking algorithms and power electronics interface.
CO5	explain the basic operation of the other renewable energy sources.

2. Syllabus:

- **PRESENT WORLD AND INDIAN ENERGY SCENARIO** **(03 Hours)**
  Conventional sources of energy, their availability and limitations, alternative sources of energy, their advantages and present status.
- **WIND ENERGY** **(10 Hours)**
  Introduction, types of wind turbines and their characteristics, wind data and energy estimation, site selection, basic components of wind electric conversion system, types of electrical machines suitable for wind energy conversion, maximum power extraction, power electronics interface for wind turbine.
- **SOLAR THERMAL ENERGY** **(05 Hours)**
  Introduction, Solar energy storage systems, thermal storage, sensible heat storage, latent heat storage, solar pond, non-conductive solar pond, Extraction of Thermal energy, Applications of Solar pond, solar thermal electric conversion.
- **SOLAR PHOTOVOLTAIC ENERGY** **(12 Hours)**
  Basics of p-n junction, p-n junction exposure to light, photovoltaic cell/module characteristics and effects of light intensity and temperature variations, maximum power point tracking algorithms, power electronics interface for solar photovoltaic, PV applications (domestic loads, battery storage, and irrigation), and different thin film PV technologies.
- **BIO ENERGY** **(06 Hours)**
  Introduction to biomass, Biomass conversion technologies, wet process and dry process, Biogas generation, classification of biogas plants, continuous & batch types, The dome and the drum types, Different variations in the drum type, Types of Biogas plants, Floating gas holder, Fixed dome digester, Biogas from plant wastes, Community biogas plants, Materials used for biogas generation, selection of site for biogas plant, Methods of maintaining Biogas generation, starting a biogas plant, Fuel properties of biogas, utilization of biogas, methods of obtaining energy from Biomass Combustion.
- **OTHER SOURCES OF RENEWABLE ENERGY** **(06 Hours)**
  Geothermal energy, classifications and prime movers used for geothermal energy, fuel cell technologies, different types of fuel cells, OTEC energy conversion.

Total Hours: 42

3. **Books Recommended:**

1. J. K. Nayak and S. P. Sukhatme, Solar Energy - Principles of thermal collection and storage, Tata Mcgraw Hill, 4th Edition, 2017.
2. J. Twidell and T. Weir, Renewable Energy Resources, E & F N Spon Ltd, London, 3rd Edition, 2015.
3. Bent Sorensen, Renewable Energy: physics, engineering, environmental impacts, economics & planning, 4th Edition, Academic Press, Gurgaon, 2011.
4. Chetan Singh Solanki, Solar Photovoltaics: Fundamental, Technologies and Applications, 2nd Edition, PHI Learning Pvt. Limited, New Delhi, 2011.
5. Gary L. Johnson, "Wind Energy Systems", Prentice Hall Inc., 1985.

B. Tech. IV (Electrical), Semester – VII

Advanced Electrical Drives (ES – III)

L	T	P	Credit
3	0	0	03

EE433 **Scheme**

1. Course Outcomes (Cos):

At the end of the course students will be able to:

CO1	explain the basic principle of operation of conventional and modern electric drives
CO2	apply the concept of reference frame theory and space vector concept for AC drives.
CO3	develop various control strategies for modern electric drives
CO4	apply the soft computing techniques for electric drives.
CO5	compare various soft computing techniques in terms of dynamic and steady state response.

2. Syllabus:

- **REVIEW OF FUNDAMENTALS OF AC DRIVE** **(06 Hours)**

  Reference frame theory, concept of space vector, state space model.
- **INDUCTION MOTOR DRIVES** **(12 Hours)**
  Introduction, Review of three phase I.M. analysis and performance, Analysis of I.M. fed from Non-sinusoidal supply voltage, PWM and SVPWM method, rotating field, dynamic d-q model, Stator voltage control, V/f controlled induction motors, DC drive analogy, field oriented control, sensor less control, doubly fed induction machine, direct torque and flux control, CSI fed induction motor drives, Applications.
- **SYNCHRONOUS MOTOR DRIVES** **(12 Hours)**
  Introduction, Sinusoidal SPM machine drives, synchronous reluctance machine drives, Trapezoidal SPM machine drive, wound field synchronous motor drive, Load-commutated Synchronous Motor Drives, Model of PMSM, Vector controlled PMSM drive, UPF control, torque angle control, optimum torque per ampere control..
- **SOFT COMPUTING FOR ELECTRICAL DRIVES** **(12 Hours)**
  PI tuning methods, speed control using fuzzy logic controllers and adaptive controllers, Application of neural network for control of electrical drives, identification and parameter estimation.

Total Hours:42

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3. Books Recommended:

1. B.K. Bose, Modern Power Electronics & AC Drives, Pearson, 1st Edition, 2005.
2. R. Krishnan, Electric Motor Drives: Modeling, Analysis and Control, Prentice Hall, 1st Edition, 2015.
3. Peter Vas, Vector Control of Electric Drives, Oxford Publishers, 1998.
4. S. Dewan, B. Slemon, A. G. R. Straughen, Power Semiconductor drives, John Wiley and Sons, NewYork 2009.
5. G. K. Dubey, Fundamentals of Electrical Drives, Narosa Publishing House, 2nd Edition, 2001.

B. Tech. IV (Electrical), Semester – VII

L	T	P	Credit
3	0	0	03

Electronic Instrumentation and Control (ES – III)

EE435 **Scheme**

1. Course Outcomes (Cos):

At the end of the course students will be able to:

CO1	classify various Digital measurement techniques and to explain working principle of various type of digital Frequency and time measuring Instruments
CO2	explain working principle of various type of Instrumentation amplifiers, multiplexers, de-multiplexers, convertors and data acquisition systems
CO3	discuss various types of Industrial automation
CO4	explain working principle of various type of sensors and transmitters
CO5	develop ladder logic program for PLC for various industrial applications including SCADA

2. Syllabus:

- **DIGITAL MEASUREMENT** **(09 Hours)**
  Digital measurement techniques for voltage, current, power, energy, resistance, capacitance and loss angle (TAN ∂), impedance and quality factor.
- **DIGITAL FREQUENCY AND TIME MEASURING INSTRUMENTS** **(05 Hours)**
  Frequency counter, period duration meter, pulse width meter, frequency ratio meter, Errors in digital instruments.
- **SIGNAL CONDITIONING, DATA ACQUISITION AND CONVERSION** **(06 Hours)**
  Review of Instrumentation amplifiers and isolation techniques, sample and hold circuits, multiplexers and de-multiplexers, digital to analog converters, data acquisition systems, encoders, grounding and shielding techniques.
- **INTRODUCTION TO INDUSTRIAL AUTOMATION** **(03 Hours)**
  Introduction, advantages and disadvantages, topologies and components of Industrial Automation.
- **INTRODUCTION TO SENSORS AND TRANSMITTER** **(05 Hours)**
  Overview of sensors to sense position, speed, temperature, pressure, flow, level etc., Transmitter, Architecture of current loop.
- **AN OVERVIEW OF PLC** **(05 Hours)**
  Introduction, definitions and history of PLC, manufacturing and assembly processes, PLC advantages and disadvantages, overall PLC system, CPU, PLC, input and output modules, program recording devices.
- **PROGRAMMING PLC** **(07 Hours)**
  Ladder diagrams, programming ON/OFF inputs to produce ON/OFF outputs, digital gate logic and contact coil logic, creating ladder diagrams from process control descriptions, timer function, counter function, arithmetic functions, comparison functions.
- **INTRODUCTION TO SCADA** **(02 Hours)**
  Introduction, need, features of SCADA.

Total Hours:42

3. Books Recommended:

1. A. D. Helfrick, W. D. Cooper, Modern electronic Instrumentation and Measurement Techniques, Prentice Hall India, 1997.
2. E. O. Doebelin, Measurement Systems - Application and Design, 4th Edition, McGraw-Hill, New York, 1992.
3. T.S. Rathore, Digital Measurement Technique, Narosa publishing house, 2nd Edition.
4. Curtis Johnson, Process Control Instrumentation Technology, Prentice Hall of India, 6th Edition.
5. John. W. Webb, Ronald A Reis, Programmable Logic Controllers - Principles and Applications, 4th Edition, Prentice Hall Inc., New Jersey, 1998.

B. Tech. IV (Electrical), Semester – VII

Power System Transients (ES – III)

L	T	P	Credit
3	0	0	03

EE437 **Scheme**

1. Course Outcomes (Cos):

At the end of the course students will be able to:

CO1	recall the fundamentals of transient analysis of RLC circuit and circuit breaker operation
CO2	identify the source and characteristics of lightning, switching, and temporary over voltages
CO3	interpret the concept of travelling wave propagation on transmission lines
CO4	analyze switching transients in electric equipment like transformer, generator and motor
CO5	evaluate different protection schemes for power system equipment against travelling wave

2. Syllabus:

- **OVERVOLTAGES IN POWER SYSTEMS** **(12 Hours)**
  Transient over voltages due to lightning, Theory of ground wires, Direct stroke to a tower, Effect of reflection up and down the tower, Tower grounding and counterpoises, Switching transients, Single and double frequency transients, Abnormal switching transients, Capacitance switching, Kilometric fault, Line dropping and load ejection, Closing and reclosing of lines, High charging currents, Over voltages induced by faults, Ferro-resonance, Switching transients in integrated systems, Peaking switching over voltages in EHV lines and cables.
- **TRAVELLING WAVES IN TRANSMISSION LINES** **(12 Hours)**
  Origin and nature of power system transients, Traveling waves on transmission lines, General wave equation, Attenuation and distortion of waves, Reflection and refraction of traveling waves at different line terminations, Bewley Lattice Diagram, Traveling waves in multi-conductor systems, Transition points on multi-conductor circuits.
- **PROTECTION AGAINST TRAVELLING WAVES** **(06 Hours)**
  Rod gap, Arcing Horn, Lightning Arresters, Surge Absorber, Insulation Coordination.
- **TRANSIENT IN TRANSFORMERS AND ROTATING ELECTRICAL MACHINES** **(12 Hours)**
  High frequency transients and voltage distribution in windings of transformer and rotating electrical machines, Surge impedance.

Total Hours: 42

3. Books Recommended:

1. I.V. Begley, Traveling waves in Transmission Systems, John Wiley (1933, 51), Dover.
2. R. Rudenberg., Electric Stroke waves in Power System, Harvard Unive rsity Press and Cambridge, Massachusetts.
3. Allan Greenwood, Electric Transients in Power Systems, Wiley Inter science 2nd Edition, 2010.
4. C.S. Indulkar and D.P. Kothari, Power System Transients, A Statistical Approach, Prentice Hall of India Pvt. Ltd., New Delhi. 110001, 2nd Edition, 2010.
5. V.A. Venikov, Transient phenomena in Electrical Power Systems, Pergamon Press, London, 2014.

B. Tech. IV (Electrical), Semester - VII

L	T	P	Credit
3	0	0	03

Advanced Industrial Automation (ES – III)

EE439 **Scheme**

1. Course Outcomes (Cos):

At the end of the course students will be able to:

CO1	classify various types of Automation
CO2	explain working principle of various component of Industrial automation
CO3	discuss various type of controller for Industrial automation
CO4	develop ladder logic program for PLC for various industrial applications including SCADA and HMI
CO5	discuss case study of Industrial automation

2. Syllabus:

- **INTRODUCTION TO INDUSTRIAL AUTOMATION** **(02 Hours)**
  Need of Industrial Automation, Advantages and disadvantages of automation, automation pyramid.
- **COMPONENTS OF INDUSTRIAL AUTOMATION** **(12 Hours)**
  Advanced sensors and measurement systems, Signal Conditioning and Processing, standard Instrumentation signal, transmitters, actuators.
- **CONTROLLERS FOR INDUSTRIAL AUTOMATION** **(12 Hours)**
  PLC, High end PLC programming, timer function, counter function, arithmetic functions, comparison functions analog input and output, subroutine, interrupt. PID Tuning, close loop speed control, closed loop temperature control.
- **HMI and SCADA** **(08 Hours)**
  Introduction to HHI and SCADA, Communication of SCADA and HMI with PLC and PC. Communication of SCADA with VFD.
- **CASE STUDY** **(08 Hours)**
  Industrial automation in various industries, like chemical, textile, oil and Gas, food and beverages etc.

Total Hours:42

3. Books Recommended:

1. John Webb, Programmable Logic Controllers Principles & Applications, Prentice Hall of India, 1st Edition, 2013.
2. Andrews, Applied Instrumentation in Process Industries, Gulf Professional Publishing; 2nd Edition, 1979.
3. D. Patranabis, Principles of Process Control, Tata Mcgraw Hill, 3rd Edition, 2017.
4. S. K. Singh, Computer Aided Process Control, Prentice Hall of India, 2004.
5. Kevin Collins, PLC Programming for Industrial Automation, Exposure Publishing, 2006.

B. Tech. IV (Electrical), Semester – VII

Reliability Evaluation of Electrical Systems (ES – III)

L	T	P	Credit
3	0	0	03

EE441 **Scheme**

1. Course Outcomes (Cos):

At the end of the course students will be able to:

CO 1	explain the basic of reliability and its importance for electrical network.
CO 2	implement and model for reliability evaluation of generating systems for LOLE and reliability indices.
CO 3	calculate the duration and frequency of outages and availability from reliability.
CO 4	evaluate the impact of interconnections on reliability.
CO 5	apply the concept of reliability for electrical distribution network for its secure and safe operation with relays, circuit breakers, switches etc.
CO 6	implement the Monte Carlo simulation concept for electrical networks for verification and execution of reliability indices.

2. Syllabus:

- **INTRODUCTION TO RELIABILITY** **(06 Hours)**
  Background, quantitative and qualitative assessment, reliability indices and criteria, reliability evaluation techniques, reliability concepts, basic probability concepts, binomial distribution for reliability and probability, engineering applications of binomial distribution, electrical power generation capacity outage probability and reliability, loss of load expectation (LOLE) and calculation of expected energy not supplied (EENS).
- **NETWORK MODELING AND RELIABILITY** **(08 Hours)**
  Simple network modeling, series, parallel system, redundant systems, perfect switching and imperfect switching, reliability of complex system, conditional probability approach, cut-set and tie-set approach, event-tree, fault-tree, multi-failure modes, Poisson's distribution, normal distribution, exponential distribution, Weibull distribution, data analysis, goodness-of-fit tests, reliability evaluation of series/parallel/stand-by systems using probability distribution. Application to electrical network for reliability estimation.
- **DISCRETE AND CONTINUOUS MARKOV PROCESS** **(08 Hours)**
  General modeling concept of discrete Markov chain, stochastic transitional probability matrix, limiting states, absorbing states, continuous Markov process, state-space diagrams, limiting and absorbing states of continuous Markov process, time dependent state probabilities, differential equation method, matrix multiplication method, repairable systems reliability, mean time to failure (MTTF), Markov process of electrical systems.
- **FREQUENCY AND DURATION TECHNIQUES** **(10 Hours)**
  Concepts of frequency and duration, multi-state problems, mean duration of individual states, frequency balance approach, two stage repair and installation process, electrical power generation model and system risk evaluation, capacity expansion, composite generation and transmission system, state selection, system and load point indices, System risk indices, Individual state load model, Cumulative state load model.
- **MONTE CARLO SIMULATION AND ITS APPLICATIONS** **(10 Hours)**
  Concepts of simulation, random variates, conversion of uniform random numbers, application of Monte Carlo Simulation, tossing a coin, throwing a die, repetitive tossing, time dependent reliability, two component non-repairable system, three component non-repairable system, repairable and standby

system evaluation, stopping rules, variance reduction techniques, Application to generation capacity reliability evaluation, Reliability/LOLE assessment with chronological /nonchronological load, Application to composite generation and transmission.

Total Hours: 42

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3. Books Recommended:

1. Roy Billinton andRonald N. Allan, Reliability Evaluation of Engineering Systems Concepts and Techniques, 2nd Edition, Springer Science, 1992.
2. Roy Billinton and Ronald N. Allan, Reliability Evaluation of Power Systems, 2nd Edition, Springer Science & Business Media, 1992.
3. T. A. Short, Taylor & Francis group, Distribution Reliability and Power Quality, 1st Edition, 2018.
4. Roy Billinton, Ajit Kumar Verma, Rajesh Karki, Reliable and sustainable Electric Power and Energy Systems Management, Springer, 2014.
5. Chetan Singh., Panida Jirutitijaroen. and Joydeeep Mitra, Electric Power Grid Reliability Evolution: Models and Methods, John Wiley & Sons, 2018.

B. Tech. IV (Electrical), Semester VII

Wind and Solar Energy (ES – III)

L	T	P	Credit
3	0	0	03

EE443 **Scheme**

1. Course Outcomes (Cos):

At the end of the course the students will be able to:

CO1	recognize the limits of the conventional energy sources and examine present scenario of wind and solar energy conversion.
CO2	explain the working principle of wind energy conversion and identify the suitable turbine and power electronic interfaces.
CO3	explain the working principle of solar energy conversion, maximum power tracking algorithms and power electronics interface.
CO4	design the wind and solar energy systems at preliminary level.
CO5	select the suitable hybrid energy system for a given application.

2. Syllabus:

- **PLACEMENTS OF WIND AND SOLAR ENERGY IN WORLD AND INDIA** **(04 Hours)**
  Conventional energy sources and their limitations, current status of renewable energy sources.
- **WIND ENERGY CONVERSION** **(15 Hours)**
  Introduction, types of wind turbines and their characteristics, wind data and energy estimation, basic components of wind electric conversion system, types of electrical machines suitable for wind energy conversion, maximum power extraction, power electronics interface for wind turbine, different configuration for wind farms.
- **SOLAR PHOTOVOLTAIC POWER CONVERSION** **(15 Hours)**
  Basics of p-n junction, p-n junction exposure to light, photovoltaic cell/module characteristics and effects of light intensity and temperature variations, maximum power point tracking algorithms, power electronics interface for solar Photovoltaics, design of PV applications (domestic loads, battery storage, and irrigation), grid connected PV systems.
- **HYBRID ENERGY SYSTEMS** **(08 Hours)**
  Why hybrid systems?, types of hybrid systems (PV-diesel-battery, wind-PV, fuel cell-PV), limitations of hybrid systems.

Total hours: 42

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3. Books Recommended:

1. J. K. Nayak and S. P. Sukhatme, Solar Energy - Principles of Thermal Collection and Storage, Tata Mcgraw Hill, 4th Edition, 2017.
2. Chetan Singh Solanki, Solar Photovoltaics: Fundamental, Technologies and Applications, 2nd Edition, PHI Learning Pvt. Limited, New Delhi, 2011.
3. Gary L. Johnson, "Wind Energy Systems", Prentice Hall Inc., 1985.
4. Klouse Jägar, et al., Solar Energy: Fundamental, Technology and Systems, Delft University of Technology, Netherlands, 2014.
5. A few IEEE review papers and industrial application notes.

B. Tech. IV (Electrical), Semester – VIII

Electric Traction and Linear Machines (ES – IV)

L	T	P	Credit
3	0	0	03

EE422 **Scheme**

1. Course Outcomes (Cos):

At the end of the course students will be able to:

CO1	describe the constructional details and classify the linear machines.
CO2	apply knowledge to find present scenario in traction system
CO3	obtain speed time curves in traction system
CO4	compute energy consumption in various traction motor system
CO5	compare various topologies and control for linear machines

2. Syllabus:

- **TRACTION SYSTEMS** **(06 Hours)**

  Introduction, systems of electric traction systems of track electrification, comparison between DC and AC systems of railway electrification from the point of view of main line and suburban line railway services, Modern traction system.

- **TRAIN MOVEMENT AND ENERGY CONSUMPTION** **(08 Hours)**

  Speed-time curves, mechanics of train movement, energy output from driving axles, factors affecting specific energy consumption of an electric train operating on a given schedule speed.

- **ELECTRIC TRACTION MOTORS AND CONTROL** **(10 Hours)**
  Features, characteristics, types, rating and ventilation, Starting and speed control of DC traction motors, starting methods, transition methods, method of speed control, thyristor control of traction motors, speed control and starting of single phase and three phase induction motors, braking; mechanical considerations and control equipment.

- **LINEAR ELECTRIC MACHINES** **(18 Hours)**
  Classifications and Applications of LEMs, Linear Induction Motors: Topologies, Circuit Theories, Transients, and Control, DC-Excited Linear Synchronous Motors, Superconducting Magnet Linear Synchronous Motors, Flat Linear Permanent Magnet Synchronous Motors: topology and control, Linear DC PM Brushless Motors, Application of linear machines in transportation system.

Total hours: 42

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3. Books Recommended:

1. Ion Boldea, Linear Electric Machines, Drives, and MAGLEVs Handbook, CRC press, 2013.
2. Jacek F. Gieras, Zbigniew J. Piech, Bronislaw Z. Tomczuk, Linear Synchronous Motors, Transportation and Automation Systems, 2nd Edition, CRC press.
3. Gupta, J.B., Utilization of Electrical Energy and Electric Traction, S.K.Kataria and sons, 10th Edition, 1990.
4. Rajput R. K.,Utilization of Electrical Power, Laxmi publications, 1st Edition, 2007.
5. H. Partab, Modern Electric Traction, Dhanpat Rai & Co., 3rd Edition, 2012.

B. Tech. IV (Electrical), Semester – VIII

EHV AC Transmission (ES – IV)

L	T	P	Credit
3	0	0	03

EE424 **Scheme**

1. Course Outcomes (Cos):

At the end of the course, the students will be able to:

CO1	enumerate the requirements of EHVAC transmission systems
CO2	calculate the line and ground parameters as well as voltage gradients of EHVAC transmission
CO3	analyze the corona effects for audible noise, power loss and radio interference
CO4	interpret the effect of electrostatic field
CO5	estimate the reactive power requirement and compensation of EHVAC transmission
CO6	design EHV transmission lines for a given specifications

2. Syllabus:

- **INTRODUCTION TO EHV AC TRANSMISSION** **(04 Hours)**
  Role of EHV AC transmission, standard transmission voltages, Average values of line parameters, power handling capacity and Line loss, surge impedance loading.
- **CALCULATION OF LINE AND GROUND PARAMETERS** **(06 Hours)**
  Resistance of conductors, Properties of bundle conductors, Inductance of EHV line configuration, Line capacitance calculation, Sequence inductance and capacitance, line parameters for Modes of propagation.
- **VOLTAGE GRADIENTS OF CONDUCTORS** **(06 Hours)**
  Field of sphere gap & line charges and their properties, charge potential relations for multi conductor lines, surface voltage gradient on conductors, gradient factors and their use, distribution of voltage gradient on sub conductors of bundle.
- **CORONA AND ITS EFFECTS** **(06 Hours)**
  Coronal loss formulas, charge- voltage diagram and corona loss, Audible noise, limits for audible noise, AN measurement and meters, formula for audible noise and use in design, radio interference, limits of radio interference fields, CIGRE formula, measurement of RI, RIV and excitation function.
- **ELECTROSTATIC FIELD OF EHV LINES** **(05 Hours)**
  Calculation of Electrostatic filed of AC Lines, Effect of High Electrostatic filed on Humans, Animals and plants, Measurement of Electrostatic filed.
- **POWER FREQUENCY VOLTAGE CONTROL AND OVER VOLTAGES** **(10 Hours)**
  Problems at Power frequency, Generalized constants, No-load voltage conditions and charging current, The power circle diagram and it use, Voltage control using synchronous condensers, Cascade connection of components- Shunt and Series Compensation, Sub synchronous resonance in series capacitor compensated line.
- **DESIGN OF EHV LINES** **(05 Hours)**
  Design factors under steady state, Line insulation design based upon transient over voltages.

Total Hours: 42

3. Books Recommended:

1. Begamudre, EHV AC Transmission Engineering, Wiley Easter Ltd. 4th Edition, 2011.
2. EPRI, Palo Alto, Transmission line Reference Book 345 KV & above".
3. W. D. Stevenson, Element of Power System Analysis, Mc Graw Hill, 4th Edition, 2017.
4. Nagrath& Kothari, Power System Engineering, 4th Edition, Tata Mcgraw Hill publishing Company Ltd, 2014.
5. A. Chakrabarti, M. L. Soni, P. V. Gupta, & U. S. Bhatnagar, A Text Book on Power System Engineering, Dhanpat Rai & Co., 2016.

B. Tech. IV (Electrical), Semester – VIII

Advanced Power Electronics (ES-IV)

L	T	P	Credit
3	0	0	03

EE426 **Scheme**

1. Course Outcomes (Cos):

At the end of the course, the students will be able to:

CO1	distinguish the power devices and their driver circuits
CO2	analyze the CCM and DCM operation switched-mode dc-dc converters
CO3	estimate the power quality indices and improve it using power electronics
CO4	apply power electronics for field applications
CO5	use simulation tools like PSIM and MATLAB

2. Syllabus:

- **MODERN SEMICONDUCTOR DEVICES** **(04 Hours)**
  Power Diodes, Power BJT, Power MOSFETs, Thyristor, GTOs, IGBT, MCT – Basic characteristics and controlling, Emerging devices and circuits, Power Integrated Circuits.
- **PRACTICAL DESIGN CONSIDERATION** **(06 Hours)**
  Gate and Base drive circuits – Design Consideration for different Devices, DC-Coupled Circuits, Isolated Drive Circuits, and Protection in Drive Circuits. Snubber circuits Designing, Temperature control and Heat sink design consideration, Design of Magnetic Components.
- **DC-DC SWITCHED MODE CONVERTERS** **(08 Hours)**
  Introduction, Step-Down (Buck) Converter, Step-Up (Boost) Converter, Buck-Boost Converter, Cuk Converter, Control Principles, Applications of DC-DC Converters.
- **SWITCHING DC POWER SUPPLIES** **(08 Hours)**
  Introduction, Linear Power Supplies, Switching Power Supplies, DC-DC Converter with isolation – Fly-back converters, Half Bridge Converters, Full Bridge converters, Forward Converter, Push-pull converter, Protection, Isolation and Design criteria for SMPS.
- **STATIC POWER ELECTRONICS APPLICATIONS** **(06 Hours)**
  Electronic Ballasts, UPSs, Power Electronics in Capacitor Charging Applications, Power Electronics for Renewable Energy Sources HVDC Transmission, Automotive Applications of Power Electronics.
- **POWER ELECTRONICS IN POWER QUALITY** **(05 Hours)**
  Power Quality, Reactive Power and Harmonic Compensation, IEEE Standards, Static VAR Compensator, Thyristor Controlled Reactor (TCR), Thyristor Switched Capacitors (TSC), Principle of Active Filters, Types of Active Power Filters, Shunt Active Power Filters, Series Active Power Filters.
- **SIMULATION OF POWER ELECTRONIC CONVERTERS AND VARIOUS CONTROL STRATEGIES USING PSIM SOFTWARE** **(05 Hours)**
  Introduction, Use of Simulation Tools for Design and Analysis, Simulation of Power Electronics Circuits with , PSIM, State-Space Averaged Models and their simulation using PSIM software.

Total Hours:42

3. Books Recommended:

1. Rashid, M. H., Power Electronics Handbook, Elsevier Academic Press, 2nd revised Edition, 2006.
2. Ned Mohan, Tore M. Undeland and William P. Robbins, Power Electronics Converters, Applications, and Design, John Willey & Sons, Inc., 2nd Edition, 1995.
3. Agrawal, J. P., Power electronic systems: Theory and design, Addison Wesley Longman (Singapore) Pte. Ltd. New Delhi, 2001.
4. Robert W. Erickson and Dragan Maksimovic, Fundamentals of Power Electronics, Springer international Edition.
5. L. Umanand, Power Electronics – Essentials & Applications, Wiley India Pvt. Ltd, 2009.

B. Tech. IV (Electrical), Semester – VIII

Nonlinear and Optimal Control (ES – IV)

L	T	P	Credit
3	0	0	03

EE428 **Scheme**

1. Course Outcomes (Cos):

At the end of the course students will be able to:

CO1	classify nonlinearity in control systems design point of view
CO2	analyze nonlinear systems based on describing functions
CO3	evaluate the stability of nonlinear systems by analyzing limit cycles
CO4	visualize and understand the response of second order nonlinear control systems using various phase-plane methods
CO5	impart the basic idea of optimal control strategies and their implementation

2. Syllabus:

- **INTRODUCTION TO NONLINEARITY:** **(06 Hours)**
  Introduction to nonlinear components and systems, inherent and intentional nonlinearity, specific example of nonlinear spring for introducing non linearity like jump resonance and variation of resonant frequency with amplitude of input, linearization of non-linear state equations, non-linear measurement systems, input-output Volterra models, variational equation approach for solving non-linear systems.
- **DESCRIBING FUNCTION ANALYSIS OF NONLINEAR CONTROL SYSTEM:** **(08 Hours)**
  Introduction to Nonlinear Systems Describing Functions for Common Types of Nonlinearities Describing Function Analysis, Stability and Limit Cycles.
- **PHASE-PLANE ANALYSIS:** **(12 Hours)**
  Introduction, Analytical Methods for constructing Trajectories, Graphical Methods for constructing Trajectories, Isocline Method, Delta Method, Pell's Method, Lienard's Method, Classification of Singular Points, Limit Cycles, Phase-Plane Analysis of Linear control systems, Phase-Plane Analysis of' Non-linear control systems, Minimum Time Trajectory, Optimum Switching Curve.
- **OPTIMAL CONTROL SYSTEM:** **(16 Hours)**
  Introduction, Calculus of Variation Fixed-End-Point Problem, Free-End-Point Problem and constrained variation problem, Optimal Control Problems, The Hamiltonian Formulation, A Linear Regulator Problem, Pontryagin's Minimum Principle, Minimum Time problems, Fuel optimal problem.

Total Hours: 42

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3. Books Recommended:

1. H. K. Khalil, Nonlinear Systems, Pearson 3rd Edition, 2001.
2. J.E. Slotine and W. Li, Applied Nonlinear Control, Prentice Hall, New Jersey, 1991.
3. D.E. Kirk, Optimal Control Theory: An Introduction, Dover Publications, Inc., 1st Edition, 2004.
4. B.D.O. Anderson & J. B. Moore, Optimal Control: Linear Quadratic Methods, Dover Publication, 2007.
5. R. C. Dorf & R. H. Bishop, Modern control system, Pearson Education Asia. 8th Edition, 2004.

B. Tech. IV (Electrical), Semester – VIII

L	T	P	Credit
3	0	0	03

Advanced Microcontroller (Digital Signal Controller) (ES – IV)

EE432 **Scheme**

1. Course Outcomes (Cos):

At the end of the course students will be able to:

CO1	explain the basics of 32-bit ARM cortex M-series (RISC) architecture and STM32F4xx MCU architecture
CO2	explore advanced concepts of Embedded C Programming.
CO3	illustrate STM32 peripherals with practice of code examples.
CO4	discuss and analyze interfacing circuits with STM32
CO5	design and develop hardware and embedded software for real life systems.

2. Syllabus:

- **INTRODUCTION TO ARM CORTEX-M ARCHITECTURE (04 Hours)**
  Von Neumann and Harvard CPU architecture, Overview of cortex M0and M4 cores, Thum-2 ISA, Registers, Operating Modes, Core buses, MPU, NVIC, System Tick Timer, Memory Map.
- **INTRODUCTION TO STM32F4XX MCU ARCHITECTURE (04 hours)**
  Memory and Bus Architecture, Power controller, Reset and Clock control.
- **INTRODUCTION TO PROGRAMMING OF STM32 CONTROLLER (04 hours)**
  Thumb-2 Instruction Set, Pointers, structure, Union, Pointer to Structure, Points to Function, enumeration, Introduction to IDE Debugging Techniques, Programming methods and addressing mechanism for Memory Mapped peripheral registers.
- **HARDWARE CONCEPT AND PROGRAMMING OF STM32 PERIPHERALS (18 hours)**
  GPIO, General purpose timers, Advanced control timers, ADC, DAC, USART, SPI, I2C.
- **INTERFACING AND PROGRAMMING OF STM32 WITH INPUT/OUTPUT SYTEMS (08 hours)**
  Pushbutton keys, Matrix keyboard, LCD display, External interrupt, Relay, ZCD circuit, Thyrisor and TRIAC Firing, encoder interface, PWM generation for buck and boost converter.
- **INTRODUCTION TO STM32 H7 MCU (04 hours)**
  6 stage pipeline with dual instruction issue, instruction cache, data cache, 64 bit AXI bus interface, instruction TCM and data TCM.

Total Hours: 42

3. Books Recommended:

1. Georey Brown, Discovering the STM32 Microcontroller, Creative Common Attribution.
2. Donald Norris, The Insider's Guide to STM32 Microcontrollers, Hitex (UK) Ltd., 1st Edition, 2018.
3. Joseph Yiu, The Definite Guide to Cortex –M3, Elsevier Publication, 2007.
4. Andrew & Sloss, ARM System Development Guide, Elsevier publication, 2007.
5. Data Sheets and User Reference Manuals of STM32f4xx, STM32h7xx.

B. Tech. IV (Electrical), Semester – VIII

Industrial Instrumentation (ES – IV)

L	T	P	Credit
3	0	0	03

EE434 **Scheme**

1. Course Outcomes (Cos):

At the end of the course students will be able to:

CO1	use transducers for industrial parameter measurements.
CO2	use transducers for process parameter measurements.
CO3	classify various analytical instruments and use them for measuring electrical and non-electrical quantities
CO4	explain industrial communication and signal transmission.
CO5	design instrumentation systems

2. Syllabus:

- **TRANSDUCER FOR INDUSTRIAL MEASUREMENTS** **(07 Hours)**
  Working principles and characteristics of transducers used for measuring weight, density, vibration, distance, thickness, torque and shaft power.
- **TRANSDUCERS FOR PROCESS MEASUREMENTS** **(07 Hours)**
  Working principle and characteristic of transducer used for measuring pressure, level, temperature, flow, moisture, humidity and pH value.
- **INSTRUMENTS FOR ANALYSIS** **(07 Hours)**
  Classification of analytic instruments, sampling for online analysis, pH measurements, electrical conductivity measurement, gas analyzer, liquid analyzer, oxygen determination.
- **CONTROL ELEMENTS** **(04 Hours)**
  Final control operations, signal conversions, actuators, control elements.
- **INDUSTRIAL COMMUNICATION SYSTEMS** **(06 Hours)**
  Role of data communication systems in industrial automation, the OSI (open system interconnection) model, RS 485 specifications, multi-drop system, automatic address recognition, biasing and termination requirements of RS 485 network, RS 485 transceiver IC, modbus protocol.
- **SIGNAL TRANSMISSION** **(05 Hours)**
  Architecture of current loop, HART protocol for sensor calibration, data transmission systems, field BUS and industrial Ethernet technology.
- **INSTRUMENTATION SYSTEM DESIGN** **(06Hours)**
  Data acquisition systems and its input and output interfacing with microcontroller and microprocessors, PC based data acquisition systems, Electromagnetic interference (EMI) and Electromagnetic Compatibility (EMC) in instrumentation system.

Total Hours: 42

3. Books Recommended:

1. Rangan Sarma, Mani, Instrumentation devices and systems, Tata Mcgraw Hill, 2nd Edition.
2. E. O. Doebelin, Measurement Systems - Application and Design, 4th Edition, McGraw-Hill, New York, 1992.
3. D. Patranabis, Principles of Industrial Instrumentation, 2nd Edition, Tata McGraw Hill, New Delhi, 1997.
4. M. M. S. Anand, Electronic instruments and instrumentation Technology, Prentice-Hall of India, 2004.
5. C. D. Johnson, Process Control Instrumentation Technology" 4th Edition, Prentice Hall of India.

B. Tech. IV (Electrical), Semester – VIII

L	T	P	Credit
3	0	0	03

Power System Operation and Control (ES – IV)

EE436 **Scheme**

1. Course Outcomes (Cos):

At the end of the course, the students will be able to:

CO1	analyze various methods of voltage control.
CO2	analyze various methods of load forecasting.
CO3	model multi-area system for frequency control.
CO4	analyze various methods of contingency analysis.
CO5	apply state estimation methods for power system state estimation.

2. Syllabus:

- **AUTOMATIC GENERATION CONTROL** **(05 Hours)**
  Single area load frequency control, speed governing system and characteristics, Multiarea load frequency control; flat frequency, flat tie-line load and tie-line load bias control, Economic Dispatch and AGC, EMS, SCADA.
- **METHODS OF VOLTAGE CONTROL** **(06 Hours)**
  Reactive power and its relation to voltage control, location of voltage control equipment, methods of voltage control, excitation control, voltage regulators, tap changing transformers, booster transformers, induction regulators, reactive power injection and voltage control by synchronous condenser.
- **UNIT COMMITMENT** **(05 Hours)**
  Constraints in Unit commitment, Spinning reserve, Thermal and hydro constraints, Unit commitment solution methods- Priority list methods, Dynamic programming solution.
- **HYDRO THERMAL SCHEDULING** **(06 Hours)**
  Short and long range hydro-thermal scheduling, hydroelectric plant models, scheduling problems, Short range hydro-thermal scheduling: Gradient approach, Pumped storage hydro plant, Dynamic programming solution to the hydrothermal scheduling problems.
- **POWER SYSTEM SECURITY** **(07 Hours)**
  Factors affecting power system security, Contingency analysis: Detection of network problems, Correcting the generation approach: Sensitivity methods, compensated factors, correcting the generation dispatch using linear programming.
- **STATE ESTIMATION IN POWER SYSTEMS** **(08 Hours)**
  Power system state estimation, least square estimation, state estimation of an AC network, Tracking state estimation of power systems, External system equivalence, Detection and identification of bad measurements, Network observability and Pseudo-measurements, Application of power system state estimation.
- **LOAD FORECASTING TECHNIQUES** **(05 Hours)**
  Forecasting methodology, Estimation of periodic components, Estimation: Time series approach, Estimation of stochastic component: Kalman filtering approach, Long term load predictions using econometric models, Reactive load forecast.

Total Hours:42

3. **Books Recommended:**

1. J. J. Grainger and W. D. Stevenson, _Power System Analysis,_ McGraw Hill, New Delhi 1st Edition, 2017.
2. A. J. Wood and B.F. Wollenberg, Power Generation Operation and Control,_John Wiley & Sons, 2nd Edition.
3. O. I. Elgerd, Electric Energy Systems Theory,_McGraw Hill, 2nd Edition, 1982.
4. Arthur R. Bergen, Vijay Vittal, _Power system Analysis,_ Pearson Education (Singapore) Pte, Ltd., 2nd Edition, 2004.
5. I. J. Nagrath & D.P. Kothari, Modern Power System Analysis,_Tata McGraw Hill, 4th Edition, 2011.

B. Tech. IV (Electrical), Semester – VIII

Power Filter Technology (ES – V)

L	T	P	Credit
3	0	0	03

EE438 **Scheme**

1. Course Outcomes (Cos):

At the end of the course the students will be able to:

CO1	describe the linear, nonlinear loads and identify the sources of power quality disturbances in the distribution system
CO2	classify and explain the functions of passive, active and hybrid power filters
CO3	develop different control techniques to mitigate the power quality disturbances
CO4	analyze and compare the merits and demerits of several power quality control techniques
CO5	design the controller for integration of the renewable energy sources to the grid through power filter technology

2. Syllabus:

- **ELECTRICAL POWER QUALITY** **(06 Hours)**
  Definitions, power quality standards, Classification of power system disturbances, power quality problems, formulations and measures used for power quality, effect of poor power quality on power system devices, non-ideal supply source, power factor correction and voltage regulation mode.
- **POWER QUALITY PROBLEM CREATING LOADS AND PASSIVE COMPENSATION** **(06 Hours)**
  Definition of linear and nonlinear loads, power electronics and electrical machine based nonlinear loads, current fed and voltage fed type nonlinear loads, mixed loads, grounding and banding, passive shunt and series compensator: operation and design methods.
- **PASSIVE POWER FILTER** **(06 Hours)**
  Classification of passive filters, application potentials and limitation of passive filter, basic principle, hybrid passive filters, design methods.
- **ACTIVE POWER FILTER** **(10 Hours)**
  Classification of active filters, application potential and advantages, basic principle, design of power circuit components, time domain control techniques: IRPT, PQ theory and SRF theory, real time implementation issues, voltage sensor and current sensors used in active filters, various topologies of active filters in three wire and four systems. Custom power devices: introduction, load compensation using DSTATCOM, DVR: structure and control, UPQC: configuration, structure and control techniques.
- **HYBRID POWER FILTER** **(08 Hours)**
  Classification of hybrid filters, applications potentials and limitation of hybrid filter, basic principle, hybrid filters, advantages, design and control techniques.
- **CUSTOM POWER DEVICES IN DISTRIBUTED GENERATION** **(06 Hours)**
  Distributed energy source: wind, hydro and solar based system, application of custom power devices for reactive power compensation, harmonic suppression and load balancing, Design problems.

Total Hours:42

3. Books Recommended:

1. E. F. Fuchs, Masoum, A. S. Mohammad, _Power Quality in Power Systems and Electrical Machines, Elsevier Academic Press, 1st Edition, 2008.
2. A. Ghosh and G. Ledwich, Power Quality Enhancement Using Custom Power Devices,_Springer International Edition, Delhi, reprint 1st Edition, 2012.
3. Hirofumi Akagi, Edson Hirokazu Watanabe and Mauricio Aredes, Instantaneous Power Theory and Applications to Power Conditioning,_Willey Interscience, New Jersey, 2nd Edition, 2017.
4. Antonio Moreno Munoz, Power Quality:Mitigation Technologies in a Distributed Environment, Springer-Verlag, London, reprint 1st Edition, 2010.
5. C. Sankaran, Power Quality,_CRC Press, New York, 2001.

B. Tech. IV (Electrical), Semester – VIII

Smart Grid Technology (ES – V)

L	T	P	Credit
3	0	0	03

EE442 **Scheme**

1. Course Outcomes (Cos):

At the end of the course the students will be able to:

CO1	identify the background for smart Grid and have knowledge of smart grid in the context of Indian grid.
CO2	classify smart grid architectures and understand the role of automation in transmission and distribution.
CO3	apply PMUs, PDCs, WAMs. Technology for smart grid
CO4	identify and apply a suitable evolutionary algorithm for the given smart grid application.
CO5	use performance analysis tools for smart grid
CO6	analyze and perform basic design of smart grid electric power systems, with emphasis on micro-grids.

2. Syllabus:

- **SMART GRID ARCHITECTURAL DESIGNS** **(07 Hours)**
  Today's Grid versus the Smart, General View of the Smart Grid Market Drivers, Stakeholder Roles and Function, Utilities, Working Definition of the Smart Grid Based on Performance, Measures, Functions of Smart Grid Components, Smart Devices Interface Component, Storage Component, Monitoring and Control Technology Component, Demand Side Management Component.

- **DISTRIBUTED ENERGY RESOURCES** **(07 Hours)**
  Introduction - Combined heat and power (CHP) systems - Solar photovoltaic (PV) systems – Wind energy conversion systems (WECS) - Small-scale hydroelectric power generation - Storage devices: Penetration and Variability Issues Associated with Sustainable Energy Technology, Demand Response Issues, Electric Vehicles and Plug-in Hybrids.

- **SMART GRID COMMUNICATIONS AND MEASUREMENT TECHNOLOGY** **(07 Hours)**
  Monitoring, PMU, Smart Meters, and Measurements Technologies, Wide Area Monitoring Systems (WAMS), Phasor Measurement Units (PMU), Smart Meters, Smart Appliances, Advanced Metering Infrastructure (AMI), Multi-agent Systems (MAS) Technology, Multi-agent Systems for Smart Grid Implementation.

- **PERFORMANCE ANALYSIS TOOLS FOR SMART GRID DESIGN** **(08 Hours)**
  Introduction to Load Flow Studies, Challenges to Load Flow in Smart Grid and Weaknesses of the present Load Flow Methods, Load Flow State of the Art: Classical, Extended Formulations, and Algorithms, Distribution Load Flow Methods, Congestion Management Effect, Load Flow for Smart Grid Design, the Development of Stochastic Dynamic.
  Optimal Power Flow (DSOPF), DSOPF Application to the Smart Grid, Static Security Assessment (SSA) and Contingencies, Contingency Studies for the Smart Grid.

- **STABILITY ANALYSIS TOOLS FOR SMART GRID** **(06 Hours)**
  Introduction to Stability, Voltage Stability Assessment, Voltage Stability and Voltage Collapse, Classification of Voltage Stability, Static Stability (Type I Instability), Dynamic Stability (Type II Instability), Angle Stability Assessment, Transient Stability, State Estimation.

- **POWER QUALITY MANAGEMENT IN SMART GRID** **(07 Hours)**
  EMC in smart grid, equipment required for grid connected systems, grid connection requirements from power provider, addressing safety and power quality for grid connection, metering and rate arrangement for grid connected systems, web based power quality monitoring.

Total hours: 42

3. Books Recommended:

1. James Momoh, Smart Grid Fundamentals of Design and Analysis, A. John Wiley & Sons, 1st Edition, 2012.
2. Bharat Modi, Anu Prakash, Yogesh Kumar, Fundamentals of smart grid technology, S. K. Kataria & Sons, 2015
3. A. Keyhani, Smart Power Grid Renewable Energy Systems, Wiley 2nd Edition, 2016.
4. I.S. Jha, Subirata Sen, Rajesh Kumar and D.P. Kothari, Smart grid: Fundamental & applications, New Age international, New Delhi, 2019.
5. Gilbert N Sorebo and Michael C. Echols, Smart grid Security, CRC press, 1st Edition, 2012.

B. Tech. IV (Electrical), Semester – VIII

L	T	P	Credit
3	0	0	03

HVDC Transmission (ES – V)

EE444 **Scheme**

1. Course Outcomes (Cos):

At the end of the course, the students will be able to:

CO1	describe the basic concepts of HVDC transmission system
CO2	analyze the convertor for HVDC transmission applications
CO3	choose between AC and DC transmission systems for an application
CO4	explain the various control methods for HVDC power flow
CO5	select the suitable protection method for various converter faults
CO6	decide the converter configuration for harmonic mitigation on both AC and DC sides

2. Syllabus:

- **INTRODUCTION** **(06 Hours)**
  Introduction to AC and DC Transmission - application of DC Transmission - description of DC transmission - DC system components and their functions - modern trends in DC Transmission.
- **CONVERTER** **(10 Hours)**
  Pulse Number - Converter configuration - analysis of Graetz circuit - converter bridge characteristics - characteristics of 12 Pulse converters.
- **HVDC CONTROLLERS** **(10 Hours)**
  General principle of DC link control - converter control characteristics - system control hierarchy - firing angle control - current and extinction angle control - Dc link power control - high level controllers.
- **FILTERS** **(08 Hours)**
  Introduction to harmonics - generation of harmonics - design of AC filters - DC filters - carrier frequency and RI noise.
- **PROTECTION** **(08 Hours)**
  Basics of protection - DC reactors - voltage and current oscillations - circuit breakers - over voltage protection - switching surges - lightning surges - lightning arresters for DC systems.

Total hours: 42

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3. Books Recommended:

1. Kimbark, Direct Current Transmission - Vol. 1, John Wiley and Sons Inc., New York, 1st Edition, 1971.
2. K. R. Padiyar, HVDC Power Transmission Systems, Wiley Eastern Limited, New Delhi, 2nd Edition, 2017.
3. J. Arrillaga, High Voltage Direct Current Transmission, Peter Peregrines, London, 2nd Edition, 1998.
4. Vijay K. Sood, HVDC and FACTS Controllers: Applications of Static Converters in Power Systems, Springer; 1st Edition, 2004.
5. Chan-Ki Kim, Vijay K. Sood, Gil-Soo Jang, Seong-Joo Lim, and Seok-Jin Lee, HVDC Transmission, Wiley-Blackwell, 2009.

B. Tech. IV (Electrical), Semester – VIII

L	T	P	Credit
3	0	0	03

Electric Vehicles (ES – V)

EE446 **Scheme**

1. Course Outcomes (Cos):

At the end of the course, the students will be able to:

CO1	explain various terminologies related to electric vehicle.
CO2	explain the concepts and drivetrain configurations of electric vehicles
CO3	develop different electric motors drive systems and energy storage system for EV.
CO4	construct different battery charger topologies for electric vehicles
CO5	design the complete electric propulsion system for EV/HEV.

2. Syllabus:

- **DESIGN OF ELECTRIC VEHICLE:** **(10 Hours)**
  Basics of vehicle dynamics, Traction Effort, Modeling of vehicle acceleration and range, Concept and role of different drive cycle for vehicle performance analysis. Sizing of propulsion motor, internal combustion engine (ICE) and power electronics; sizing of the energy storage system, Electronic Control Units, In-vehicle Communications between Electronic Control and Supporting subsystems.
- **ENERGY STORAGE SYSTEM:** **(06 Hours)**
  Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Terminologies related to Energy storage system, Battery, Fuel Cell, Ultra Capacitor and Flywheel based energy storage and its analysis, Hybridization of different energy storage devices, design of power source for different types of vehicle, Energy Management system - Charge Balancing circuits for the Energy storage system.
- **ELECTRIC PROPULSION DRIVE AND CONTROLLER:** **(10 Hours)**
  Selection of Motor drive based on vehicle torque and speed characteristics, Electric Motors in EV, Configuration and control of BLDC Motor drives, Induction Motor drives, Permanent Magnet Motor drives, and Switch Reluctance Motor drives, controllers, drive system efficiency.
- **ENERGY MANAGEMENT STRATEGIES FOR EV:** **(04 Hours)**
  Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies.
- **ENERGY MANAGEMENT STRATEGIES FOR EV:** **(04 Hours)**
  Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies.

Total Hours:42

3. Books Recommended:

1. Iqbal Hussain, Electric & Hybrid Vehicles – Design Fundamentals, 2nd Edition, CRC Press, 2011.
2. James Larminie, Electric Vehicle Technology Explained, John Wiley & Sons, 2nd Edition, 2012.
3. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2nd Edition, 2009.
4. Chris Mi, Dearborn, M. Abul Masrur, David Wenzhong Gao, Hybrid electric Vehicles Principles and applications With practical perspectives, A John Wiley & Sons, Ltd., 2011.
5. Iqbal Hussain, Electric & Hybrid Vehicles – Design Fundamentals, 2nd Edition, CRC Press, 2011.

B. Tech. IV (Electrical), Semester - VIII

Digital Signal Processing (ES – V)

L	T	P	Credit
3	0	0	03

EE448 **Scheme**

1. Course Outcomes (Cos):

At the end of the course, the students will be able to:

CO1	classify the discrete time signals, systems
CO2	design optimum structures for realizing IIR and FIR systems
CO3	apply signal processing techniques to real situation problems
CO4	design and implement different types of FIR/IIR filters
CO5	develop various DSP FFT algorithms through software like MATLAB

2. Syllabus:

- **INTRODUCTION** **(03 Hours)**
  Review of continuous-time signals and systems, convolution of continuous-time signals, Laplace transform, the Fourier series and Fourier transform.
- **DISCRETE-TIME SIGNALS AND SYSTEMS** **(05 Hours)**
  Sequences, discrete-time systems, linear time-invariant systems, convolution representation of linear time-invariant discrete-time systems, convolution of discrete-time signals, linear difference equations with constant coefficients, realizations, frequency-domain representation of discrete-time signals and systems.
- **SAMPLING OF CONTINUOUS-TIME SIGNALS** **(08 Hours)**
  Periodic sampling, frequency-domain representation of sampling, reconstruction of a band-limited signal, discrete-time processing of continuous-time signals, continuous-time processing of discrete-time signals, changing the sampling rate using discrete-time processing.
- **THE Z-TRANSFORM** **(09Hours)**
  The Z-transform, properties of the Z-transform, transfer function representation, Inverse Z-transform, Z-transform applied to difference equations, the complex convolution theorem, stability of discrete-time systems, frequency response of discrete-time systems.
- **THE DISCRETE FOURIER TRANSFORM** **(09 Hours)**
  Discrete-time Fourier transform (DTFT), the discrete Fourier series, the Fourier transform of periodic signals, discrete Fourier transform (DFT), properties of the DFT, system analysis via the DTFT and DFT, circular convolution, linear convolution using the DFT. The Fast Fourier Transform (FFT) Algorithms: Decimation in time FFT, introduction to radix-2 FFTs, some properties of radix-2 decimation in time FFT, decimation in frequency algorithm, computing the inverse DFT by doing a direct DFT.
- **INTRODUCTION TO DIGITAL FILTERS** **(08 Hours)**
  Recursive digital filters-infinite impulse response (IIR) Filters: Analog approximations, impulse invariant method, bilinear transformation method, matched Z-transform method, realizations, non-recursive digital filters – finite impulse response (FIR).

Total Hours: 42

3. Books Recommended:

1. Proakis and Manolakis, Digital Signal Processing, Prentice Hall of India, 4th Edition, 2007.
2. S. K. Mitra, Digital Signal Processing" McGraw Hill Education, 4th Edition, 2016.
3. Ashok Ambardar, Analog and Digital Signal Processing, Brooks and Cole Publication, 1st Edition, 2007.
4. Oppenhein-Schafer, Discrete Time Signal Processing, Prentice Hall of India, 3rd Edition, 2014.
5. Rabiner-Gold, Theory and Application of Digital Signal Processing, Prentice Hall of India, 1st Edition, 2015.

B. Tech. IV (Electrical), Semester – VIII

Modern Materials for Electrical Engineering (ES – V)

L	T	P	Credit
3	0	0	03

EE452 **Scheme**

1. Course Outcomes (Cos):

At the end of the course the students will be able to:

CO1	understand the properties of liquid, gaseous and solid insulating materials.
CO2	classify various materials based on their magnetic properties
CO3	explain semiconductor material technology.
CO4	apply their knowledge on materials for electrical engineering and applications
CO5	evaluate insulating, conducting and magnetic materials used in electrical machines.
CO6	identity and use special purpose materials.

2. Syllabus:

- **DIELECTRIC MATERIALS** **(09 Hours)**
  Dielectric as Electric Field Medium, leakage currents, dielectric loss, dielectric strength, breakdown voltage, breakdown in solid dielectrics, liquid dielectric, Electric conductivity in solid, liquid and gaseous dielectrics, Properties of ferroelectric materials in static fields, Spontaneous polarization, Curie point, Anti-ferromagnetic materials, Piezoelectric and Pyroelectric materials.

- **MAGNETIC MATERIALS** **(09 Hours)**
  Classification of magnetic materials, spontaneous magnetization in ferromagnetic materials, magnet anisotropy, magnetostriction, diamagnetism, magnetically soft and hard materials, special purpo materials, feebly magnetic materials, Ferrites, cast and cermet permanent magnets, ageing of magnet factors effecting permeability and hysteresis.

- **SEMICONDUCTOR MATERIALS** **(8 Hours)**
  Method of semiconductor material preparation, Purification and Doping, Introduction to process of Manufacturing Semiconductor Devices, Transistors, Integrated Circuits. Monolithic Diodes, Integrated Resistors and Integrated Capacitor.

- **MATERIALS FOR ELECTRICAL APPLICATIONS** **(8 Hours)**
  Materials used for resistors, rheostats, heaters, transmission line structures, stranded conductors, bimetals fuses, soft and hard solders, electric contact materials, electric carbon materials, thermocouple materials. Solid, liquid and gaseous insulating materials. Effect of moisture on insulation.

- **SPECIAL PURPOSE MATERIALS** **(8 Hours)**
  Refractory Materials, Structural Materials, Radioactive Materials, Galvanization and Impregnation (materials, Processing of electronic materials, Insulating varnishes and coolants, Properties ar applications of mineral oils, Testing of Transformer oil as per ISI.

Total Hours: 42

3. Books Recommended:

1. A. J. Dekkar, Electrical Engineering Materials, Prentice Hall Publications Co., Reprint Edition, 2009.
2. S. O. Kasap, Principle of Electronic Materials and Devices, 2nd Edition, Tata McGraw- Hill.
3. C. Indulkar, Introduction to Electrical Engineering Materials, S. Chand & Company Ltd-New Delhi, 4th Edition, 2004.
4. S.P. Seth and P.V. Gupta, A course in Electrical Engineering Materials, Dhanpat Rai & Sons, 3rd Edition, 2011.
5. T. K. Basak, A course in Electrical Engineering Materials, New Age Science Publications, 2009.

B. Tech. III (Electrical), Semester VIII

Special Electrical Machines and Drives (ES-V)

L	T	P	Credit
3	0	0	03

EE454 **Scheme**

1. Course Outcomes (Cos):

At the end of the course students will be able to:

CO1	describe the basic principles of special Electrical machines
CO2	analyze the steady state performance of special Electrical machines
CO3	compare the performance of various special electric machines
CO4	identify the special constructional and operating features of special electrical machines
CO5	analyze the controlling method of special electric machines
CO6	select appropriate special electric machine for given application

2. Syllabus:

- **PERMANENT MAGNET BRUSHLESS D.C. MOTORS** **(07 Hours)**
  Fundamental equations – EMF and Torque equations – Torque speed characteristics – Rotor position sensing – Sensor less motors – Motion control

- **PERMANENT MAGNET SYNCHRONOUS MOTORS** **(07 Hours)**
  Construction - Principle of operation – EMF and torque equations – Starting – Rotor configurations – Dynamic model –control strategy

- **SYNCHRONOUS RELUCTANCE MOTORS** **(07 Hours)**
  Construction – axial and radial flux motors – operating principle – characteristics-drive circuit

- **SWITCHED RELUCTANCE MOTORS** **(07 Hours)**
  Construction-principle of operation-torque production-characteristics-power controller

- **STEPPING MOTORS** **(07 Hours)**
  Features – fundamental equations – PM stepping motors – Reluctance stepping motors – Hybrid stepping motors – Torque and voltage equations – characteristics-microprocessor based control

- **LINEAR MACHINES** **(07 Hours)**
  Classification of LEMS, linear motors and levitation machines - linear induction motors - linear synchronous motors - DC linear motors - linear levitation machines-performance characteristics and control of LEMS

Total Hours: 42

3. Books Recommended:

1. T. J. E. Miller, Brushless Permanent Magnet and Reluctance Motor Drives, Oxford Science Publications, 1989.
2. T. Kenjo and A. Sugawara, Stepping Motors and their Microprocessor Controls, Oxford Science Publications, 2nd Edition, 2017.
3. K. Venkataratnam, Special Electrical Machines, CRC Press, 1st Edition, 2008.
4. S. A. Nasar and Boldeal, Linear Motion Electric Machine, John Wiley, 1976.
5. V. V. Athani, Stepper Motors, New Age International Pub., 1997.

B. Tech. Iv (Electrical), Semester – VIII

Switched Mode Power Supply (ES – VI)

L	T	P	Credit
3	0	0	03

EE456 **Scheme**

1. Course Outcomes (Cos):

At the end of the course the students will be able to:

CO1	explain the principle of switched-mode dc-dc power conversion.
CO2	design of reactive components for SMPS
CO3	analyze CCM and DDM operations of switched-mode power conversion.
CO4	modellingof switch mode power converters
CO5	design the controller for closed loop operation of the SMPS system

2. Syllabus:

- **THE PRINCIPLES OF SWITCHING POWER CONVERSION** **(07 Hours)**
  Introduction, evolution of switching topologies, switching devices - ideal and real characteristics, control, drive and protection.
- **REACTIVE COMPONENT DESIGNING** **(10 Hours)**
  Inductor, Transformer, Capacitor, Issues related to switches, Energy storage, their selection and design.
- **SWITCHING POWER CONVERTERS** **(15 Hours)**
  Switching power converters - circuit topology, operation, steady-state model, dynamic model.
  Analysis, modeling and performance functions of switching power converters.
  Non-isolated converters, Isolated converters, CCM and DCM operation of converters, Modeling of converters.
- **CONTROLLER DESIGNING** **(10 Hours)**
  Review of linear control theory, Closed-loop control of switching power converters, Sample designs and construction projects.

Total Hours: 42

3. Books Recommended:

1. Fang Lin Luo and Hong Ye. _Power Electronics: Advanced Conversion Technologies,_ CRC Press, Taylor & Francis Group, Boca Raton London New York, 2^{nd} Edition, 2018.
2. Middlebrook, Robert David and Slobodan Cuk, Advances in Switched-Mode Power Conversion, Volumes 1 and 2, 2^{nd} Edition, TESLA co., 1983.
3. Erickson, W. Robert, Fundamentals of Power Electronics, Chapman & Hall, 2^{nd} Edition, 1997.
4. A. Pressman, Switching Power Supply Design, McGraw-Hill, 3^{rd} Edition, 2009.
5. V. Ramanarayanan, Course Material on Switched Mode Power Conversion, Department of Electrical Engineering, IISc, Bangalore 560012. http://minchu.ee.iisc.ernet.in/new/people/faculty/vr/book.pdf

B. Tech. IV (Electrical), Semester VIII

Computer Methods for Power Systems (ES – VI)

L	T	P	Credit
3	0	0	03

EE458 **Scheme**

1. Course Outcomes (Cos):

At the end of the course the students will be able to:

CO1	illustrate various methods of solving linear system
CO2	apply various methods of solving non- linear system to power system problems.
CO3	apply various methods of solving sparse matrices to power system problems.
CO4	use various methods of numerical integration to solve differential equation pertaining to power system.
CO5	use modal analysis for small signal stability study of power systems.
CO6	Estimate states of the system using optimization techniques

2. Syllabus:

- **SOLUTION OF LINEAR SYSTEMS** **(06 Hours)**
  Gaussian elimination, LU factorization with partial and complete pivoting, condition numbers and error propagation, relaxation methods, conjugate gradient methods.
- **SOLUTION OF NONLINEAR SYSTEMS** **(07 Hours)**
  Method to solve nonlinear system: Newton's method, Broyden's method, Finite difference method, Power system applications: Power flow, regulating transformers, Decoupled power flow, Fast Decoupled power flow, PV curves and continuation power flow, Three phase power flow.
- **SPARSE MATRIX SOLUTION TECHNIQUES** **(06 Hours)**
  Storage methods, sparse matrix representation, Ordering schemes: Scheme O, Scheme I, Scheme II, Other scheme, Power system applications.
- **NUMERICAL INTEGRATION** **(07 Hours)**
  explicit methods, implicit methods, One step methods, Multistep methods, fixed step methods, variable step methods, Stability and accuracy-analysis of numerical methods, stiff systems, step size selection, differential algebraic systems, Power system application: Transient stability analysis.
- **EIGENVALUE PROBLEMS** **(08 Hours)**
  Eigen value computations methods: QR algorithm, Power method, Arnoldi methods, Prony method. Power system applications: Modal analysis, participation factors, SSR analysis.
- **OPTIMIZATION** **(08 Hours)**
  Least squares optimization, Weighted Least square optimization, Steepest Descent algorithm, Newton's method. Power system applications: Optimal power flow, Linear and Nonlinear least square state estimation.

Total Hours:42

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3. Books Recommended:

1. J. K. Nayak and S. P. Sukhatme, _Solar Energy - Principles of Thermal Collection and Storage,_ Tata McGraw Hill Publishing Company, New Delhi, 4th Edition, 2017.
2. J. Twidell and T. Weir, _Renewable Energy Resources,_ E & F N Spon Ltd, London, 3rd Edition, 2015.
3. Bent Sorensen, Renewable Energy: physics, engineering, environmental impacts, economics & planning, 4th Edition, Academic Press, Gurgaon, 2011.
4. Chetan Singh Solanki, Solar Photovoltaics: Fundamental, Technologies and Applications, 2nd Edition, PHI Learning Pvt. Limited, New Delhi, 2011.
5. Gary L. Johnson, "Wind Energy Systems", Prentice Hall Incorporation, 1985.

B. Tech. IV (Electrical), Semester – VIII

Robotics (ES – VI)

L	T	P	Credit
3	0	0	03

EE462 **Scheme**

1. Course Outcomes (Cos):

At the end of the course the students will be able to:

CO1	classify and characterize the robots based on the configuration and work volume.
CO2	analyze the manipulator design, including actuator, drive and sensor issues.
CO3	design the robots that addresses the human limitations and meets societal requirements.
CO4	apply the forward kinematics, inverse kinematics and Jacobean for serial and parallel robots.
CO5	explain and solve the problems related to robot design and control.

2. Syllabus:

- **INTRODUCTION AND ROBOT KINEMATICS** **(09 Hours)**
  Basic concepts of Robots and automation, classification, specifications, Application, Notation – Direct Kinematics, Co-ordinate frames, rotations, Homogeneous coordinates, the Arm equation – Kinematic analysis of a typical Robot.

- **DYNAMIC OF ROBOTS** **(08 Hours)**
  Continuous path motion-interpolated motion – Straight line motion – Tool configuration Jacobian matrix and manipulator Jacobian – Manipulator Dynamics – Kinetic of potential energy –Energized forces – Lagrange's Equation – Euler Dynamic model.

- **ROBOT DRIVES AND CONTROL** **(09 Hours)**
  Design of drive systems, Hydraulic and Pneumatic drives, Linear and rotary actuators and control valves, Electro hydraulic servo valves, electric drives, Motors, designing of end effectors, Vacuum, magnetic and air operated grippers. The control problem – state equation – Single axis PID control – PD gravity control –Computed torque control – Variable Structure control – Impedance control.

- **ROBOT VISION AND CELL DESIGN APPLICATION** **(08 Hours)**
  Fundamentals of Robot applications – Robot vision – Image representation – Template – matching – Robot cell design – Safety in Robotics, Robot cell layouts, Multiple Robots and machine interference.

- **ROBOT PROGRAMMING AND APPLICATIONS** **(08 Hours)**
  Methods of Robot Programming, Characteristics of task level languages lead through programming methods. Types of applications – material handling applications – Machine loading and unloading – spot welding – arc welding – spray painting, workspace analysis and trajectory planning – work envelope of different robots, the pick and place operation.

Total Hours: 42

3. Books Recommended:

1. Robert J. Schilling, Fundamentals of Robotics Analysis and Control, PHI Learning, 2015.
2. S. B. Niku, Introduction to Robotics, Analysis, Systems, Applications, Prentice Hall, 2nd Edition, 2011.
3. Richard D. Klafter, Thomas A Chmielewski, Michael Negin, Robotics Engineering – An Integrated Approach, Eastern Economy Edition, Prentice Hall of India P Ltd., 2006.
4. Saha S. K., Introduction to Robotics, Tata McGraw Hill Education Pvt. Ltd, 2nd Edition, 2017.
5. K. S. Fu, R. C. Gonzalez and C. S. G. Lee, Robotics: Control, Sensing, Vision and Intelligence, McGraw Hill, 2017.

B. Tech. IV (Electrical), Semester – VIII

Communication Engineering (ES – VI)

L	T	P	Credit
3	0	0	03

EE464 **Scheme**

1. Course Outcomes (Cos):

At the end of the course students will be able to:

CO1	visualize the fundamental blocks of communication systems
CO2	analyze the signal modulation and demodulation in communication
CO3	compare the advantage of frequency modulation technique over analog modulation
CO4	evaluate the effect of noise in various modulation schemes
CO5	analyze different use modulation techniques

2. Syllabus:

- **COMMUNICATION FUNDAMENTALS** **(10 Hours)**
  Basic blocks of Communication System. Amplitude (Linear) Modulation – AM, DSB-SC, SSB-SC and VSB-SC. Methods of generation and detection. FDM. Super Heterodyne Receivers.
- **FREQUENCY AND PHASE MODULATION** **(11 Hours)**
  Angle (Non-Linear) Modulation - Frequency and Phase modulation. Transmission Bandwidth of FM signals, Methods of generation and detection. FM Stereo Multiplexing.
- **NOISE ANALYSIS** **(11 Hours)**
  Noise - Internal and External Noise, Noise Calculation, Noise Figure. Noise in linear and nonlinear AM receivers, Threshold effect. Noise in FM receivers, Threshold effect, Capture effect, FM Threshold reduction, Pre-emphasis and De-emphasis.
- **PULSE MODULATION TECHNIQUES** **(10 Hours)**
  Pulse Modulation techniques – Sampling Process, PAM, PWM and PPM concepts, Methods of generation and detection. TDM. Noise performance.

Total Hour: 42

3. Books Recommended:

1. S. Haykins, Communication Systems, Wiley, 4th Edition, 2009.
2. D. Kennedy, Electronic Communication Systems, McGraw Hill, 4th Edition, 2008.
3. B. Carlson, Introduction to Communication Systems, McGraw Hill, 4th Edition, 2009.
4. J. Smith, Modern Communication Circuits, McGraw Hill, 2nd Edition, 1997.
5. J. Beasley, J. Miller, Modern Electronic Communication, 9th Edition, Prentice Hall, 2008.

B. Tech. IV (Electrical), Semester – VIII

VLSI Technology (ES – VI)

L	T	P	Credit
3	0	0	03

EE466 **Scheme**

1. Course Outcomes (Cos):

At the end of the course students will be able to:

CO1	explain the different VLSI design methodologies and design styles.
CO2	state the insights into the MOS devices and their characteristics
CO3	design the CMOS combinational logic and sequential circuits.
CO4	describe transistor level circuit design issues.
CO5	develop digital modeling and simulation with hardware description language (VHDL).

2. Syllabus:

- **INTRODUCTION TO VLSI DESIGN:** **(08 Hours)**
  Historical Perspective, Design Hierarchy, Concepts of Regularity, Modularity and Locality, VLSI Design Styles, VLSI Design Flow, Semi-Custom- Full Custom IC Design Flow, Data Path, Control Path Programmable Logic Array, CMOS And Bipolar Transistor Gate Arrays And Their Limitations, Standard Cells, FPGA/CPLD Architecture, Computer-Aided Design Technology.
- **CMOS FABRICATION:** **(06 Hours)**
  N-well, P-well, Twin-tub processes, Fabrication steps, Crystal growth, Photolithography, Oxidation, Diffusion, Ion implantation, Etching, Metallization.
- **CMOS COMBINATIONAL AND SEQUENTIAL LOGIC CIRCUITS:** **(08 Hours)**
  CMOS Logic Circuits, Complex Logic Circuits, CMOS Transmission Gate, Behavior of MOS Logic Elements, SR Latch Circuit, Clocked Latch and Flip-Flop Circuits, CMOS D-Latch and Edge-Triggered Flip-Flop, Dynamic logic circuit- Basic of Pass Transistor Circuits, Synchronous Dynamic Circuit Techniques.
- **CIRCUIT CHARACTERIZATION AND PERFORMANCE ESTIMATION:** **(08 Hours)**
  MOSFET Scaling and Small Geometry Effects, Delay Estimation, Logical Efforts And Transistor Sizing, Power Dissipation, Interconnect, Design Margin, Reliability.
- **DIGITAL MODELING AND SIMULATION WITH VHDL:** **(12 Hours)**
  Introduction to VHDL, Basic Language Elements, Behavioral Modeling, Dataflow Modeling, Structural Modeling, Generics, Configurations, Packages, Design of basic Arithmetic blocks- Adder, Multiplexer, Flip-Flop.

Total hours: 42

3. Books Recommended:

1. H. E. Weste Neil, D. Harris and A. Banerjee, CMOS VLSI Design: A Circuits and Systems Perspective, Pearson Education, 3rd Edition, 2002.
2. Debaprasad Das, VLSI Design, Oxford University Press, 2nd Edition, 2015.
3. Ken Martin, Digital Integrated Circuits, Oxford University Press, 2014.
4. Peter Van, Microchip Fabrication, Mc-Graw Hill Professional, 6th Edition, 2014.
5. J.P. Uyemura, Introduction to VLSI Circuits and Systems, John Wiley & Sons (Asia), 2006.

B. Tech. IV (Electrical), Semester – VIII

Antenna and Wave Propagations (ES – VI)

L	T	P	Credit
3	0	0	03

EE468 **Scheme**

1. Course Outcomes (Cos):

At the end of the course students will be able to:

CO1	review the fundamentals of electromagnetic theory and its application to antenna
CO2	distinguish transmitting and receiving antenna, and to analyze their characteristics
CO3	recognize the need of antenna arrays and their mathematical formulations
CO4	apply the concepts of optics and acoustics principle to differentiate and evaluate the characteristics of primary and secondary antennas
CO5	classify the various factors involved during the propagation of radio waves using practical antennas

2. SYLLABUS:

- **RADIATION FUNDAMENTALS** **(06 Hours)**
  Radiation fundamentals, Potential theory, Helmholtz integrals, Radiation from a current element, Basic antenna parameters, Radiation field of an arbitrary current distribution, Small loop antennas.
- **ANTENNAS** **(12 Hours)**
  Receiving antenna, Reciprocity relations, Receiving cross section and its relation to gain, Reception of completely polarized waves, Linear antennas, Current distribution, Radiation field of a thin dipole, Folded dipole, Feeding methods, Baluns.
- **ANTENNA CONSTRUCTION** **(12 Hours)**
  Antenna arrays, Array factorization, Array parameters, Broad side and end fire arrays, Yagi-Uda arrays Log-periodic arrays, Aperture antennas, Fields as sources of radiation, Horn antennas, Babinet's principle, Parabolic reflector antenna, Micro strip antennas.
- **WAVE PROPAGATION** **(12 Hours)**
  Propagation in free space, Propagation around the earth, surface wave propagation, structure of the ionosphere, propagation of plane waves in ionized medium, Determination of critical frequency, MUF, Fading, tropospheric propagation, Super refraction.

Total hours: 42

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3. Books Recommended:

1. R. Collin, Antennas and Radio Wave Propagation, McGraw Hill, 1st Edition, 2013.
2. W. Stutzman, G. Thiele, Antenna Theory and Design, Wiley, 2012.
3. K. Lee, Principles of Antenna Theory, Wiley, 1984.
4. B. Carlson, Introduction to Communication Systems, McGraw Hill, 4th Edition, 2009.
5. F. Terman, Electronic Radio Engineering, 4th Edition, McGraw Hill, 1955.

B. Tech. IV (Electrical), Semester VIII

Cryptography and Cyber Security for Smart Grids (ES – VI)

L	T	P	Credit
3	0	0	03

EE472 **Scheme**

1. Course Outcomes (Cos):

At the end of the course, the students will be able to:

CO1	explain the concept of encryption and privacy issues and its significance in cyber security
CO2	explain cryptography and risk analysis using various terms and methods such as attack classification, ciphers, keys etc.
CO3	evaluate the impact of bad data injection and identification for cyber security using encryption.
CO4	employ cloud network for information storage for smart grids and its security. The Indian perspective will also be explored.
CO5	explore the privacy prevention and its methods for smart grids and its management and legal concerns and rules/protocols for cyber security.

2. Syllabus:

- **INTRODUCTION AND OVERVIEW OF THE SECURITY AND PRIVACY ISSUES IN ELECTRICAL NETWORK** **(04 Hours)**
  Security issues in smart grids, Physical network security, Information network security, Privacy issues in smart grids, Reliability in smart grid- preliminaries on reliability quantification, System adequacy quantification, Congestion prevention: An economic dispatch algorithm.
- **CRYPTOGRAPHY FOR CYBER SECURITY** **(10 Hours)**
  Introduction and Overview of Cryptography and security, Historical perspective, Threats, risks, consequences, Physical and Information network security, Preventive and remedial measures, Basics of cryptography: Confusion vs. diffusion, Stream ciphers vs. block ciphers, Symmetric vs asymmetric key cryptography, Merkle Damgard construction, MD family, SHA family, Digital signatures , RSA algorithm, Encryption using non-cryptographic tools, Authentication principles and methods, Passwords, two-factor authentication.
- **BAD DATA DETECTION** **(06 Hours)**
  Preliminaries on falsification detection algorithms, Autocorrelation function (ACF), Time series modeling of load power: Outline of the proposed methodology, Seasonality, Fitting the AR and MA models, Case study: Stabilizing the variance, Fitting the stationary signal, Model fine-tuning and evaluation
- **CLOUD NETWORK DATA SECURITY IN SMART GRID** **(10 Hours)**
  Introduction, Service-level agreements, Live migration of a VM image in cloud computing: Data Migration, Network migration, Architecture and Solutions for: Application Manager, Site Broker, Hybrid cloud broker, Smart Meters and Smart Loads: The Advance Metering Infrastructure (AMI), Internet-Protocol-Based Mesh AMI, Standardization of AMI: ANSI C12.22, IEC 62056, AMI and Distribution Management System Integration (DMI), Software Architecture and Evaluation.
- **PRIVACY PRESERVATION IN SMART GRID** **(08 Hours)**
  End- User Privacy: Introduction and Preliminaries to privacy preservation methods, K- Anonymity cloaking, Location obfuscation, Privacy Preservation using location obfuscation methods, Preliminaries on Mobile nodes trajectory privacy, Location based services, Privacy preservation

quantification: Probabilistic model, A Vernoi-based location obfuscation method, Computing the instantaneous privacy level, concealing the movement path.

- **MANAGEMENT ASPECTS IN CYBER SECURITY** **(04 Hours)**
  System Administration policies, Security audit, Penetration testing and ethical hacking, Mandatory Access control, Discretionary Access Control, Monitoring and logging tools, Legal aspects.

Total Hours: 42

3. Books Recommended:

1. William Stallings,_Cryptography and network security,_Pearson Education.
2. Atul Kahate,_Cryptography and Network Security,_2nd Edition Tata McGraw Hill Publication, New Delhi-2006.
3. G. Kianoosh, Boroojeni, M.Hadi Amini and S.S. Iyengar, Smart Grids: Security and Privacy Issues,_Springer, 2017.
4. Wade Trapple, Lawrence C. Washington, Introduction to Cryptography with coding Theory,_2nd Edition pearson Education.
5. E.D Knapp, Raj Samani, Applied Cyber Security and the Smart Grid,_Elsevier-SYNGRESS.

B. Tech. IV (Electrical), Semester – VIII

Innovation, Incubation and Entrepreneurship

L	T	P	Credit
3	0	0	03

HU410 **Scheme**

1. Course Outcomes (Cos):

At the end of the course, the students will be able to:

CO1	explain the concepts of entrepreneurship
CO2	develop skills related to various functional areas of management (Marketing Management, Financial Management, Operations Management, Personnel Management etc.)
CO3	develop skills related to Project Planning and Business Plan development
CO4	demonstrate the concept of Innovation, Intellectual Property Rights (IPR) and Technology Business incubation
CO5	build knowledge about Sources of Information and Support for Entrepreneurship
CO6	develop Entrepreneurial Culture

2. Syllabus:

- **CONCEPTS OF ENTREPRENEURSHIP** **(10 Hours)**
  Scope of Entrepreneurship, Definitions of Entrepreneurship and Entrepreneur, Characteristics of an Entrepreneur, Entrepreneurial Development models and Theories, Entrepreneurs Vs Managers Classification of Entrepreneurs; Major types of Entrepreneurship – Techno Entrepreneurship, Women Entrepreneurship, Social Entrepreneurship, Intrapreneurship (Corporate entrepreneurship), Rural Entrepreneurship, Family Business etc.; Problems for Small Scale Enterprises and Industrial Sickness; Entrepreneurial Trait Tests; Entrepreneurial Environment – Political, Legal, Technological, Natural, Economic, Socio – Cultural etc. ; Motivation; Business Opportunity Identification

- **FUNCTIONAL MANAGEMENT AREA IN ENTREPRENEURSHIP** **(12 Hours)**
  Marketing Management: Basic concepts of Marketing, Development of Marketing Strategy and Marketing plan, Online Marketing, New Product Development Strategy
  Operations Management: Basic concepts of Operations management, Location problem, Development of Operations strategy and plan
  Personnel Management: Main operative functions of a Personnel Manager, Development of H R strategy and plan
  Financial Management: Basics of Financial Management, Ratio Analysis, Capital Budgeting, Working Capital Management, Cash Flow Statement, Break Even Analysis

- **PROJECT PLANNING** **(06 Hours)**
  Product Development – Stages in Product Development; Feasibility analysis – Technical, Market, Economic, Financial etc.; Project report; Project appraisal; Setting up an Industrial unit – procedure and formalities in setting up an Industrial unit; Business Plan Development

- **PROTECTION OF INNOVATION THROUGH IPR** **(04 Hours)**
  Introduction to Intellectual Property Rights – IPR, Patents, Trademarks, Copy Rights

- **INNOVATION AND INCUBATION** **(06 Hours)**
  Innovation and Entrepreneurship, Creativity, Green Technology Innovations, Grassroots Innovations, Issues and Challenges in Commercialization of Technology Innovations, Introduction to Technology Business Incubations, Process of Technology Business Incubation.

- **SOURCES OF INFORMATION AND SUPPORT FOR ENTREPRENEURSHIP** **(04 Hours)**
  State level Institutions, Central Level institutions and other agencies

Total Hours: 42

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3. Books Recommended:

1. Desai Vasant, Dynamics of Entrepreneurial Development and Management, Himalaya Publishing House, India, 6th Revised Edition, 2011.
2. P. M. Charantimath, Entrepreneurial Development and Small Business Enterprises, Pearson Education, 3rd Edition, 2018.
3. H. Holt David, Entrepreneurship: New Venture Creation, Pearson Education, 2016.
4. P. Chandra, Projects: Planning, Analysis, Selection, Financing, Implementation and Review, Tata McGraw Hill, 9th Edition, 2019.
5. T. R. Banga and S. C. Sharma, Industrial Organization& Engineering Economics, Khanna Publishers, 25th Edition, 2015.

Electronics Engineering Department

B. Tech. Electronics and Communication Engineering

Scheme

SEMESTER – III

Sr. No.	Subject	Code	Scheme	Credit	Examination Scheme				
					Theory Marks	Tutorial Marks	Term work Marks	Practical Marks	Total Marks
1.	Engineering Mathematics-III *	MA 217	3-1-0	04	100	25	-	-	125
2.	Core-1 – Electronic Circuits	EC 201	3-1-2	05	100	25	25	25	175
3.	Core-2 – Digital Logic Design	EC 203	3-1-2	05	100	25	25	25	175
4.	Core-3 – Signals and Systems	EC 205	3-1-0	04	100	25	-	-	125
5.	Interdisciplinary Subject 1– Network Analysis and Synthesis	EE 207	3-1-0	04	100	25	-	-	125
		Total	**15-5-4=24**	**22**	**500**	**125**	**50**	**50**	**725**

SEMESTER – IV

Sr. No.	Subject	Code	Scheme	Credit	Examination Scheme				
					Theory Marks	Tutorial Marks	Term work Marks	Practical Marks	Total Marks
1.	Core-4 - Statistical Signal Analysis	EC 202	3-1-0	04	100	25	-	-	125
2.	Core-5 – Principles of Communication Systems	EC 204	3-1-2	05	100	25	25	25	175
3.	Core-6 – Microprocessors and Microcontrollers	EC 206	3-1-2	05	100	25	25	25	175
4.	Core-7 - Linear IC Applications	EC 208	3-1-2	05	100	25	25	25	175
5.	Interdisciplinary Subject 2 – Core-8 – Control Systems	EE 214	3-1-0	04	100	25	-	-	125
		Total	**15-5-6=26**	**23**	**500**	**125**	**75**	**75**	**775**

*Syllabus is prepared by input from department will be taught by the Applied Mathematics and Humanities Department.

ELECTRONIC CIRCUITS

L	T	P	Credit
3	1	2	05

EC 201

Scheme

1. **Course Outcomes (COs):**

At the end of the course the students will be able to:

CO1	**Describe** single stage / multistage amplifiers and its frequency response characteristics.
CO2	**Apply** the concept of current sources / sinks in the differential amplifiers.
CO3	**Analyze** different amplifiers configurations by deploying negative feedback therein.
CO4	**Evaluate** the criterion for the stability of analog circuits.
CO5	**Design** solid state power amplifiers.

2. **Syllabus:**

- **HIGH FREQUENCY AMPLIFIERS: (10 Hours)**
  Classification of Amplifiers, Distortion in Amplifiers, Frequency Response of An Amplifier, Bode Plots, Step Response of Amplifiers, CE Short Circuit Current Gain, High Frequency Response of a CE Stage, Gain Bandwidth Product, Emitter Follower at High Frequencies, Common Source and Common Drain Amplifier at High Frequencies. Analysis of Multistage Amplifier, Design of Two Stage Amplifier, Frequency Response of Multistage Amplifier, Two Pole Analysis.

- **DIFFERENTIAL AMPLIFIERS (10 Hours)**
  Differential amplifiers, AC/DC Analysis of Various Differential Amplifiers using BJT/MOSFET, CMRR and I/O Resistances, Active Load Differential Amplifiers, Current Mirrors using MOSFET, Widlar Current Source, Cascaded Differential Amplifier Stages and Level Translator.

- **FEEDBACK AMPLIFIERS: (10 Hours)**
  Representation of Amplifiers, Feedback Concept, Transfer Gain with Feedback, Characteristics of Negative Feedback Amplifiers. I/O Impedance in Feedback Amplifiers, Analysis of Amplifiers having Voltage Series, Current Series, Current Shunt and Voltage Shunt Feedback, General Analysis of Multistage Feedback Amplifiers, Effect of Negative Feedback on Bandwidth, Frequency Response of Feedback Amplifiers.

- **OSCILLATORS: (06 Hours)**
  Stability Criterion, Sinusoidal Oscillators, Barkhausen Criterion, Analysis and design of RC phase shift (FET/ BJT) Oscillator, Wien Bridge Oscillators. Resonant Circuit Oscillators, General form of Oscillator Circuit (Hartley and Colpitts), Crystal Oscillators, Non-Sinusoidal Signal Generators using BJT/FET.

- **POWER AMPLIFIERS: (06 Hours)**
  Class A, B, AB, and C Power Amplifiers, Push – Pull and Complementary Symmetry Push-Pull Amplifier, Heat Sinks, Power Output, Efficiency, Crossover Distortion and Harmonic Distortion, Tuned Amplifiers.

- **TUTORIALS** **(14 Hours)**

(Total Contact Hours : 56)

3. Practicals:

Practicals are to be performed using breadboard and SPICE Simulators.

1. Study and design a single stage RC coupled amplifier and obtain its frequency response curve.
2. Study and design a double stage RC coupled amplifier and obtain its frequency response curve.
3. Study and design a differential amplifier and measure its differential and common mode output voltages.
4. Study and design Voltage Series Feedback amplifier and obtain its frequency response characteristics with and without feedback.
5. Study and design Current Series Feedback amplifier and obtain its frequency response characteristics with and without feedback.
6. Study and design RC phase shift oscillator using BJT/FET/Op-Amp.
7. Study and design Wein Bridge oscillator using BJT/FET/Op-Amp.
8. Study and design Hartley/Colpitt oscillator using BJT/FET.
9. Study and design Push-Pull Amplifier and obtain its efficiency.
10. Mini Project.

4. Books Recommended:

1. Millman Jacob, Halkias Christos C. and Parikh C., "Integrated Electronics", 2nd Ed., McGraw-Hill, 2017.
2. Sedra and Smith, "Microelectronic Circuits", 5th Ed., Oxford University Press, 2005.
3. Md.Gausi, "Electronic circuits", 1st Ed., John Wiley, 2014.
4. A. S. Sedra & K. C. Smith, "Micro Electronic Circuits", 4th Ed., Oxford press, 1998.
5. Boylestad Robert L. and Nashlesky Louis, "Electronics Device & Circuits and Theory", PHI, 10th Ed., 2009.

5. Reference Book:

1. Schilling Donald L. and Belove E., "Electronics Circuits - Discrete and Integrated", 3rd Ed., McGraw-Hill, 1989, Reprint 2008.

DIGITAL LOGIC DESIGN

L	T	P	Credit
3	1	2	05

EC 203 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	**Describe** combinational logic problems and solve using truth table. Optimize using K-map and other equivalent techniques.
CO2	**Apply** various options for implementing sequential synchronous logic.
CO3	**Analyze** operation of synchronous sequential circuit, counters, registers and memory.
CO4	**Evaluate** RTL (register transfer language) statements to describe complex digital hardware. Derive or infer logic circuit from RTL Description.
CO5	**Design** circuits for ALU and Shifter. Design and investigate various Control unit architecture (Hardwired, Microprogram, PLA etc.) to control and sequence hardware operations.

2. Syllabus:

- **BOOLEAN ALGEBRA AND SIMPLIFICATION** **(08 Hours)**
  Basic Logic Operation and Logic Gates, Truth Table, Basic Postulates and Fundamental Theorems of Boolean Algebra, Standard Representations of Logic Functions- SOP and POS Forms, Simplification of Switching Functions-K-Map and Quine-Mccluskey Tabular Methods, Synthesis of Combinational Logic Circuits

- **COMBINATIONAL LOGIC CIRCUITS** **(08 Hours)**
  Binary Parallel Adder, BCD Adder, Encoder Priority Encoder, Decoder, Multiplexer and Demultiplexer Circuits, Implementation of Boolean Functions using Decoder and Multiplexer, Arithmetic and Logic Units, BCD-To-Segment Decoder, Common Anode and Common Cathode, 7-Segment Displays, Random Access Memory, Read Only Memory and Erasable Programmable ROMs, Programmable Logic Arrays(PLA) and Programmable Array Logic(PAL)

- **LATCHES AND FLIP-FLOPS** **(06 Hours)**
  Cross Coupled SR Flip-Flop Using NAND or NOR Gates, Clocked Flip-flops, D-Types and Toggle Flip-flops, Truth Tables and Excitation Tables for Flip-flop.. Master Slave Configuration, Edge Triggered and Level Triggered Flip-flop, Flip-flop with Preset and Clear

- **SEQUENTIAL LOGIC CIRCUIT** **(06 Hours)**
  Introduction to State Machine, Mealy and Moore Model, State Machine Notation, State Diagram, State Table, Transition Table, Table Excitation, Table and Equation, Basic Concepts of Counters and Register, , Shift Left and Right Register, Registers with Parallel Load, Serial-in-Parallel-Out(SIPO) and Parallel-In-Serial-Out(PISO), Register Using Different Types of Flip-flop, Binary Counters, BCD Counters, Up Down Counter, Johnson Counter, Module-N Counter, Design of Counter using State Diagrams and Tables, Sequence Generators

- **REGISTER TRANSFER LOGIC** **(04 Hours)**
  Arithmetic Logic and Shift Micro-Operation, Conditional Control Statements, Fixed-Point and Floating-Point Data, Arithmetic Shifts, Instruction code and Design of Simple Computer

- **PROCESSOR DATA PATH AND CONTROL UNIT** **(06 Hours)**
  Processor Organization, Design of Arithmetic Logic Unit (ALU), Design of Accumulator, Control Organization, Hard-Wired Control, Micro Program Control, Control of Processor Unit, PLA Control

- **INTRODUCTION TO VHDL** **(04 Hours)**
  Introduction, Gate-Level Modeling, Data Type, Operators, Operands, Process and Behavioral Modeling, Timing Controls, Structural modeling, Registers, Flip-flop, Counter, Multiplexer, Adder/Subtracters, Tri-State Buffers

- **TUTORIALS** **(14 Hours)**

(Total Contact Hours: 56)

3. Practicals:

(Following practicals are to be performed using discrete components)

1. Introduction to variety of logic gates and digital ICs
2. Flip-flops using NAND/ NOR Gate.
3. Half-Adder/ Half-subtarctor Circuits using a serial Input.
4. Full-Adder/ Full-subtarctor Circuits using a serial Input.
5. Parity checker and parity generator circuit
6. 4-Bit Gray To Binary/ Binary To Gray Code convertor using Select input.

(Following practicals are to be performed on CPLD/FPGA kit using VHDL)

7. Logic expression with the Help of MUX IC 74153.
8. (a) Modulo-7 Ripple Counter with synchronous reset.
   (b) 4-bit up/down ripper counter with asynchronous reset
9. 4-Bit Shift Left/Right Register.
10. Sequence Generator using LFSR method.
11. Excess-3 BCD Adder/ Subtractor with Select Input.

4. Books Recommended:

1. Mano Morris, "Digital Logic and Computer Design", 4th Ed., Pearson Education, 2006.
2. Anand Kumar, "Fundamentals of Digital Circuits", 4th Ed., PHI, 2016.
3. Jain R. P. and Anand M. H. S., "Digital Electronics Practices using Integrated Circuits", 1st Ed., TMH, 2004.
4. Lee Samual, "Digital Circuits and Logic Design", 1st Ed., PHI, 1998.
5. Floyed Thomas L. and Jain R. P., "Digital Fundamentals", 8th Ed., Pearson Education, 2006.

5. Reference Book:

1. Brown S. and ZvonkoVranesic, "Fundamental of Logic with Verilog Design", 1st Ed., Tata McGraw Hill, 2003.

SIGNALS AND SYSTEMS

L	T	P	Credit
3	1	0	04

EC 205 **Scheme**

1. **Course Outcomes (COs):**

At the end of the course the students will be able to:

CO1	**Describe** Discrete Time Signal, System, Z-Transform and Sampling
CO2	**Apply** Frequency domain Analysis of Linear Time-Invariant system.
CO3	**Analyze** Discrete Time Fourier Transform and Discrete Fourier Transform
CO4	**Design** Signal Flow graph.

2. **Syllabus:**

- **INTRODUCTION** **(04 Hours)**
  Classification of Signal, Concept of Frequency in Continuous-Time and Discrete-Time Signal.

- **DISCRETE TIME SIGNAL AND SYSTEM** **(06 Hours)**
  Discrete-Time Signals, Discrete Time Systems, Linear Time-Invariant Systems, Properties of LTI Systems, Causal LTI Systems Described by Difference equations, Frequency Domain Representation of Discrete-Time Signals and Systems, Representation of sequences by Fourier Transforms and its properties.

- **Z-TRANSFORM** **(06 Hours)**
  Z-transform, Properties of Region of convergence, Inverse Z-transform, properties of Z-transform.

- **SAMPLING** **(06 Hours)**
  Sampling theorem, Periodic Sampling, Frequency-Domain Representation of Sampling, Reconstruction of a Bandlimited Signals, Discrete-Time Processing of Continuous-Time Signals, Continuous the Sampling Processing of Discrete-Time Processing.

- **FREQUENCY DOMAIN ANALYSIS OF LINEAR TIME-INVARIANT SYSTEMS** **(08 Hours)**
  Frequency Response of LTI Systems, Systems characterized by Linear Constant Coefficient Differential Equations, Frequency Response for Rational systems Functions, Relationship between Magnitude and Phase, Time domain and Frequency domain aspects of ideal and non-ideal filters.

- **DISCRETE TIME FOURIER TRANSFORM (DTFT) and DISCRETE FOURIER TRANSFORM (DFT)** **(08 Hours)**
  Representation of Periodic Sequence: The Discrete Fourier, Properties of the Discrete Fourier Series, Fourier Transform of Periodic Signals, Sampling the Fourier Transform, The Discrete Fourier Transform, Properties of the Discrete Fourier Transform.

- **SIGNAL FLOWGRAPHS** **(04 Hours)**
  Impulse Response and Transfer function of linear Systems, Block diagrams, Signal flow graphs, Basic properties of SFG, SFG Terms, SFG Algebra, Gain formula, Application of gain formula to block diagrams

- **TUTORIALS** **(14 Hours)**

(Total Contact Hours: 56)

3. **Books Recommended:**

1. Barry Van Veen Simon Haykin, “Signals and Systems”, 2nd Ed., Wiley, 2007
2. Alan V. Oppenheim, Alan S. Willsky, S. Hamid Nawab, “Signals and Systems Prentice Hall India”, 2nd Ed., Pearson, 2009.
3. B.P. Lathi, “Principles of Linear Systems and Signals”, 2nd Ed., oxford, 22 Jul 2009
4. John G. Proakis, Dimitris G. Manolakis, “Digital Signal Processing, Principles, Algorithms, and Applications”, 4th Ed., PHI, 2007.
5. Robert A. Gable, Richard A. Roberts, “Signals & Linear Systems”, 3rd Ed., John Wiley, 1995.

NETWORK ANALYSIS AND SYSNTHESIS

L	T	P	Credit
3	1	0	04

EE 207 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	**Identify** a mathematical model (differential equations) of a given electric circuit and solve it using technique of domain transformation.
CO2	**Solve** AC and DC Transients Analysis.
CO3	**Analyze** various parameters of two-port network and inter relationship between them.
CO4	**Evaluate** filter circuits for given specifications.
CO5	**Create** the electrical network from the given transfer function

2. Syllabus:

- **GRAPH THEORY AND ITS APPLICATIONS** **(06 Hours)**
  Fundamental concepts, definitions of a graph and various related terms, cut sets and tie sets, matrices of oriented graphs, properties and inter relationships of incidence, tie set and cut set matrices, complete circuit analysis using tie set and cut set techniques

- **LAPLACE TRANSFORMATION** **(06 Hours)**
  Laplace transform properties and theorems, Laplace transform of standard functions, Laplace transforms for periodic functions, initial and final value theorems, Inverse Laplace transform using partial fraction expansion, Waveform synthesis.

- **AC AND DC TRANSIENTS** **(06 Hours)**
  Initial and final conditions of networks and their S-domain equivalent circuits , R-L, R-C and R-L-C DC transients, two mesh transients, R-L, R-C and R-L-C sinusoidal transient analysis using Laplace transform methods, two mesh AC transients, complete response of RL, RC and RLC circuits to step, sinusoidal, exponential, ramp, impulse and the combinations of these excitations.

- **TWO PORT NETWORK ANALYSIS** **(06 Hours)**
  Two port network concepts, impedance, admittance, hybrid and transmission line parameters for two port networks and their interrelationship. Bridged T, Parallel T and Lattice network.

- **TWO TERMINAL PAIR REACTIVE NETWORKS (FILTERS)** **(06 Hours)**
  Ladder network and its decomposition into tee, pie, and L sections, image impedance, image transfer function and applications to LC networks, attenuation and phase shift in symmetrical Tee and Pie networks, constant K-filters, m-derived filters, problems of terminations

- **NETWORK FUNCTIONS** **(06 Hours)**
  Poles and zeros of a function, physical and analytical concepts, terminals and terminal pairs, driving point immittances, transfer functions, restrictions on locations of poles and zeros in S-plane. time domain behavior from pole zero locations in the S plane, procedure for finding network functions for general two terminal pair network

- **NETWORK SYNTHESIS** **(06 Hours)**
  Two-terminal network synthesis. Properties of Hurwitz polynomial and Positive real function. Synthesis of LC, RC and RL Networks, Foster Forms and Cauer Forms.

- **TUTORIALS** **(14 Hours)**

(Total Contact Hours: 56)

3. Books Recommended:

1. M.E.Van Valkenburg, "Network Analysis", 3rd Ed., Prentice Hall, India, 2002.
2. Charles K. Alaxander, Matthew N.O. Sadiku, "Fundamentals of electric circuits", 5th Ed., Tata McGraw Hill, 2013.
3. Edminister Joseph A., "Electrical circuits", Schaum's outline series, 2nd Ed., McGraw hill, 1983.
4. Hayt W. H., Kemmerly J. E, Durbin S. M., "Engineering Circuit Analysis", 6th Ed., Tata McGraw Hill, 2006.
5. Raymond A. Decarlo, Pen-Min Lin, "Linear Circuit Analysis", 2nd Ed., Oxford University Press, 2003.

4. Reference Books:

1. J. David Irwin, Robert M. Nelms., "Engineering Circuit Analysis", 10th Ed., Wiley India, 2013.
2. A.Chakrabarti, "Circuit Theory", 6th Ed., Dhanpat Rai & Co., 2012.
3. Wadhwa C.L., "Network Analysis & Synthesis", 3rd Ed., New Age International, Revised 2007.

ENGINEERING MATHEMATICS-III

L	T	P	Credit
3	1	0	4

MA 217

Scheme

1. Course Outcomes (COs):

At the end of the course the students will be able to :

CO1	**Describe** the convergence and divergence of infinite series.
CO2	**Apply** a Fourier series for periodic functions in different cases.
CO3	**Analyze** the Fourier integral and Fourier transform of a function.
CO4	**Evaluate** the basic properties of matrices, eigenvalue and eigenvectors with applications.
CO5	**Develop** basic concept of the linear algebra to electronics engineering problems.

2. Syllabus:

- **INFINITE SERIES** **(07 Hours)**

  Introduction, Positive term series, Comparison test, Cauchy's root test, D'Alembert's test, Raabe's test, Logarithmic test, Integral test, Gauss's test, Series with arbitrary terms, Rearrangement of terms

- **FOURIER SERIES** **(06 Hours)**

  Definition, Fourier Series with Arbitrary Period, In Particular Periodic Function With Period 2π. Fourier Series of Even and Odd Functions, Half Rang Fourier Series.

- **FOURIER INTEGRAL AND TRANSFORM** **(07 Hours)**

  Fourier Integral Theorem, Fourier Sine and Cosine Integral Complex Form Of Integral, Inversion Formula For Fourier Transforms, Fourier Transform of derivative of a Functions.

- **MATRICES** **(08 Hours)**

  Properties of matrices, Non-singular Matrices, Reduced Row-Echelon form, Systems of linear equations, Solution of system of linear equations,LU Decomposition Method.

- **EIGENVALUES AND EIGENVECTORS** **(07 Hours)**

  Eigen values and eigenvectors, Characteristic polynomials, Minimal polynomials, Diagonalizability, Triangularization, Rational canonical form, Jordon canonical form, Positive Define Matrices, Singular Value Decomposition.

- **VECTOR SPACE AND SUBSPACES** **(07 Hours)**

  Fields, Vector spaces over a field, subspaces, Linear independence and dependence, coordinates, Bases and dimension,Gram-Schmidt orthonormalization, Orthonormal basis, Orthogonal projection.

(Total Contact Hours : 42)

3. Books Recommended:

1. Malik S.C., and Arora S., "Mathematical Analysis", 5th Ed., Wiley Eastern Ltd., New Age International Publishers, 2017.
2. Kreyszig E., "Advanced Engineering Mathematics", 10th Ed., John Wiley, 2015.
3. Wiely C. R., "Advance Engineering Mathematics", 6th Ed., McGraw-Hill, 1995.
4. Gilbert Strang, "Introduction to Linear Algebra", 5th Ed., Wellesley-Cambridge Press, 2016.
5. Kenneth Hoffman and Ray Kunze, "Linear Algebra", 2nd Ed. PHI publication, 2009.

STATISTICAL SIGNAL ANALYSIS

L	T	P	Credit
3	1	0	4

EC 202 **Scheme**

1. **Course Outcomes (COs):**

At the end of the course the students will be able to:

CO1	**Describe** probability, random variable and random process and parameters related to them.
CO2	**Classify** different types of random variables and random processes.
CO3	**Analyze** random variables and random processes using knowledge of pdfs, cdfs, autocorrelation functions, power spectral density, etc.and LTI systems with random inputs.
CO4	**Evaluate** moments & characteristic functions and understand the concept of inequalities and probabilistic limits.
CO5	**Design** problems based on probability, random variables and random processes.

2. **Syllabus:**

- **COMBINATORIAL ANALYSIS** **(03 Hours)**
  Introduction, The Basic Principle of Counting, Permutations, Combinations, Multinomial Coefficients, The Number of Integer solutions of Equations

- **PROBABILITY THEORY** **(04 Hours)**
  Scope and History, Probability as Frequency of Occurrence, Set, Fields, Sample Space and Events, Axiomatic Definition of Probability, Mutually Exclusive Events, Joint Probability, Conditional Probability and Statistical Independence, Bays Theorem.

- **RANDOM VARIABLES** **(10 Hours)**
  Continuous and Discrete Random Variables, Cumulative Distribution Function (CDF), Probability Density Function (PDF), Properties of CDF and PDF, Some Special PDFs: Uniform, Gaussian, Rayleigh, Chi-Square, Binomial, Poisson, Transformations of Random Variables, PDF of Transformed Random Variable, Mean and Variance, Chebyshev's Inequality, Moments, Characteristic Functions, Simulation Techniques in MATLAB

- **MULTIPLE RANDOM VARIABLES** **(10 Hours)**
  Bivariate Distributions, One Function to Two Random Variables, Two Function to Two Random Variables, Joint Moments, Multivariate Expectations, Mean And Variance of The Sum of Random Variables, Multivariate Gaussian Distribution, Conditional Distributions, Conditional Expected Values, Correlation Between Random Variables, Law of Large Numbers, Central Limit Theorem and its Significance, Simulation Techniques in MATLAB

- **STOCHASTIC PROCESS** **(07 Hours)**
  Definitions, Statistics of Stochastic Process, Mean, Autocorrelation, Auto covariance, Stationary Processes: Strict Sense Stationary and Wide Sense Stationary, Power Spectral Density, Joint Statistical Averages of Two Random Processes, Cross Correlation and Cross Covariance, Ergodicity, Ergodic Processes, Simulation Techniques in MATLAB

- **SOME SPECIAL PROCESSES** **(04 Hours)**
  Gaussian Processes, Poisson Processes, The Markov Processes With Examples.

- **RANDOM PROCESSES IN LINEAR SYSTEMS** **(04 Hours)**
  Transmission of a Random Process Through LTI System, Stationarity of the Output, Autocorrelation and Power Spectral Density of the Output, Examples with White Noise as the Input, Linear Shift Invariant Discrete Time System with a WSS Sequence as Input

- **TUTORIALS** **(14 Hours)**

(Total Lecture Hours : 56)

3. Books Recommended:

1. Papoulis A., S. Unnikrishna Pillai, "Probability, Random Variables and Stochastic Processes", 4th Ed., McGraw-Hill, 2006.
2. Alberto Leon-Garcia, "Probability, Statistics, and Random Processes for Electrical Engineering", 3rd Ed., Pearson, 2007.
3. Steven Kay, "Intuitive Probability and Random Processes using MATLAB", 1st Ed., Springer, 2006.
4. Sheldon Ross, "A First Course in Probability", 9th Ed., Pearson, 2012.
5. Montgomery and Ruger, "Applied Statistics and Probability for Engineers", 1st Ed., John Wiley, 2006.

PRINCIPLES OF COMMUNICATION SYSTEMS

L	T	P	Credit
3	1	2	05

EC 204

Scheme

1. **Course Outcomes (COs):**

At the end of the course the students will be able to:

CO1	**Describe** the basic principles of communication techniques including important terminology like baseband signals, modulation, bandwidth, noise, system parameters etc.
CO2	**Explain** about sampling with ADC, signal processing and statistical aspects involved in communication with time and frequency domain fundamentals.
CO3	**Implement** analog communication systems and digital baseband preparation stage.
CO4	**Analyze** the performance of various modulation techniques, case study and problem solving as per given parameters.
CO5	**Evaluate** the various stages of analog communication link, baseband digital and point to point link performance parameters by experimentation using modern tools/simulators and hardware.
CO6	**Design** various stages of analog communication systemand digital database preparation with optimum parameter selection criteria satisfying performance requirements overcoming noise and interference.

2. **Syllabus:**

- **ANALYSIS AND TRANSMISSION OF SIGNALS** **(07 Hours)**
  Fourier Series, Fourier Transform Properties and their applications in communication systems, The Exponential Fourier Series, Aperiodic signal representation by Fourier Integral, Transmission of some useful functions, Negative frequency concepts, Signal Transmission Through a Linear System and Convolution concepts, Ideal versus Practical Filter, Channel as a filter, Signal Distortion over a Communication Channel, Signal Energy and Energy Spectral Density, Signal Power and Power spectral Density.

- **AMPLITUDE MODULATION AND DEMODULATION** **(08 Hours)**
  Band-pass Signal Representation Baseband Vs Carrier Communications, DSB-C And DSB-SC Amplitude Modulation, Bandwidth Efficient AM: SSB, Vestigial Sideband (VSB) Transmission, Local Carrier Synchronization, Frequency Division Multiplexing, Phase Looked Loop and Some Applications.

- **ANGLE MODULATION AND DEMODULATION** **(08 Hours)**
  Nonlinear Modulation, Bessel's function, Carson's Rule, Bandwidth of Angle Modulated Waves, NBFM and WBFM, Generating FM Waves, Demodulation of FM Signals, Effects Of Nonlinear Distortion and Interferences, Phase Modulation Concepts.

- **AM/FM TRANSMITTERS AND RECEIVERS** **(06 Hours)**
  AM/FM Transmitter Designs, AM/FM Receiver designs, Super-Heterodyne Principle: RF front end, Local oscillator, Mixer, Intermediate frequency stage, Image Frequency, Automatic Frequency Control, Automatic Gain Control, AM/FM Receivers, FM Broadcasting System. Preemphasis and Deemphasis.

- **NOISE** **(06 Hours)**
  Various Types of Noises: Internal (Shot, Thermal, Agitation, Transit Time) Noise and External (Atmospheric, Extra-Terrestrial, Industrial) Noise, White Noise and Filtered Noise, AWGN Properties, Noise Equivalent Bandwidth Concept, Noise Sampling, Signal To Noise Ratio.AM and FM systems in presence of noise.

- **PULSE MODULATION TECHNIQUES** **(07 Hours)**
  Sampling and A to D conversion, Quantization techniques—Uniform and Non-uniform, A-law and μ-law, Pulse Code Modulation, Pulse Amplitude Modulation, Pulse Position Modulation, Pulse Width modulation, Digital Telephony Example-T1/E1 carrier system, TDM, DPCM and ADPCM, Delta Modulation.

- **TUTORIAL** **(14 Hours)**

(Total Contact Hours: 56)

3. Practicals:

1. Study of the Spectrum Analyzer.
2. Study of Various Signals and their Spectrum Using MATLAB.
3. DSB-SC And DSB-C AM Transmitter and Receiver with Tone and Voice Input.
4. FM Transmission and Reception Techniques.
5. Frequency Division Multiplexing Techniques.
6. Simulation of AM and FM transceiver models.
7. AM and FM Simulation on MATLAB with AWGN Channel and Concept of SNR.
8. Study of various Pulse Modulation Techniques
9. Sampling and Pulse Code modulation Technique and ADCPM Technique.
10. Delta modulation and demodulation

4. Books Recommended:

1. Lathi B. P., and Ding Zhi, "Modern Digital and Analog Communication Systems", 4th Ed., Oxford University Press 2010/ 5th Ed., 2018.
2. Proakis J. and Salehi M., "Fundamental of Communication Systems", 1st Ed., PHI/Pearson Education-LPE, 2006.
3. Carlson Bruce A., Paul B Crilly "Communication Systems- An Introduction to Signal and Noise in Electrical Communication", 5th Ed., McGraw-Hill, 2011.
4. Leon W. Couch, II "Digital and Analog Communication Systems", 8th Ed., Pearson Education-LPE, 2013.
5. Taub Herbert, Donald Schilling, Goutam Saha "Principal of Communication Systems", 4th Ed., Tata McGraw-Hill, 2013.

MICROPROCESSOR AND MICROCONTROLLERS

L	T	P	Credit
3	1	2	05

EC 206 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	**Classify** microprocessor and microcrontoller with RISC & CISC architectures.
CO2	**Describe** 8-bit/16-bit microcontroller.
CO3	**Analyze** merits of ARM controllers along with architectural features and instructions of ARM Cortex-M microcontroller.
CO4	**Elevate** the knowledge gained for Programming ARM Cortex M for different applications.
CO5	**Design** embedded system with various peripheral interfacing.

2. Syllabus:

- **INTRODUCTION TO MICROPROCESSORS AND MICROCONTROLLER** **(06 Hours)**
  Microprocessor architectures basics, 8085 as Von Neumann CISC CPU. Bus system and its operation. Memory and peripheral interfacing. Advanced Microprocessors, Von Neumann vs Harvard, CISC vs RISC architecture, Overview and features of 8051 microcontroller, Overview of the various commercially available 8-bit/16-bit Microcontrollers

- **ARM 32-BIT MICROCONTROLLER** **(10 Hours)**
  Architecture of ARM Cortex M0+, Various Units in the architecture, Thumb-2 technology, Debugging support, General Purpose Registers, Special Registers, exceptions, interrupts, stack operation, reset sequence. Other Cortex series processors

- **ARM CORTEX M0+ INSTRUCTION SETS AND PROGRAMMING** **(12 Hours)**
  Arm & Thumb Instruction Set: Data Processing Instruction, Branch Instruction, Load Store Instruction, Special instructions, Bit-band operations and CMSIS, Assembly and C Language Programming.

- **EMBEDDED SYSTEM COMPONENTS** **(14 Hours)**
  Embedded Vs General computing system, Classification of Embedded systems, Major applications and purpose of ES. Core of an Embedded System including all types of processor/controller, Peripheral interfacing such as timers, ADC, DAC, Sensors, Actuators, LED/LCD display, Push button switches, Communication Interface standards (onboard and external), Embedded firmware, Other system components, RTOS based embedded system..

- **TUTORIALS** **(14 Hours)**

(Total Contact Hours: 56)

3. Practicals:

(The practical set is based on ARM Cortex-M Kit)

1. Introduce Keil ARM – MDK development flow
2. Write an program to flash simple LEDs (D0, D1, ..., D7) connected to Ports in various patterns
3. Write code to show up/down BCD count on Multiplexed 7-segment LED display updated every second. Use two keys (up & down) to change direction of counting.
4. Write a program to display "Welcome to SVNIT" as welcome message on LCD interface.
5. Interface 4x4 keypad and pressed display key on LCD
6. Establish full duplex ASCII communication between kit and PC using UART
7. Generate Sine wave/Triangle/Square wave using SPI based DAC and observe on CRO. Increase or Decrease frequency using Keys in decades.
8. Using the internal PWM module of ARM controller generate PWM and vary its duty cycle
9. Interface DC and stepper motor and demonstrate its operation
10. Demonstrate the use of an external interrupt to toggle an LED ON/OFF
11. Display digital output for given analog input using internal ADC

4. Books Recommended:

1. Joseph Yiu, "The Definitive Guide to the ARM Cortex-M0/M0+ processors, 2nd Ed., Newnes, (Elsevier), 2015.
2. A.N.Sloss, D.Symes and C. Wright, "ARM System Developer's Guide: Designing and Optimizing System Software", Elsevier, 2004.
3. ARM Cortex M0 Technical Reference Manual. Available at:http://infocenter.arm.com/help/topic/com.arm.doc.ddi0432c/DDI0432C_cortex_m0_r0p0_trm.pdf
4. Gaonkar R. S., "Microprocessor Architecture, Programming and Applications with 8085", 5th Ed., Penram International, Indian, 2002.
5. Ram B., "Fundamental of Microprocessor & Microcomputers", 6th Ed., Dhanpat Rai Publications, 2003.

5. Reference Book:

1. Shibu K V, "Introduction to Embedded Systems", 2nd Ed., Tata McGraw Hill, 2009

LINEAR IC APPLICATIONS

L	T	P	Credit
3	1	2	05

EC 208

Scheme

1. **Course Outcomes (COs):**

At the end of the course the students will be able to:

CO1	**Describe** an op-amp fundamentals and its specifications.
CO2	**Analyze** and design active filters and oscillators using op-amp and functional ICs.
CO3	**Classify** the working principle of data converters and selecting appropriate D/A and A/D converters for signal processing applications.
CO4	**Compare** the working of multi vibrators using special application IC 555 and general-purpose op-amp.
CO5	**Design** the linear and nonlinear applications of an op-amp using IC 741.

2. **Syllabus:**

- **OPERATIONAL AMPLIFIER FUNDAMENTALS** **(06 Hours)**
  Operational Amplifier, Basic Op-Amp Configuration, An Op-Amp with Negative Feedback, Voltage Series and Voltage Shunt Configurations, Difference Amplifiers, Instrumentation Amplifier, Specification of an Op-Amp, Offset Voltages and Currents, CMRR, Slew Rate, PSRR, Input Bias and Offset Currents, Frequency Response, GBW Product, Compensated Op-amp and Non-Compensated Op-Amp.

- **GENERAL LINEAR APPLICATIONS** **(06 Hours)**
  Summing, Scaling and Averaging Amplifiers, Concept of Negative Resistance, Voltage to Current Converter with Floating and Grounded Load, Current to Voltage Converter, Integrator and Differentiator, Gyrator, Frequency dependent negative resistance circuit.

- **ACTIVE FILTERS AND OSCILLATORS** **(12 Hours)**
  First Order Active Filters, Second-Order Active Filters, Multiple Feedback Filters (Band Pass and Band Reject Filters), All Pass Filter, Cascade design of filters, Magnitude and Frequency scaling concept, Oscillators, Phase Shift and Wien Bridge Oscillators, Square, Triangular and Saw Tooth Wave Generators.

- **NON-LINEAR CIRCUITS** **(05 Hours)**
  Schmitt Trigger, Voltage Comparator, Voltage Limiters and Window Detector, Concept of Clippers and Clampers Circuit using passive component, Clippers and Clampers using OpAmp, Peak Detector, Precision Rectifiers, Analog Switches.

- **MULTI-VIBRATOR CIRCUIT** **(05 Hours)**
  Concept of Multi-vibrator Circuit using passive component, the 555 Timer, Astable Mode operation, Monostable Mode operations, Applications of 555 Timer Circuit.

- **D/A AND A/D CONVERTERS** **(08 Hours)**
  Introduction, D/A Converters, Performance Parameters of D/A Converter, Basic D/A Conversion Techniques, Sources of Errors in D/A Converters, D/A Converter IC, A/D Converters, Performance parameters of A/D Converter, Counter Type A/D converter, Successive approximation Conversion, Flash A/D, Single and Dual Slope A/D, A/D Converter IC.

- **TUTORIALS** **(14 Hours)**

(Total Contact Hours: 56)

3. Practicals:

1. Design and implement Zero Crossing Detector, Positive Level Detector and Negative Level Detector or inverting and non-inverting configuration using IC 741.
2. To study the effect of Loading and input impedance for Inverting and Non-inverting negative feedback amplifier using IC 741.
3. Design and implement Inverting and Non-inverting negative feedback amplifier for given gain using IC 741. Also analyze the frequency response.
4. Design and implement Summing, Averaging and Scaling amplifier. Also implement 4 input Subtractor using IC 741.
5. Design and implement Practical Integrator for given cut-off frequency using IC 741. Also analyze the frequency response.
6. Design and implement Practical Differentiator for given cut-off frequency using IC 741. Also analyze the frequency response.
7. Design and implement 1st and 2nd order Low-pass filter for given cut-off frequency using IC 741. Also analyze the frequency response.
8. Design and implement 1st and 2nd order High-pass filter for given cut-off frequency using IC 741. Also analyze the frequency response.
9. Design and implement Notch filter for given notch frequency using IC 741. Also analyze the frequency response.
10. Design and implement All pass filter for given phase difference using IC 741.
11. Design and implement RC Phase shift and Wein bridge oscillator using IC 741.
12. Design and implement Square wave Generator using IC 741.
13. Design and implement Monostable and Astable Multivibrator using 555 timer.
14. Design and implement Voltage Regulator using IC 7805. Also perform Load and Line Regulation.

4. Books Recommended:

1. Sergio Franco, "Design with Operational Amplifiers and Analog Integrated Circuits", 4th Ed., McGraw- Hill, Published: May 11, 2016.
2. Coughlin and Driscol, "Op-Amps And Linear Integrated Circuits", 6th Ed., PHI, 2003
3. GayakwadRamakant, "Op-Amps and Linear Integrated Circuits", 4th Ed., PHI, 2003.
4. Salivahanan S., "Linear Integrated Circuits", 4th Reprint, McGraw-Hill, 2010.
5. Roy Choudary D. and Shail B. Jain, Linear Integrated circuits, 4th Ed., New Age International Publishers, 2010.

5. Reference Book:

1. William D. Stanley, “Operational Amplifiers with Linear Integrated Circuits”, 4th Ed., Old Dominion University, Pearson Education, 2002.

CONTROL SYSTEMS

L	T	P	Credit
3	1	0	04

EE 214 **Scheme**

1. **Course Outcomes (COs):**
   At the end of the course the students will be able to:

CO1	**Describe** various types of control systems and to impart knowledge of mathematical modelling of physical systems.
CO2	**Explain** the response of various control systems in the time domain.
CO3	**Demonstrate** the stability of control systems using a variety of methods.
CO4	**Analyze** the response and stability of control systems using frequency domain techniques.
CO5	**Evaluate** various control schemes for linear systems.
CO6	**Design** of P, PI, PID controllers.

2. **Syllabus:**
   - INTRODUCTION TO CONTROL SYSTEMS **(02 Hours)**
     Open loop control and close loop control; illustrative examples of control systems.

   - **MATHEMATICAL MODELS OF PHYSICAL SYSTEMS** **(10 Hours)**
     Linear and non-linear systems; equations and transfer functions for linear mechanical translational systems and linear electrical network; Force-Voltage and Force-Current analogy; Block diagram representation of control systems; Block diagram reduction; Transfer functions of armature-controlled and field-controlled DC servomotors and 2-phase AC servomotors; Signal flow graph and Mason's gain formula.

   - **TIME DOMAIN ANALYSIS OF CONTROL SYSTEMS** **(06 Hours)**
     Typical test signals; Response of first-order systems; Transient response of a second order system due to step input; Time domain specifications of a second order system; Impulse and ramp response of second order system; Steady-state errors; Static error coefficients; Error series and dynamic error coefficients.

   - CONCEPTS OF STABILITY **(08 Hours)**
     Introduction to stability, definition through impulse response function, asymptotic stability and relative stability, Routh-Hurwitz stability criterion. Basic Properties of Root Loci, Construction of Root Loci, Effects of Adding Poles and Zeros.

   - **FREQUENCY DOMAIN ANALYSIS OF CONTROL SYSTEMS** **(08 Hours)**
     Steady state response of a system due to sinusoidal input; Frequency response; Logarithmic plots or Bode diagrams; Log-magnitude versus phase plots; Resonant peak and resonant frequency of a second order system; Polar plots; conformal mapping, principal of argument, Nyquist stability criterion, Stability analysis; Relative stability; Gain margin and phase margin; Closed loop frequency response.

   - **DESIGN OF CONTROL SYSTEMS** **(08 Hours)**
     Introduction to phase lag, phase lead and phase lag-lead networks and their applications. P, PI, PID Controllers.

   - **TUTORIALS** **(14 Hours)**

(Total Contact Hours : 56)

3. Books Recommended:

1. I.J. Nagrath, M. Gopal, "Control system engineering", New Age International Publishers, 3rd Ed., 2001.
2. K. Ogata, "Modern control system engineering", Pearson Education Asia, 4th Ed., 2002.
3. B.C. Kuo, "Automatic control system", Prentice Hall of India, 7th Ed., 1995
4. R.C. Dorf, R.H. Bishop, "Modern control system", Pearson Education Asia. 8th Ed., 2004.
5. N. S. Nice, "Control System Engineering", John willey& sons, 4th Ed., 2004.

4. Reference Book:

1. K. Dutton, S. Thompson, B. Barralough, "The Art of Control Engineering", Prentice Hall, 1997

Electronics Engineering Department

B. Tech. Electronics and Communication Engineering

Scheme

SEMESTER – V

Sr. No.	Subject	Code	Scheme	Credit	Examination Scheme				
					Theory Marks	Tutorial Marks	Term work Marks	Practical Marks	Total Marks
1.	Core-9 – Transmission Lines and Electromagnetic Waves	EC 301	3-1-2	05	100	25	25	25	175
2.	Core-10 – Digital Communication	EC 303	3-1-2	05	100	25	25	25	175
3.	Core-11 – Digital Signal Processing	EC 305	3-1-2	05	100	25	25	25	175
4.	Seminar	EC 307	0-0-2	01	-	-	25	25	50
5.	Institute Elective-1 - Sensors and Transducers - Neural Networks - Multimedia Communication	EC 361 EC 363 EC 365	3-0-0	03	100	-	-	-	100
6.	Core Elective- I - Computer Architecture and Organization - Data Structures and Algorithms - VLSI Technology - Digital Image Processing	EC 321 EC 323 EC 325 EC 327	3-0-0	03	100	-	-	-	100
		Total	**15-3-8=26**	**22**	**500**	**75**	**100**	**100**	**775**

SEMESTER – VI

Sr. No.	Subject	Code	Scheme	Credit	Examination Scheme				
					Theory Marks	Tutorial Marks	Term work Marks	Practical Marks	Total Marks
1.	Professional Ethics, Economics and Business Management*	HU 304	3-1-0	04	100	25	-	-	125
2.	Core-12 – Wireless and Mobile Communication	EC 302	3-1-2	05	100	25	25	25	175
3.	Core-13 – Digital Integrated Circuits	EC 304	3-1-2	05	100	25	25	25	175
4.	Core Elective Lab # - Optical Fiber Comm. lab - Electronic Instrumentation lab - Machine Learning lab - Communication Networks lab	EC 306 EC 308 EC 312 EC 314	0-0-2	01	-	-	25	25	50
5.	Institute Elective-2 - High Performance Computing - Computer Vision - Micro - Electromechanical Systems	EC 362 EC 364 EC 366	3-0-0	03	100	-	-	-	100
6.	Core Elective- II - Optical Fiber Communication - Electronic Instrumentation - Machine Learning - Communication Networks	EC 322 EC 324 EC 326 EC 328	3-0-0	03	100	-	-	-	100
		Total	**15-3-6=24**	**21**	**500**	**75**	**75**	**75**	**725**

*Syllabus is prepared jointly by ASHD and concerned department and one hour on Ethics will be taught by the concerned department

The Core elective Labs are offered with reference to subjects offered under the pool of Core Elective-II and students have to elect the same Lab based on the their choice of subject as Core Elective -II

TRANSMISSION LINES AND ELECTROMAGNETIC WAVES

L	T	P	Credit
3	1	2	05

EC 301 **Scheme**

1. Course Outcomes (COs):

At the end of the course students will be able to:

CO1	**Decribe** the basic concepts and theorems of electromagnetic theory and its applications.
CO2	**Explain** the wave propagation and radiation phenomenon in different environments
CO3	**Apply** the principles of electromagnetic theory and wave propagation to model transmission line and radiating systems.
CO4	**Analyze** the theoretical concepts based on Maxwell's equation, transmission line theory and antennas.
CO5	**Evaluate** the wave propagation behavior between two mediums.
CO6	**Formulate** the aspects of electromagnetic theory for different application.

2. Syllabus:

- **TRANSMISSION LINE ANALYSIS** **(11 Hours)**
  Transmission Line Equations, Voltage and Current Waves, Solutions for Different Terminations, Transmission-line Loading, Impedance Transformation and Matching, Smith Chart, Quarter-wave and Half-wave Transformers, The Multiple Reflection Viewpoint, Binomial and Tchebeyshev Transformers, Single and Double Stub Matching, Introduction to Microstrip lines, Slot lines and Coplanar lines.

- **ELECTROMAGNETIC THEOREM and MAXWELL'S EQUATIONS** **(08 Hours)**
  Divergence and Stoke's Theorem, Coulomb's law, Gauss's law and Applications, Electric Potential, Poisson's and Laplace Equations, Biot-Savart's law, Faraday's law and Ampere's Work law in the Differential Vector form , Flux rule for Motional EMF, Magnetic Vector Potential, Introduction to The Equation of Continuity For Time Varying Fields, Inconsistency of Ampere's Law, Maxwell's Equation, Condition at a Boundary Surface, Poynting Theorem.

- **ELECTROMAGNETIC WAVES** **(06 Hours)**
  Solution for Free Space Conditions, Uniform Plane Waves and Propagation, The Wave Equations for a Conducting Medium, Sinusoidal Time Variations, Conductors and Dielectrics, Polarization, Reflection by a Perfect Conductor: Normal Incidence and Oblique Incidence, Reflection by a Perfect Dielectric: Normal Incidence and Oblique Incidence, Reflection at the Surface of a Conductive Medium.

- **RADIATION** **(11 Hours)**
  Potential functions and the Electromagnetic field, Oscillating Electric Dipole derivations for E and H field components in spherical coordinate systems, Power Radiated by a Current Element, Application to Antennas, Radiation from Quarter wave Monopole and Half wave Dipoles, Derivation for Radiation Resistance, Application of Reciprocity Theorem to Antennas, Equality of Directional Patterns and Effective Lengths of Transmitting and Receiving Antennas, Directional Properties of Dipole Antennas, Antenna Feeding Methods, Antenna Parameters and Definitions, Radiation from Wire Antenna.

- **GROUNDWAVE PROPAGATION** **(03 Hours)**
  Plane Earth Reflection, Spherical Earth Propagation, Tropospheric Waves.

- **IONOSPHERIC PROPAGATION** **(03 Hours)**
  The Ionosphere, Reflection and Refraction Waves by the Ionosphere, Regular and Irregular Variations of the Ionosphere.

- **TUTORIALS** **(14 Hours)**

(Total Contact Hours: 56)

3. Practicals:

1. To obtain Radiation Pattern of Dipole Antenna in two planes.
2. To observe Current Distribution on Dipole Antenna.
3. To obtain radiation Pattern of Yagi-Uda Antenna in two planes.
4. Measurement of Dielectric Constant using Solid Dielectric Cell
5. To determine the Standing Wave-Ratio and Reflection Coefficient for different loads
6. To measure an unknown impedance of the given load using Smith chart
7. Phase shift measurement of the given DUT
8. To do gain measurement of different antennas.
9. To realize impedance matching using single and double stub
10. Return loss measurement of given DUT
11. Insertion loss measurement of given DUT
12. To simulate Dipole antenna / Microstip Patch Antena in HFSS
13. To simulate waveguide based components in HFSS.

4. Books Recommended:

1. E.C. Jordan & G. Balmain, “Electromagnetic Waves and Radiating Systems”, 2nd Ed., PHI, Reprint 2011.
2. R. K. Shevgaonkar, “Electromagnetic Waves”, 1st Ed., Tata McGraw Hill, 2006.
3. M.N.O. Sadiku, “Principles of Electromagnetics”, 4th Ed., Oxford University Press, 2011.
4. W.H. Hayt, “Engineering Electromagnetics”, 7th Ed., McGraw Hill, 2006.
5. Roger F. Harrington, “Time-Harmonic Electromagnetic Fields”, Wiley-IEEE Press, 2001.

DIGITAL COMMUNICATION

L	T	P	Credit
3	1	2	05

EC 303 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	**Decribe** the basic knowledge of Digital communication including source coding, channel coding, modulation, line coding and equalization techniques as per the channel capacity requirements over various channels and also the point to point link for data communication
CO2	**Explain** about signal processing aspects involved in digital communication with time and frequency domain fundamentals
CO3	**Solve** the problems of digital communication techniques for optimizing the performance
CO4	**Compare** performance analysis of various digital modulation and coding techniques for a link, case study and problem solving as per given parameters.
CO5	**Evaluate** various stages of digital communication link and system performance parameters by experimentation using modern tools/simulators and hardware
CO6	**Design** the digital/data communication link with optimum parameter selection criteria satisfying given requirements

2. Syllabus:

- **INTRODUCTION TO INFORMATION THEORY AND CODING** **(10 Hours)**
  Measurement of Information and Entropy, Mutual Information, Joint Entropy, Source Encoding fundamentals, Kraft Inequality, Shanon-Fano and Huffman Coding, Error-Free Communication over Channel, Channel Capacity, Shannon's Capacity Equation, Introduction to Vector Space, Introduction to Channel Coding fundamentals and Error Correcting Codes. Linear Block codes, Convolution codes

- **PRINCIPLES OF DIGITAL DATA TRANSMISSION AND RECEPTION** **(10 Hours)**
  Digital Communication System, Line Coding, Pulse Shaping For Optimum Transmission, ISI and ISI-Free transmission, Band-limiting of Rectangular Pulses, Raised Cosine Filtering, Duo binary Signaling, Scrambling, Regenerative Repeaters, Matched Filter And Equalizers, Timing Extraction, Eye Diagrams, M-ary Baseband Signaling For Higher Data Rate.

- **BANDPASS SIGNAL TRANSMISSION-DIGITAL CARRIER SYSTEM** **(10 Hours)**
  Representation Of Digital Modulated Signal, ASK, PSK, FSK, QAM (MODEMs) with Mathematics and Constellation Diagram, Spectral Characteristics of Digitally Modulated Signals. M-Ary Digital Carrier Modulation. Advance Modulation technique OFDM, Mathematical aspects of OFDM, OFDM transceiver.

- **BANDPASS SIGNAL RECEPTION** **(06 Hours)**
  Synchronization, Decision Theory, Bandpass Receiving Filter, Error Performance of Bandpass Systems, Performance Evaluation of Communication Systems, BER.

- **DIGITAL DATA COMMUNICATION FUNDAMENTALS** **(06 Hours)**
  Asynchronous And Synchronous Transmission over point to point link, Concept of Frames, Packets and Segments, Frame Error handling, Error Detection, Error Correction, Line Configurations, Serial Interface.

- **TUTORIAL** **(14 Hours)**

(Total Lecture Hours : 56)

3. Practicals:

1. Simulation of ASK, FSK, PSK, QAM with Performance Analysis under Channel Effects and BER.
2. Simulation of Line Coding Techniques.
3. Simulation and Implement the Effect of Raised Cosine Filter.
4. Simulation of Eye Diagram, Constellation Diagram, Etc.
5. Source Coding Techniques
6. Error Control Coding Techniques.
7. Data communication serial link analysis
8. OFDM modulator and demodulator by simulation

4. Books Recommended:

1. John G. Proakis and Masoud Salehi, “Digital Communications”, 5th Ed., McGraw-Hill, 2014.
2. Bhattacharya Amitabh, "Digital Communication", 1st Ed., Tata McGraw-Hill, 2006.
3. Lathi B.P. and Ding Zhu, "Modern Digital And Analog Communication Systems", 4th Ed., Oxford University Press, 2010.
4. Sklar Bernard, "Digital Communications — Fundamentals and Applications", 2nd Ed., Pearson Education-LPE, 2009.
5. Leon W. Couch, II “Digital and Analog Communication Systems”, 8th Ed., Pearson Education-LPE, 2013.

5. Reference Book:

1. R.N.Mutagi, “Digital communication- Theory, Techniques and Applications”, 1st Ed., Oxford Publications, 2012.

DIGITAL SIGNAL PROCESSING

L	T	P	Credit
3	1	2	05

EC305 **Scheme**

1. **Course Outcomes (COs):**

At the end of the course the students will be able to:

CO1	**Describe** Discrete Time Signal, System and Discrete Fourier Transform.
CO2	**Implement** FIR and IIR Filters
CO3	**Analyze** Finite word length effect in Digital System
CO4	**Evaluate** various Realizations of filter structure
CO5	**Design** Multirate Signal Processing Systems.

2. **Syllabus:**

- **REVIEW OF DISCRETE TIME SIGNAL AND SYSTEMS** **(06 Hours)**
  Discrete - Time Signals, Signal classification, Discrete-time system & analysis of Discrete-time linear time invariant systems, Correlation of Discrete-time signals, Analysis of Linear Time invariant System in Z Domain, One sided Z-transform.

- **COMPUTATION OF THE DISCRETE FOURIER TRANSFORM** **(06 Hours)**
  Introduction, Direct evaluation of DFT, DFT symmetry relation, Fast Fourier Transform, Goertzel algorithm, Decimation-in-Time algorithm, Decimation-in-Frequency algorithm, Approaches to design radix-m algorithm. Implementation of DFT using convolution algorithm, The Discrete Time Cosine Transform, The Haar transform.

- **FIR FILTER DESIGN** **(07 Hours)**
  Causality and its implications, Linear Phase FIR filters, Frequency response of linear Phase FIR filters, Location of zeros of linear phase FIR filters, The Fourier Series method of designing FIR Filters, Design of FIR filter using different Windowing techniques, Digital differentiator, Hilbert transform, Frequency sampling method for designing FIR Filters, Various approach to design Optimum linear phase FIR filters.

- **IIR FILTER DESIGN** **(08 Hours)**
  Introduction, Frequency selective filter, Design of Digital Filter from Analog Filter, Analog low pass filter design, Analog low pass Butterworth filter, Analog low pass Chebyshev filter, Comparison between Butterworth filter and Chebyshev filter, Frequency transformation in analog domain, Design of high pass filter, bandpass and bandstop filters, Design of IIR filters From analog filters, Approximation of derivatives transformation method, Design of IIR filter using Impulse invariance technique, Design of IIR filter using Bilinear transformation, frequency transformation in digital Domain.

- **REALIZATION OF FILTER STRUCTURE** **(06 Hours)**
  Realization of FIR filters, Transversal structure, Linear phase realization, Lattice structure of FIR filter, Polyphase realization of FIR filter, Realization of Digital filter, Direct Form-I realization, Direct Form-II realization, Signal Flow Graph, Transposition theorem &Transposed structure, Cascade form, Parallel form structure, Lattice structure of IIR system, Comb Filter design, All-pass filter, Minimum phase, Maximum phase & Non-minimum phase systems. Tunable IIR digital filter

- **FINITE WORD LENGTH EFFECT IN DIGITAL SYSTEM** **(04 Hours)**
  Floating point numbers representation, Block floating point numbers representation, Quantization noise, Input Quantization error, Product Quantization error, Coefficient Quantization error, Quantization In floating point realization of IIR digital filters, Finite word length effect in FIR digital filters, Signal to Noise ratio in low-order IIR filter, Limit cycle in IIR digital filter, Round-off error in FFT Algorithm.

- **MULTIRATE SIGNAL PROCESSING** **(05 Hours)**
  Introduction, Down Sampling, Spectrum of down sampled signal, Up Sampling Spectrum of Up-sampled signal, Anti-Imaging filter, Cascading sample rate converters, Efficient transversal structure for decimator, Efficient transversal structure for interpolator, Polyphase structure of decimator, Polyphase decimation using Z-transform, Polyphase structure of interpolator, Polyphase interpolation using Z-transform, Multistage implementation of sampling rate conversion.

- **TUTORIAL** **(14 Hours)**

(Total Lecture Hours : 56)

3. Practicals:

1. Implementation of DFT & FFT algorithms
2. Finding the DFT and FFT for real-time signal.
3. Finding liner convolution and circular convolution for given signal.
4. Design FIR Filter for given specifications.
5. Design IIR Filter for given specification
6. Implementation of digital system and analysis finite word length effect for system.
7. Implementation of interpolation and decimation for given rate-conversion.
8. Speech and Musical sound processing.
9. Study of DSP Processor &Implement FIR Filter.
10. Linear prediction and optimum linear filter design using simulation & hardware.
11. Power spectrum analysis using the simulation.

4. Books Recommended:

1. Proakis J. G. and Manolakis D. G., "Digital Signal Processing: Principles, Algorithms And Applications", 4th Ed., Pearson Education, 2014.
2. Babu Ramesh P., "Digital Signal Processing", 4th Ed., SciTech Publication, 2008.
3. MitraSanjit K., "Digital Signal Processing: A Computer Based Approach", 4th Ed., Tata McGraw-Hill, 2011.
4. Oppenhein A. V. and Shafer R. W., "Discrete-Time Signal Processing", 3rd Ed., PHI, 2014.
5. Shaliwahan S., Vallavaraj A. and Gnanapriya C., "Digital Signal Processing", 2nd Ed., Tata McGraw-Hill, 2012.

5. Reference Books:

1. Padmanabhan K.,"A Practical Approach to Digital Signal Processing", 1st Ed., New Age International, 2001.
2. SudhankarRadhakrishna, "Application of Digital Signal Processing through practical Approaches", 1st Ed., Intech Open, http:://dx.doi.org/10.5772/59529. 2015.
3. Fredric Cohen Tenoudji, "Analog and Digital Signal Analysis: From Basic to Applications", Modern Acoustic and signal Processing. Ecllipse-Edition marketing, Paris-2012.

COMPUTER ARCHITECTURE AND ORGANIZATION

L	T	P	Credit
3	0	0	03

EC 321 **Scheme**

1. **Course Outcomes (COs):**

At the end of the course the students will be able to:

CO1	**Identify** the functional architecture of computing systems.
CO2	**Estimate** the performance of various classes of machines, memories, pipelined architectures etc.
CO3	**Compare** CPU implementations, I/O methods etc.
CO4	**Analyze** fast methods of ALU and FP unit implementations.
CO5	**Design** an instruction encoding scheme for an ISA and Build large memories using small memories for better performance.

2. **Syllabus:**

- **DESIGN OF INSTRUCTION SET ARCHITECTURE (ISA)** **(12 Hours)**
  Various Addressing Modes and Designing of an Instruction Set, Concepts of Subroutine and Subroutine call and return, Introduction to CPU design, Instruction Interpretation and Execution, the instruction set of a modern RISC processor, including how constructs in high-level languages are realized;

- **PROCESSING UNIT** **(10 Hours)**
  The representation of both fixed- and floating-point numbers, together with hardware algorithms for fixed-point arithmetic operations; Basic processor organization, Data path in a CPU, Instruction cycle, Organization of a control unit - Operations of a control unit, Hardwired control unit, Micro programmed control unit.

- **MEMORY SUBSYSTEMS** **(10 Hours)**
  Memory Hierarchy; Cache memory design, Virtual Memory, A Real-World Example of Memory Management, DMA Controller, Overview of SRAM and DRAM Design; Memory bus between CPU and DDR3/DDR4 based SDRAM, Memory controller for DDR3/DDR4.

- **BUSES AND PROTOCOLS** **(10 hours)**
  Introduction to Input/output Processing, Programmed Controlled I/O transfer, Interrupt Controlled I/O transfer, Introduction to serial and parallel Bus systems, Popular bus architecture standard such as IDE, SCSI, ATA, SATA, USB and IEEE 1394, Network component and protocols such as Ethernet and CAN.

(Total Contact Hours: 42)

3. **Books Recommended:**

1. David. A. Patterson and John L. Hennessy, “Computer Organization and Design: The Hardware/Software Interface”, 5th Ed., Morgan-Kaufmann Publishers Inc. 2014
2. Linda Null and Julia Lobur, “The Essentials of Computer Organization and Architecture”, 4th Ed., Jones & Bartlett Learning, 2014
3. Alan Clements, “Principles of Computer Hardware”, 4th Ed., Oxford University Press, 2006
4. Stephen Brown and Zvonko Vranesic, “Fundamentals of Digital Logic with Verilog Design”, McGraw-Hill, 2003
5. M. Morris Mano, “Digital Design”, 3rd Ed., Prentice Hall, Upper-Saddle River, New Jersey, 2002

DATA STRUCTURES AND ALGORITHMS

L	T	P	Credit
3	0	0	03

EC 323 **Scheme**

1. **Course Outcomes (COs):**

At the end of the course the students will be able to:

CO1	**Describe** the concept of dynamic memory management, data types, algorithms, Big-O notation, arrays, linked lists, stacks and queues.
CO2	**Apply** the hash function and concepts of collision and its resolution methods.
CO3	**Analyze** problems involving graphs, trees and heaps.
CO4	**Evaluate** algorithms for solving problems like sorting, searching, insertion and deletion of data.
CO5	**Design** a data structure to real-life problem.

2. **Syllabus:**

- **INTRODUCTION** **(04 Hours)**
  Algorithms as opposed to programs, Four Fundamental Data Structure, Complexity of Algorithms, Big Oh Notation, Complexity of Mergesort, Role of constant. Big Omega and Big Theta Notions, Time versus space complexity, Worst versus average complexity, Concrete measures for performance, Big-O notation for complexity class, Formal definition of complexity classes.

- **TYPE OF LIST** **(02 Hours)**
  Implementation of Lists, Array Implementation, loops and Iteration Pointer Implementation, Double Linked List Implementation, Stack, Queues, Circular array Implementation, Double linked list, Buddy System Memory Allocation
  SEARCHING ALGORITHMS
  Requirements for searching, Specification of the search problem, A simple algorithm: Linear Search, A more efficient algorithm: Binary Search.

- **DICTIONARIES& HASH TABLES** **(06 Hours)**
  Various Sets of Dictionary, Implantation of Dictionaries, Hash Tables, Closing of Hashing, Analysis of Closed Hashing, Skip Lists, Analysis og Skip Lists.

- **BINARY TREES** **(05 Hours)**
  Definition, Quad trees, Preorder, Inorder, Postorder, Data structures for tree representation, Binary Trees, Binary Trees for Huffman Code construction, Binary Search Tree, Splay Trees, Search, Insert, Delete in Bottom-up Splay, Amortized Algorithm Analysis.

- **BALANCED TREES** **(04 Hours)**
  AVL Trees, Maximum Height of an AVL Tree, Insertions and Deletions, Red-Black Trees, 2-3 Trees, B-Trees, Variants of B-Trees

- **PRIORITY QUEUES AND HEAP TREES** **(04 Hours)**
  Binary Heaps, Creating heap, Implementation of Binary heap, Binomial Queues, Binomial Queue Operations, Binomial Amortized Analysis, Lazy Binomial Queues, Fibonacci heaps, heap time complexity comparision.

- **DIRECTED GRAPHS** **(07 Hours)**
  Data Structures for Graph Representation, Shortest path Problem, Single shortest paths problmes, Dynamic programing Algorithms, Warshall's Algorithms, Depth First Search and breadth search, Directed Acyclic Graphs.

- **UNDIRECTED GRAPHS** **(04 Hours)**
  Some Definitions, Breadth-first search of undirected graphs, Minimum-Cost Spanning, MST Property, Prim's Algorithm, Kruskal's Algorithm, Traveling Salesman Problem using greedy algorithm.

- **SORTING METHODS** **(06 Hours)**
  Bubble Sort, Insertion Sort, Selection Sort, Shellsort, Heap Sort, Quick Sort, Algorithm for Partitioning, Average Case Analysis, Order Statistics, Lower Bound on Complexity for Sorting Methods, Lower Bound on Worst Case Complexity, Lower Bound on Average Case Complexity, Radix Sorting, Merge Sort, Heap Sort and Quicksort, Mergesort.

(Total Lecture Hours:42)

3. **Books Recommended:**
   1. Mark A. Weiss, "Data Structures and Algorithm Analysis in C++", 4th Ed., Published by Pearson (June 13th 2013).
   2. Gilles Brassard, "Fundamentals of Algorithms", Pearson Education 2015.
   3. E. Horowitz, S. Sahni and S. Rajasekaran, "Computer Algorithms/C++", Second Edition, University Press, 2007.
   4. A. V. Aho, J. E. Hopcroft, and J. D. Ullman. Data Structures and Algorithms. Addison-Wesley, Reading, Massachusetts, 1983.
   5. Anany Levitin "Introduction to the Design and Analysis of Algorithms" Pearson Education, 2015.

4. **Book Recommended:**
   1. Richard F. Gilberg, Behrouz A. Forouzan, "Data Structures – A Pseudocode Approach with C++", Thomson Brooks / COLE, 1998.

VLSI TECHNOLOGY

L	T	P	Credit
3	0	0	03

EC 325 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	**Explain** various aspects of VLSI chip fabrication and techniques used for realizing metals, semiconductors and insulators on a wafer.
CO2	**Illustrate** micro-fabrication processes along with their flow diagrams for various geometrical shapes.
CO3	**Analyze** micro-fabrication practices and their variants.
CO4	**Evaluate** the suitability of processes depending on the structures to be fabricated.
CO5	**Develop** process flow for various devices.

2. Syllabus:

- **SILICON WAFERS** **(08 Hours)**
  Clean Room and Safety Requirements, Crystals and Growth, Wafer Cleaning, Wet Chemical Etching Techniques, Plasma Enhanced and RIE Etching, Oxidation and Oxide Kinetics.

- **IMPURITY INCORPORATION** **(06 Hours)**
  Concept of Doping, Diffusion Modeling and Technology, Ion Implantation Modeling and Technology, Damage Annealing, Characterization of Impurity Profiles, RTP Techniques for Annealing.

- **PATTERNING** **(06 Hours)**
  Photolithography, E-Beam Lithography, Newer Lithography Techniques for VLSI / ULSI, Mask Generation, Limits of Lithography.

- **DEPOSITION** **(06 Hours)**
  CVD Techniques for Deposition of Polysilicon, Silicon Dioxide, Silicon Nitride, High K And Low K Dielectrics For ULSI, Epitaxial Growth of Silicon, Plasma Enhanced CVD.

- **METALLIZATION** **(04 Hours)**
  Evaporation and Sputtering Techniques, Failure Mechanisms in Metal Interconnects, Multi-level Metallization Schemes.

- **CMOS PROCESS** **(12 Hours)**
  Basic n–well CMOS Process, Gate Surround Process, Layout Design Rules and Back-end Design, Latch-up: Origin, Triggering, Prevention Techniques, Interconnects, Bonding and Packaging, Process Integration, SOI Technology, 3D Integration Techniques.

(Total Lecture Hours:42)

3. Books Recommended:

1. Sze S. M., "Semiconductor Devices, Physics and Technology", 2nd Ed., John Wiley and Son's, 2002.
2. Plummer, Deal, Griffin, "Silicon VLSI Technology Fundamentals Practice and Modeling", Pearson Education Limited, 2014.
3. Baker R. Jacob, "CMOS Circuit Design, Layout and Simulation", 4th Ed., Wiley-IEEE Press, 2019.
4. Ghandhi S. K., "VLSI Fabrication Principles", 2nd Ed., John Wiley Inc., New York, 1994.
5. Kang, Leblebici, "CMOS Digital Integrated Circuits: Analysis and Design", 4th Ed., Mc Graw Hill India, 2016.

4. Reference Books:

1. Rabaey Jan, Chandrakasan Anantha and Borivoje Nikolic,"Digital Integrated Circuits: A Design Perspective", Pearson Education, 2nd Ed., Second Impression, 2008.
2. J. Knechtel, O. Sinanoglu, I. M. Elfadel, J. Lienig, C. C. N. Sze, "Large-Scale 3D Chips: Challenges and Solutions for Design Automation, Testing, and Trustworthy Integration", IPSJ Transactions on System LSI Design Methodology, vol. 10, pp. 45–62, Aug. 2017.
3. International Technology Roadmap for Semiconductors 2011 Edition.
4. Garrou, Philip (6 August 2008). "Introduction to 3D Integration" (PDF). Handbook of 3D Integration: Technology and Applications of 3D Integrated Circuits. Wiley-VCH.

DIGITAL IMAGE PROCESSING

L	T	P	Credit
3	0	0	03

EC 327 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	**Discuss** Fourier transform for image processing in frequency domain and Compare the image compression techniques in spatial and frequency domains.
CO2	**Apply** techniques for image enhancement both in spatial and frequency domains.
CO3	**Analyze** causes for image degradation and apply restoration techniques.
CO4	**Evaluate** different image segmentation techniques.
CO5	**Develop** solutions using morphological concepts.

2. Syllabus:

- **INTRODUCTION** **(02 Hours)**
  Digital Image, Image Processing origins; Imaging in X-Rays, Ultraviolet, Visible Infrared, Visible, Microwave and Radio Bands; Fundamentals of Image Processing; Components of Image Processing Systems.

- **DIGITAL IMAGE FUNDAMENTALS** **(06 Hours)**
  Visual Perception — Human Eye, Brightness Adaptation and Discrimination, Electromagnetic Spectrum; Image Sensing and Acquisition — Single, Strip and Array Sensors, Image Formation Models; Image Sampling and Quantization — Basic Concepts, Representation of Image, Special and Gray Level Resolution, Aliasing, Zooming and Shrinking; Relationships Between Pixels-Nearest Neighbor, Adjacency, Connectivity, Regions, and Boundaries; Distance Measures; Image Operations on a Pixel Basis; Linear and Nonlinear Operations.

- **IMAGE ENHANCEMENT** **(08 Hours)**
  Gray Level Transformations-Image Negatives, Log, Power-Law and Piecewise Linear Transformation Functions; Histogram Processing -Equalization, Matching; Enhancement Operations - Arithmetic, Logic, Subtraction and Averaging; Spatial Filtering -Linear and Order-Statistics for Smoothing, First and Second Derivatives/Gradients for Sharpening, 2-D Fourier Transform, Its Inverse and Properties; Discrete and Fast Fourier Transform; Convolution and Correlation Theorems; Filtering in Frequency Domain - Low Pass Smoothing, High Pass Sharpening, Homomorphic Filtering.

- **IMAGE RESTORATION** **(08 Hours)**
  Image Degradation and Restoration Processes; Noise 'Models - Spatial Properties, Noise Probability Density Functions, Periodic Noise, Estimation Of Noise Parameters; Restoration in the Presence Of Noise and Mean Filters, Order-Statistics Filters, Adaptive Filters; Linear Position-Invariant Degradations and Estimation; Geometric Transformations - Spatial Transformation, Gray-Level Interpolation.

- **IMAGE COMPRESSION** **(04 Hours)**
  Fundamentals of Compression, Image Compression Model, and Error free Compression, Lossy Predictive Coding, and Transform Coding.

- **MORPHOLOGICAL IMAGE PROCESSING** **(04 Hours)**
  Preliminaries-Set Theory and Logic Operations in Binary Images; Basic Morphological Operations - Opening, Closing Operators, Dilation and Erosion, Morphological Algorithms - Boundary Extraction, Region Filling, Extraction of Connected Components, Convex Hull, Thinning, Thickening, Skeletons; Extension of Morphological Operations to Gray-Scale Images.

- **IMAGE SEGMENTATION** **(06 Hours)**
  Detection of Discontinuities - Point, Line and Edges; Edge Linking and Boundary Detection-Local Processing, Global Processing Using Hough Transform; Thresholding - Local, Global and Adaptive; Region-Based Segmentation - Region Growing, Region Splitting and Merging; Motion Detection.

- **IMAGE REPRESENTATION AND DESCRIPTION** **(04 Hours)**
  Representations - Chain Codes, Polygonal Approximations, Signatures, Boundary Segments, Skeletons; Boundary Descriptors - Shape Numbers, Statistical Moments; Regional Descriptors - Topological, Texture and Moments Of 2-D Functions.

(Total Contact Hours : 42)

3. **Books Recommended:**

1. Gonzalez R. C. and Woods R. E, "Digital Image Processing", 3rd Ed., Pearson Prentice Hall, 2008.
2. Sonka M. Hlavac V., Boyle R., "Image Processing, Analysis and Machine Vision", Cengage Learning, 2nd Ed. Indian Reprint, 2009.
3. Jain R., Kasturi R. and Schunk B., "Machine Vision", 1st Ed., McGraw - Hill, 1995.
4. Jain A. K., "Fundamentals of Digital Image Processing", 1st Ed., PHI, 1989.
5. W Pratt, “Digital Image Processing”, Wiley , 2001

SENSORS AND TRANSDUCERS

L	T	P	Credit
3	0	0	03

EC 361 **Scheme**

1. Course Outcomes (COs):

At the end of the course students will be able to:

CO1	**Explain** the different types of sensors and transducers with working principle.
CO2	**Apply** the concepts of sensors for various applications.
CO3	**Analyze** different sensors and transducers for various applications.
CO4	**Evaluate** the applications of sensors in instrumentation.
CO5	**Design** the sensors systems for different applications.

2. Syllabus:

- **INTRODUCTION TO SENSOR-BASED MEASUREMENT SYSTEMS (04 Hours)**
  General Concepts And Terminology, Definition of Sensor, Transducer And Actuator, Transducer/Sensor Classification, Criteria to Choose a Transducer/Sensor, Static and Dynamic Characteristics of Sensors.

- **RESISTIVE TRANSDUCERS (05 Hours)**
  Potentiometers Type: Forms, Materials, Resolution, Accuracy, Sensitivity, Strain Gauges: Theory, Types, Materials, Design Consideration, Sensitivity, Gauge Factor, Adhesives, Rosettes, Applications Force, Velocity and Torque Measurements, Resistive Temperature Detectors (RTDs), PTD, Thermistors, Light-Dependent Resistors (LDRs), Resistive Hygrometers, Resistive Gas Sensors.

- **CAPACITIVE TRANSDUCERS (05 Hours)**
  Working Principle of Capacitive Transducer, Variable Distance-parallel plate type, Variable Area-parallel plate, Serrated plate/teeth Type and Cylindrical Type, Variable Dielectric constant type: calculation of sensitivities; proximity measurement, displacement, force, pressure measurement, stretched diaphragm type: microphones, response characteristics, applications of capacitive sensors for measurement of different analytes.

- **INDUCTIVE AND MAGNETIC TRANSDUCERS (05 Hours)**
  Inductive Transducers: Self-inductive transducer, Mutual inductive transducers, Linear Variable Differential Transformer-LVDT Accelerometer, Applications of Inductive Transducers such as proximity sensors for position measurement, dynamic motion measurement, Magnetic Sensors: Sensors based on Hall Effect, Performance Characteristics and Applications.

- **ACTIVE TRANSDUCERS (05 Hours)**
  Principle of operation, construction, theory, advantages and disadvantages and applications of following transducers: Thermocouple, Piezo-electric transducer, Pyroelectric transducers, Photo-voltaic transducer and Electrochemical transducer.

- **OPTICAL AND ACOUSTIC TRANSDUCERS** **(05 Hours)**
  Principle of Optical fiber based sensors, Types of optical sensors, Applications of optical sensors and biosensors. Principle Acoustic transducers, SAW and IDT sensors, Applications of Acoustic transducers, Ultrasonic Sensor.

- **FLOW, PRESSURE AND LEVEL TRANSDUCERS** **(06 Hours)**
  Flow Transducers Like Differential Pressure, Variable Area, Positive Displacement, Electromagnetic, Anemometer, Ultrasonic Flow meter, Turbine Flow meter, Vortex Flow meter. Pressure Transducers Like Mercury Pressure Sensor, Bellows, and Membranes And Thin Plates, Piezoresistive, Capacitive Sensors, VRP Sensors, Optoelectronic Sensors, Vacuum Sensors. Level Transducers Like Displacer, Float, Pressure Gages, Balance Method, Level Measurements By Detecting Physical Properties.

- **ADVANCEMENTS IN SENSORS AND TRANSDUCERS** **(07 Hours)**
  Sensors For Robotics, Sensors Used In Smartphone, Sensors Used In Smartcity, MEMS, Nano Sensors, Smart Sensors, Integrated Sensors, IoT Applications, Study of Sensor IC/Module datasheet.

(Total Lecture Hours : 42)

3. Books Recommended:

1. Patranabis D., "Sensors and Transducers", 2nd Ed., Prentice-Hall India, 2004.
2. Ramon Pallas & John G. Webster, "Sensors and Signal Conditioning", 2nd Ed., John Wiley & Sons, 2001.
3. Alok Barua, “Fundamental of Industrial Instrumentation”, 1st Ed., Wiley India, 2011.
4. Jacob Fraden, "Handbook of Modern Sensors: Physics, Designs and Applications", 3rd Ed., Springer, 2004.
5. Shawhney A. K., "Electrical and Electronics Measurements and Instrumentation", Dhanpat Rai & Sons, 1994.

NEURAL NETWORKS

L	T	P	Credit
3	0	0	03

EC 363 **Scheme**

1. **Course Outcomes (COs):**

At the end of the course the students will be able to:

CO1	**Explain** fundamentals and types of neural networks, learning and adaptation capability of neural networks.
CO2	**Implement** neural network models.
CO3	**Analyze** the concept of CNN architectures.
CO4	**Evaluate** the concepts of fuzzy sets, knowledge representation using fuzzy rules, approximate reasoning, fuzzy inference systems, and fuzzy logic.
CO5	**Design** engineering applications that can learn using neural networks.

2. **Syllabus:**

- INTRODUCTION **(12 Hours)**
  Introduction to neural networks: Biological and Artificial neurons, learning in ANNs, Perceptrons–classification and linear separability, XOR problem, Network architectures, Multilayer feedforward networks and recurrent networks, Generalized delta rule.

- MULTILAYER NETWORKS **(10 Hours)**
  Back propagation (BP) network, BP training algorithm, Radial basis function (RBF) networks, Applications of BP and RBF networks. Recurrent networks and unsupervised learning, Hopfield network - energy; stability; capacity; Application to optimization problems, Counter back propagation network, Boltzmann machine, Kohonen's self-organizing feature maps, Adaptive resonance theory.

- **ASSOCIATIVE MEMORY** **(08 Hours)**
  Matrix associative memory, Auto associative memories, Hetero associative memories, Bi-directional associative memory, Applications of associative memories

- **CONVOLUTIONAL NEURAL NETWORKS** **(04 Hours)**
  History, Convolution and pooling, LeNet, AlexNet, ZF-Net, VGGNet, GoogLeNet, ResNet.

- **FUZZY SYSTEMS AND NEURO FUZZY SYSTEMS** **(04 Hours)**
  Relevance of Integration between fuzzy sets and neural network, Fuzzy neural network, Neuro fuzzy systems, Fuzzy associative memories.

- **APPLICATION OF NEURAL NETWORKS** **(04 Hours)**
  Applications in Pattern recognition,Image Processing and Computer vision,

(Total Contact Hours: 42)

3. Books Recommended:

1. Simon Haykin, "Network N. A comprehensive foundation. Neural Networks", 2nd Ed., PHI, 1998.
2. Simon Haykin, "Neural Networks & Learning Machines", 3rd Ed., Pearson Education India, 2016.
3. R. Rajasekaran and G. A and Vijayalakshmi Pa, Neural Networks, Fuzzy Logic, and Genetic Algorithms: Synthesis and Applications, 2nd Ed., PHI, 2003.
4. Satish Kumar, Neural Networks, A classroom approach, 2nd Ed., Mc Graw Hill 2018.
5. Kosko, Bart, "Neural networks and fuzzy systems: a dynamical systems approach to machine intelligence", PHI India, 1994.

4. Reference Books:

1. LaureneFausett, "Fundamentals of Neural Networks: Architectures, Algorithms, and Applications", 1st Ed., PHI, 1994.
2. Christopher M. Bishop & Geoffrey Hinton, "Neural Networks for Pattern Recognition", 1st Ed., OXFORD University Press, 2005.

MULTIMEDIA COMMUNICATION

L	T	P	Credit
3	0	0	03

EC 365 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	**Describe** the basic knowledge of multimedia communication technologies including audio, image, video, text coding and compression, distributed multimedia system, Standard compressed file formats
CO2	**Demonstrate** about signal processing aspects involved in multimedia including signal properties and human properties, networking aspects of DMS.
CO3	**Implement** source coding/data compression techniques in recent applications for data storage and communication of multimedia
CO4	**Compare** various coding/compression techniques.
CO5	**Design** various multimedia application across network.

2. Syllabus:

- **MULTIMEDIA PROCESSING** **(08 Hours)**
  Digital Media--Digital Audio, Digital Image and Digital Video, Input and Output devices, DPI And PPI, Signal Pre and Post Processing Elements, Revision of Fourier Transform, DFT and DCT, Challenges of Multimedia Information Processing, Storage, Retrieval Issues and Communication issues, Signal Processing For Networked Multimedia, Multimedia Processors.

- **DATA COMPRESSION TECHNIQUES** **(16 Hours)**
  Speech properties, VOCODERS, Audio perception parameters, Concept of Audio Threshold of Hearing, Cochlear filter, Critical Bandwidth, Noise masking Tone and Tone masking Noise, Temporal masking, Vector Quantization, Source Coding techniques, Lossless and Lossy Compression Techniques, Perceptual Coding fundamentals, Parametric coders, Transform Coders, Sub-Band Coders, Hybrid Coders

- **DATA COMPRESSION STANDARDS** **(06 Hours)**
  CD quality Audio Coding For Multimedia Applications, Audio, Image and Video Coding Standards--MPEG—MP3 MP4 etc and JPEG standards.

- **AUDIO-VISUAL INTEGRATION** **(04 Hours)**
  Human Speech Generation Model, Synthetic Speech Generation, Media Interaction, Bimodality of Human Speech, Speech Signal Properties and Visual Properties, Lip Reading, Speech-Driven Talking Heads, Lip Synchronization, Lip Tracking, Audio-To-Visual Mapping, Bimodal Person Verification, Joint Audio-Video Coding techniques.

- **MULTIMEDIA COMMUNICATION ACROSS NETWORKS** **(08 Hours)**
  Network Requirements, Real Time Packet Transfer Concept, Multimedia Requirements and ATM Networks, Packet Audio Video in The Network Environment, Video Transport Across Generic Networks, VOIP Application. Distributed Multimedia System constraints, architecture and protocols

(Total Lecture Hours : 42)

3. Books Recommended:

1. Rao K. R., Bojkovic Zoran S. and Milovanovic Dragorad A. "Multimedia Communication Systems: Techniques, Standard and Networks", 1st Ed., PHI, 2002.
2. Vaseghi Saeed V., "Multimedia Signal Processing Theory and Application in Speech, Music and Communications", 1st Ed., Wiley, 2007.
3. Rao Kamisetty, Bojkovic Zoras and Dragorad, "Introduction to Multimedia Communications", 1st Ed., Wiley, 2006.
4. Ohm and Jens R., "Multimedia Communication Technology", 1st Ed., Springer, 2004.
5. Mihaela Vander Scharr and Chow Philip A., "Multimedia Over 1P and Wireless Networks— Compression, Networking and Systems", 1st Ed., Academic Press, 2007.

WIRELESS AND MOBILE COMMUNICATION

L	T	P	Credit
3	1	2	05

EC 302 **Scheme**

1. **Course Outcomes (COs):**

At the end of the students will be able to:

CO1	**Describe** the terminology related to mobile cellular system, traffic, diversity, channel and established standards
CO2	**Explain** the wireless channel scenario with latest techniques, Cellular structure applied in the Mobile Technology by illustrating the various methods and open challenges for the improvement of wireless communication link.
CO3	**Experiment** with the traffic calculation formulas to design and optimize the load at the cellular network with the coverage area optimization using various techniques.
CO4	**Classify** the evolution of the various generation of the Mobile standards, channel models and the technological advancement achieved over the years.
CO5	**Evaluate** the major breakthrough in the field of voice and data services by assessing the latest technology standard.
CO6	**Design** the advance schemes to support the technological advancement for the user demand of higher data rate with improved quality of service.

2. **Syllabus:**

- **INTRODUCTION TO WIRELESS CHANNEL** **(04 Hours)**
  AWGN Channel, Multipath and Fading Effects, maximum delay spread, RMS delay spread, coherence bandwidth, coherence time, Large and Small Scale Fading, Flat and Frequency Selective Fading, Slow and Fast Fading, BER performance of communication systems

- **OUTDOOR AND INDOOR CHANNEL MODELLING** **(08 Hours)**
  Outdoor Channel Models: ground wave propagation model, Terrain Models, City Models, Indoor Models: Rayleigh, Rician and Nakagami Channel Models, BER performance of wireless channel, channel estimation, equalization

- **DIVERSITY TECHNIQUES** **(08 Hours)**
  Introduction to Diversity, Types of Diversity- Space, Time, Frequency

- **CELLULAR MOBILE SYSTEMS** **(08 Hours)**
  Spread spectrum technology, CDMA, WCDMA, A Basic Cellular System, Cellular Communication Infrastructure: Cells, Clusters, Cell Splitting, Frequency Reuse Concept and Reuse Distance Calculation, Cellular System Components, Operations of Cellular Systems, Call Setup, Handoff/Handover, Channel Assignment-Fixed and Dynamic, Cellular Interferences: Co-Channel and Adjacent Channel, Antennas for The Base Stations, Sectorization., Mobile Traffic Calculation - Grade of Service, Erlang B and C Formula, Traffic Calculation Examples

- **MOBILE STANDARDS** **(08 Hours)**
  GSM: Global System for Mobiles Communications, GPRS: General Packet Radio Service, EDGE: Enhanced Data - Rates for Global Evolution , UMTS: Universal Mobile Telecommunication System

- **INTRODUCTION TO LTE AND 5G** **(06 Hours)**
  Long Term Evaluation Architecture and concept, LTE protocol, physical layer aspects of LTE

- **TUTORIALS** **(14 Hours)**

(Total Contact Hours: 56)

3. Practical:

1. Implement and simulate the various modulation schemes and analyze their performance
2. Implement and simulate M-PSK and M-QAM Modulation Techniques with the help of MATLAB software where M= 4, 8, 16, 32, 64.
3. To Simulate M-PSK and M-QAM Modulation Techniques using AWGN channel considering input as an Image with the help of MATLAB software. Plot SNR v/s BER where M= 4, 8, 16, 32, 64 and constellation as well.
4. To Simulate M-PSK and M-QAM Modulation Techniques using Rayleigh Fading channel considering input as an Image with the help of MATLAB software. Plot SNR v/s BER where M= 4, 8, 16, 32, 64 and constellation as well.
5. Implement and simulate Diversity techniques (frequency) and observe the improvement in the results with respect to previous practical.
6. Implement and simulate any one channel estimation and observe the improvement in the results with respect to previous practical.
7. Implement and simulate any one channel equalization and observe the improvement in the results with respect to previous practical.
8. Analyze the performance of various blocks of Mobile Phone Trainer.
9. To Simulate BPSK, QPSK Modulation Techniques with the help of COMMSIM simulator.
10. Develop the android application using 4G trainer kit
11. Study of Direct Sequence Spread Spectrum (DSSS) Modulation and Demodulation Process.
    11.1: Study of Spreading and Dispersing based on Spread Spectrum technique
    11.2: Study of DSSS Modulation/Demodulation Using Analog Signal as an Input.
    11.3: Study of DSSS Modulation/Demodulation Using Digital Signal as an Input
12. To perform various AT commands for mobile communication

4. Books Recommended:

1. Dalal Upena," Wireless and Mobile Communication ", 1st Ed., Oxford University Press, 2016.
2. Lee William C. Y. "Mobile Cellular Telecommunications", 3rd Ed., McGraw-Hill, 2008.
3. Rappaport Theodore, "Wireless Communications - Principles and Practice", 2nd Ed., Pearson Education LPE, 2010.
4. Andreas F. Molisch, "Wireless Communications" 2nd Ed., Wiley, 2010.
5. Andrea Goldsmith, "Wireless Communication", Cambridge University Press, reprint, 2011.

DIGITAL INTEGRATED CIRCUITS

L	T	P	Credit
3	1	2	05

EC 304

Scheme

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	**Recognize** the fundamental concepts of devices and various logic families with their comparative analysis
CO2	**Explain** the operation of MOS transistor and scaling trends in MOSFETs and illustrate various short channel effects.
CO3	**Illustrate** the various processing techniques of NMOS and CMOS technology.
CO4	**Analyze** the design of inverter using CMOS logic and estimate the switching parameters therein. Also analyze the power dissipation and CMOS-TTL interfacing.
CO5	**Evaluate** the performance of different sequential and combinational circuits using CMOS logic.
CO6	**Design** the sequential and combinational circuits using CMOS with layout and stick diagrams.

2. Syllabus:

- **OVERVIEW OF HIGH-SPEED LOGIC FAMILIES** **(06 Hours)**
  BJT Inverter, DC Switching Characteristic, Introduction to TTL, Schottky TTL, and ECL Logic Family, Concept of Noise margin, Fan Out and Propagation Delay, NMOS, PMOS, CMOS, Bi-CMOS Circuits.

- **MOS TRANSISTORS** **(12 Hours)**
  Structure and Operation, MOSFET Structure and Operations, MOSFET Current- Voltage Characteristics, Channel Length Modulation, Substrate Bias Effect, MOSFET Capacitances, MOSFET Model, Modeling of MOS Transistor using Spice, Scaling and Small Geometry Effects, MOSFET capacitances, Fabrication Process Flow, CMOS N-Well Process and Twin Tub Process.

- **NMOS AND CMOS LOGIC DESIGN** **(12 Hours)**
  Various NMOS Inverters, Determination of VTC, Calculation of VTC Critical Points, CMOS Inverter Technology, VTC, Static Characteristics, Dynamic Behavior, Static and Dynamic Power Dissipation, Power-Delay Product, TTL-CMOS Interfacing.

- **CMOS COMBINATIONAL AND SEQUENTIAL LOGIC CIRCUITS** **(12 Hours)**
  CMOS Logic Circuits, Complex Logic Circuits, Pass transistor and Transmission gate, Behavior of MOS Logic Elements.
  The Bistability Principle, SR Latch Circuit, Clocked Latch and Flip-Flop Circuits, CMOS D-Latch and Edge-Triggered Flip-Flop. Layout Design Rules, Full-Custom Mask Layout Design and Stick Diagrams Antenna effect.

- **TUTORIALS** **(14 Hours)**

(Total Contact Hours: 56)

3. Practical:

1. Introduction to SPICE Circuit Simulator.
2. Realization of MOSFET Characteristics Using Circuit Simulator Characteristics and BSIM Models.
3. Realization of NOR Gate Using RTL Logic. Obtain & Plot its Transfer Characteristics And Determine Noise Margins, Fan-Out and Propagation Delay.
4. Realization of NAND Gate Using TTL Logic. Obtain & Plot Its Transfer Characteristic and Determine Noise margins, Fan-out and Propagation Delay.
5. Implementation of NMOS Inverter, Obtain & Plot Its Transfer Characteristics and Determine Noise margins And Measure Propagation Delay.
6. Implementation of CMOS Inverter. Obtain & Plot Its Transfer Characteristics, Determine Noise Margins and Measure Propagation Delay.
7. Realization Of Inverter Gate Using BiCMOS Logic, Obtain & Plot Its Transfer Characteristics, Determine Noise Margins.
8. Design and Implementation of TTL-CMOS & CMOS-TTL Interfacing.
9. Design and Implementation of Pass transistor and Transmission gate based logic circuits.
10. Design And Implement of JK & SR Flip-Flop using CMOS.
11. Layout of CMOS Inverter and Parasitic Extraction and Obtain VTC of Extracted Net List.

4. Books Recommended:

1. Taub H. and Schilling D., "Digital Integrated Electronics", International Ed., McGraw-Hill, 2008.
2. Sung-Mo Kang and Leblebici Y., "CMOS Digital Integrated Circuits: Analysis and Design", 3rd Ed., Tata McGraw-Hill; 2003.
3. Rabaey Jan, Chandrakasan Anantha Nikolic, "Digital Integrated Circuits: A Design Perspective", 2nd Ed., Pearson Education, 2008.
4. Hodges D. A. and Jackson H. G. "Analysis And Design Of Digital Integrated Circuits", 3rd Ed., McGraw-Hill, 2004.
5. Baker R. J., Li H. W. and Boyce D. E., "CMOS Circuits Design Layout and Simulation", 2nd Ed., PHI 2005.

FIBER OPTICS COMMUNICATION LAB

L	T	P	Credit
0	0	2	01

EC 306 **Scheme**

1. Course Outcomes (COs):

At the end of the course students will be able to:

CO1	**Apply** the concepts of light transmission in optical fiber communication link.
CO2	**Analyze** fiber, optical source, detector and components.
CO3	**Evaluate** optical fiber communication link parameters.
CO4	**Design** the optical fiber communication system.

2. Syllabus:

1. To implement and plot the I-V and I-P characteristics of LED.
2. To implement and plot the I-V and I-P characteristics of LASER Diode.
3. To implement and plot the I-V and I-P characteristics of Photo Detector.
4. To implement, study and analyze numerical aperture and losses in optical fiber.
5. To study and analyze modes and power in optical fiber using software.
6. To implement and study FM and PWM through optical link.
7. To implement and study free space optics using LASER module.
8. To implement and find the BER and EYE Pattern.
9. To implement and study power margin and sensitivity of optical system.
10. Design and performance analysis of a single channel link using Optisystem.
11. Design and performance analysis of a WDM link using Optisystem.
12. Link budget and rise time budget analysis of a single channel optical link using Optisystem.

ELECTRONICS INSTRUMENTATION LAB

L	T	P	Credit
0	0	2	01

EC 308 **Scheme**

1. **Course Outcomes (COs):**

At the end of the course the students will be able to:

CO1	**Illustrate** data acquisition and converter systems
CO2	**Analyze** data for different types of signal conditioning circuits.
CO3	**Evaluate** different signal converters
CO4	**Design** instrumentation system that meets desired specifications and requirements.

2. **Syllabus:**

1. Design and Implement Simple V to I converter and modified Howland V to I Convertor.
2. Design and Implement V to V Convertor given specifications.
3. Design and Implement R to V convertor.
4. Bridge Linearity technique using Op-AMP.
5. Measurement of Phase Difference Using X-OR and SR Flip-Flop Methods.
6. Instrumentation amplifier using Feedback.
7. Two Position digital controller with dead-Zone.
8. Instrumentation Trainer.
9. RS485 communications.
10. DATA acquisition using DAQ card.

MACHINE LEARNING LAB

L	T	P	Credit
0	0	2	01

EC 312 **Scheme**

1. **Course Outcomes (COs):**

At the end of the course students will be able to:

CO1	**Demonstrate** unsupervised and Reinforcement learning.
CO2	**Implement** feature extraction and selection to represent data as features to serve as input to machine learning models build an application that is based on machine learning.
CO3	**Design** given application based on suitable machine learning task.

2. **Syllabus:**

1. Implement and demonstrate the **FIND-S algorithm** for finding the most specific hypothesis based on a given set of training data samples. Read the training data from a .CSV file.
2. For a given set of training data examples stored in a .CSV file, implement and demonstrate the **Candidate-Elimination algorithm** to output a description of the set of all hypotheses consistent with the training examples.
3. Write a program to demonstrate the working of the decision tree based **ID3 algorithm**. Use an appropriate data set for building the decision tree and apply this knowledge to classify a new sample.
4. Build an Artificial Neural Network by implementing the **Back propagation algorithm** and test the same using appropriate data sets.
5. Write a program to implement the **naïve Bayesian classifier** for a sample training data set stored as a .CSV file. Compute the accuracy of the classifier, considering few test data sets.
6. Assuming a set of documents that need to be classified, use the **naïve Bayesian Classifier** model to perform this task. Built-in Java classes/API can be used to write the program. Calculate the accuracy, precision, and recall for your data set.
7. Write a program to construct a **Bayesian network** considering medical data. Use this model to demonstrate the diagnosis of heart patients using standard Heart Disease Data Set. You can use Java/Python ML library classes/API.

8. Apply **EM algorithm** to cluster a set of data stored in a .CSV file. Use the same data set for clustering using ***k*-Means algorithm**. Compare the results of these two algorithms and comment on the quality of clustering. You can add Java/Python ML library classes/API in the program.
9. Write a program to implement ***k*-Nearest Neighbour algorithm** to classify the iris data set. Print both correct and wrong predictions. Java/Python ML library classes can be used for this problem.
10. Implement the non-parametric **Locally Weighted Regression algorithm** in order to fit data points. Select appropriate data set for your experiment and draw graphs.

COMMUNICATION NETWORKS LAB

L	T	P	Credit
0	0	2	01

EC 314 **Scheme**

1. **Course Outcomes (COs):**

At the end of the course the students will be able to:

CO1	**Apply** the protocols and techniques in developing the standard networks using standard tools or software overcoming the constraints
CO2	**Analyze** the performance of various techniques and protocols in a given network topology, case study and problem solving as per given data.
CO3	**Design** the codes for the given protocols using appropriate tools

2. **Syllabus:**

1. Introduction to TCP/IP Networking Commands.
2. Cyclic Redundancy Check (CRC) Method for Error Detection.
3. Hamming Code for Error Detection and Correction.
4. Bit Stuffing.
5. Shortest Path Routing Algorithm.
6. Symmetric Key Ciphering and Deciphering using Classical Ciphers.
7. Asymmetric Key Ciphering and Deciphering using Modern Ciphers.
8. Introduction to Network Simulator (NS2)
9. Elementary Network Model design using NS2
10. Dynamic Network Model design for Optimum Routing using NS2
11. Local Area Network Architecture and its Performance Analysis using NS2
12. Wireless Network Implementation using NS2.

OPTICAL FIBER COMMUNICATION

L	T	P	Credit
3	0	0	03

EC 322 **Scheme**

1. Course Outcomes (COs):

At the end of the course students will be able to:

CO1	**Explain** the different types of fibers and optical components of an optical communication link.
CO2	**Apply** the concepts of light transmission in optical fiber communication link.
CO3	**Analyze** fiber, optical source, detector and components.
CO4	**Evaluate** optical fiber communication link parameters.
CO5	**Design** the optical fiber communication system.

2. Syllabus:

- **LIGHTWAVE TRANSMISSION** **(06 Hours)**
  Nature Of Light, Basic Optical Laws, Propagation Of Light In Fiber, Elements Of Fiber Optic Communication, Optical Spectrum, Optical Power, Types of Optical Fiber, Fiber Fabrication, Fiber Cables.

- **SIGNAL DEGRADATION AND MEASURMENTS** **(08 Hours)**
  Degradation Of Signals In Optical Fiber, Attenuation, Absorption Losses, Scattering Losses, Bending Losses, Effect Of Dispersion On Pulse Transmission, Intermodal, Intramodal and Waveguide Dispersion, Total Dispersion And Maximum Transmission Rates, Nonlinear Effects In Fiber, Numerical Aperture Measurements, Attenuation Measurement, Dispersion Measurement, OTDR Field Applications.

- **OPTICAL SOURCES** **(06 Hours)**
  Basic Structure, Principle And Operation and Types of Light Emitting Diode, Laser Diode, Comparison Between LED And LD.

- **PHOTO DETECTORS AND RECEIVER SYSTEM** **(06 Hours)**
  PIN Photodiode, Avalanche Photodiode, Comparison Between PIN Photodiode And APD, Fundamental Receiver Operation, Receiver Sensitivity, System Performance Evaluation Criteria, Eye Diagram, BER, OSNR, And Q-Factor.

- **POWER LAUNCHING, COUPLING AND LINK DESIGN** **(04 Hours)**
  Source To Fiber Power Launching, Lensing Schemes, Fiber To Fiber Joints, Connectors, Splicing, Point To Point Link, System Design Considerations, Power Budget, Rise Time Budget, Power Penalty.

- **OPTICAL AMPLIFIERS** **(04 Hours)**
  Principle of Optical Amplification, Erbium-Doped Fiber Amplifiers, Raman Amplifiers, Semiconductor Optical Amplifiers.

- **WDM CONCEPTS AND COMPONENTS** **(08 Hours)**
  Principles Of WDM, WDM System Configuration, Types of WDM System, WDM Components, Applications of WDM Systems.

(Total Contact Hours: 42)

3. Books Recommended:

1. Gerd Kaiser, "Optical Fiber Communication", 4th Ed., McGraw Hill, 2008.
2. Senior J. M., "Optical Fiber Communication - Principle and Practice", 3rd Ed., PHI, 2010.
3. T. L. Singhal, "Optical Fiber Communications: Principles and Applications", 1st Ed., Cambrige, 2015.
4. Ramaswami Rajiv and Sivarajan K. N., "Optical Networks A Practical Perspective", 3rd Ed., Elsevier, Morgan Kaufmann Publishers, 2009.
5. Agrawal G.P., "Fiber Optic Communication Systems", 4th Ed., John Wiley & Sons, 2010.

ELECTRONIC INSTRUMENTATION

L	T	P	Credit
3	0	0	03

EC 324 **Scheme**

1. **Course Outcomes (COs):**

At the end of the course the students will be able to:

CO1	**Describe** the fundamentals of Electronic Instrumentation, signal condition, signal converter, isolation techniques for different applications.
CO2	**Illustrate** data acquisition and converter systems
CO3	**Analyze** data for different types of signal conditioning circuits.
CO4	**Evaluate** different signal converters
CO5	**Design** instrumentation system that meets desired specifications and requirements.

2. **Syllabus:**

- **SIGNAL CONDITIONING FOR RESISTIVE / REACTIVE / SELF-GENERATING SENSORS** **(08 Hours)**
  Signal Conditioning For Resistive Sensors: Amplifiers For Voltage Dividers, Wheatstone Bridge: Balance Measurements, Deflection Measurements, Differential And Instrumentation Amplifiers, Interference, Signal Conditioning For Reactance Variation Sensors: AC Bridges, Carrier Amplifiers And Coherent Detection, Specific Signal Conditioners For Capacitive Sensors, Resolver-To-Digital And Digital-To-Resolver Converters, Signal Conditioning For Self-Generating Sensors: Chopper And Low-Drift Amplifiers, Electrometer And Trans-impedance Amplifiers, Charge Amplifiers, Noise In Amplifiers.

- **SIGNAL CONVERTERS** **(06 Hours)**
  I To P / P To I Converter, Temperature to Voltage Converter, Conversion To Frequency, Period, or Time Duration, Measurement of Phase Difference Using X-OR and SR Flip-Flop Method, Measurement of Active And Reactive Power of Supply Line, Locking Amplifiers, Variable Oscillators, Direct Sensor-Microcontroller Interfacing.

- **ISOLATION TECHNIQUES** **(06 Hours)**
  Transformer Isolation, Optical Isolation, Digital Techniques For Optical Isolation, Hall-Effect Principle and Measurement of Displacement, Current and Power Using Hall Sensors, Amplifications of Low Level Signals, Guarding, Shielding.

- **DATA ACQUISITION AND CONVERSION** **(06 Hours)**
  Analog Signal Processing, Sample And Hold Operation, S/H Circuits Using Op-Amps, Introduction To Data Acquisition System, Various DAS Configurations, Single Channel DAS, Multi-Channel DAS, IC Based DAS, Data Acquisition, Data Acquisition in PLC, SCADA.

- **TELEMETRY SYSTEMS** **(10 Hours)**

  Introduction To Telemetry System, Current Telemetry: 4 To 20 mA Loop, Design Of 2/4 Wire Transmitters, Simultaneous Analog And Digital Communication, Intelligent Sensors, Sensor Buses: Fieldbus, RS232, RS485, MODBUS, AS-I, Devicenet, Profibus, Foundation Fieldbus, Industrial Ethernet, Industrial IoT, Industry 4.0.

- **INSTRUMENTATION STANDARDS** **(06 Hours)**

  Static and Dynamic Characteristic Instrument Enclosure type: NEMA and Ingress protection standards, Test and Calibration: Primary and Secondary Standard, Safety Standard

(Total Contact Hours: 42)

3 Books Recommended

1. Ramon Pallas and John G. Webster, "Sensors and Signal Conditioning", 2nd Ed., John Wiley & Sons, 2001.
2. Rangan C. S., Sarma G. R. and Mani V. S. V., "Instrumentation Devices and Systems", 2nd Ed., Tata McGraw-Hill, 2004.
3. Helfrick Albert D. and Cooper W. D., "Modern Electronic Instrumentation and Measurement Techniques", 1st Ed., Prentice Hall India, 1990.
4. A. J. Bouvens, "Digital Instrumentation", 1st Ed., McGraw-Hill, 1997.
5. Johnson Curtis D., "Process Control Instrumentation Technology", 7th Ed., Prentice Hall, 2003.

MACHINE LEARNING

L	T	P	Credit
3	0	0	03

EC 326

Scheme

1. Course Outcomes (COs):

At the end of the course students will be able to:

CO1	**Describe** the differences in approaches and applicability of regression, classification, and clustering.
CO2	**Demonstrate** unsupervised and Reinforcement learning.
CO3	**Implement** feature extraction and selection to represent data as features to serve as input to machine learning models build an application that is based on machine learning.
CO4	**Design** given application based on suitable machine learning task.

2. Syllabus:

- **INTRODUCTION** **(10 Hours)**
  Introduction, Machine learning basics, Supervised Learning: Artificial Neural Network, classifying with k-Nearest Neighbour classifier, Support vector machine classifier, Decision Tree classifier, Naive Bayes classifier, Bagging, Boosting, Improving classification with the AdaBoost meta algorithm.

- **FORECASTING AND LEARNING THEORY** **(08 Hours)**
  Regression, Linear Regression, Multivariate Regression, Logistic regression, Principal Component Regression, Tree-based regression. Bias/variance trade-off, Union and Chernoff/Hoeffding bounds, Vapnik–Chervonenkis (VC) dimension.

- **UNSUPERVISED LEARNING** **(08 Hours)**
  Grouping unlabeled items using k-means clustering, Association analysis with the Apriori algorithm, efficiently finding frequent item sets with FP-growth.

- **REINFORCEMENT LEARNING** **(08 Hours)**
  Markov decision process (MDP), Bellman equations, Value iteration and policy iteration, Linear quadratic regulation, Linear Quadratic Gaussian, Q-learning, Value function approximation, Policy search, Reinforce, POMDPs.

- **DIMENSIONALITY REDUCTION** **(08 Hours)**
  Feature extraction - Principal component analysis, Singular value decomposition. Feature selection – feature ranking and subset selection, filter, wrapper and embedded methods. Machine Learning for Big data: Big Data and Map Reduce.

(Total Contact Hours: 42)

3. Books Recommended:

1. E. Alpaydin, "Introduction to Machine Learning", 2nd Ed., MIT Press, 2009.
2. T. M. Mitchell, "Machine Learning", McGraw-Hill, 1997.
3. Christopher M. Bishop, "Pattern Recognition and Machine Learning", 2nd Ed., Springer; 2011.
4. Miroslav Kubat , "An Introduction to Machine Learning", Springer (2017)
5. GopinathRebala, Ajay Ravi, Sanjay Churiwala, "An Introduction to Machine Learning", Springer (2019).

COMMUNICATION NETWORKS

L	T	P	Credit
3	0	0	03

EC 328 **Scheme**

1. **Course Outcomes (COs):**

At the end of the course the students will be able to:

CO1	**Describe** the basic knowledge of data communication methods, centralized/distributed networking architectures, OSI reference model, networking issues, protocols
CO2	**Illustrate** the suitable network protocols at various layers in computer networks along with the constraints
CO3	**Apply** the protocols and techniques in developing the standard networks using standard tools or software overcoming the constraints
CO4	**Analyze** the performance of various techniques and protocols in a given network topology, case study and problem solving as per given data.
CO5	**Design** the codes for the given protocols using appropriate tools

2. **Syllabus:**

- **DATA COMMUNICATION AND NETWORKING OVERVIEW** **(06 Hours)**
  A Communication Model, Data Communication, Networking Concept, Topology And Transmission Media, Subnet, Concept of Client and Server, An Example Configuration, The Need For Protocol Architecture, Protocol Architecture and peer processes, OSI Reference Model, The TCP/IP Protocol Stack.

- **DATA LINK CONTROL** **(05 Hours)**
  Medium Access Control (MAC) And Logical Link Control (LLC) Sublayer Issues, Flow Control, Error Control, Access Control, Sliding Window Protocol, Polling, High-Level Data Link Control (HDLC), PPP, Performance Issues.

- **LOCAL AREA NETWORKS — OVERVIEW** **(05 Hours)**
  LAN Protocol Architecture, Bridges, Emergence of High Speed LANs, Ethernet, Wireless LAN Technology (Wi-Fi) Protocols.

- **ROUTING AND CONGESTION CONTROL** **(06 Hours)**
  Logical Addresses, Circuit-Switching and Packet Switching Networks, Classful Addressing, Classless Addressing (CIDR), Subnetting, Supernetting, Network Address Translation, Routing In Packet-Switching Networks, Broadcasting, Multicasting, Flooding, Routing Algorithms, Effects Of Congestion, Congestion Control In Packet-Switching Networks. IP address classes, Ad-Hoc network Routing constraints. Mobile IP and its architecture

- **INTERNETWORK PROTOCOLS** **(05 Hours)**
  Basic Protocol Functions, Principles Of Internetworking, Fragmentation Concept, Connectionless Internetworking, Gateway And Routers, The Internet with IPv4 and IPv6 packet formats, ARP, RARP, DHCP, ICMP, IGMP.

- **TRANSPORT PROTOCOLS** **(04 Hours)**
  Port Addresses, Quality Of Service Parameter, TCP, UDP and SCTP Protocols Mobile TCP

- **NETWORK SECURITY** **(04 Hours)**
  Security Requirement And Attacks, Cryptography, Classical Ciphers, Modern Ciphers, Confidentiality With Encryption, Message Authentication And Hash Functions, Public-Key Encryption And Digital Signatures

- **DISTRIBUTED APPLICATIONS** **(07 Hours)**
  Network Virtual Terminal (TELNET), File Transfer Protocol (FTP), Electronic Mail - SMTP And MIME, Hyper Transfer Protocol (HTTP), Network Management - SNMP, Domain Name Server (DNS), URL, WWW.

(Total Contact Hours: 42)

3. Books Recommended:

1. David. A. Patterson and John L. Hennessy, "Computer Organization and Design: The Hardware/Software Interface", 5th Ed., Morgan-Kaufmann Publishers Inc. 2014.
2. Linda Null and Julia Lobur, "The Essentials of Computer Organization and Architecture", 4th Ed., Jones & Bartlett Learning, 2014.
3. Alan Clements, "Principles of Computer Hardware", 4th Ed., Oxford University Press, 2006.
4. Stephen Brown and Zvonko Vranesic, "Fundamentals of Digital Logic with Verilog Design", McGraw-Hill, 2003.
5. M. Morris Mano, "Digital Design", 3rd Ed., Prentice Hall, Upper-Saddle River, New Jersey, 2002.

HIGH PERFORMANCE COMPUTING

L	T	P	Credit
3	0	0	03

EC 362 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	**Explain** parallel programs for scientific computations.
CO2	**Demonstrate** tools for performance optimization and debugging.
CO3	**Analyze** code with respect to performance and suggest and implement performance improvements.
CO4	**Appraise** on performance analysis in clear and correct writing.
CO5	**Develop** different HPC solutions to common problems found in Computational Science.

2. Syllabus:

- **PARALLEL PROCESSING CONCEPTS (QUICK OVERVIEW)** **(04 Hours)**
  Levels of parallelism (instruction, transaction, task, thread, memory, function), Models (SIMD, MIMD, SIMT, SPMD, Dataflow Models, Demand-driven Computation etc), Architectures: N-wide superscalar architectures, multi-core, multi-threaded

- **PARALLEL PROGRAMMING WITH CUDA** **(10 Hours)**
  Processor Architecture, Interconnect, Communication, Memory Organization, and Programming Models in high performance computing architectures: (Examples: IBM CELL BE, Nvidia Tesla GPU, Intel Larrabee Microarchitecture and Intel Nehalem microarchitecture), Memory hierarchy and transaction specific memory design, Thread Organization

- **FUNDAMENTAL DESIGN ISSUES IN PARALLEL COMPUTING** **(10 Hours)**
  Synchronization, Scheduling, Job Allocation, Job Partitioning, Dependency Analysis, Mapping Parallel Algorithms onto Parallel Architectures, Performance Analysis of Parallel Algorithms

- **FUNDAMENTAL LIMITATIONS FACING PARALLEL COMPUTING** **(06 Hours)**
  Bandwidth Limitations, Latency Limitations, Latency Hiding/Tolerating Techniques and their limitations

- **POWER-AWARE COMPUTING AND COMMUNICATION** **(06 Hours)**
  Power-aware Processing Techniques, Power-aware Memory Design, Power-aware Interconnect Design, Software Power Management

- **ADVANCED TOPICS** **(06 Hours)**

  Petascale Computing, Optics in Parallel Computing, Quantum Computers, Recent developments in Nanotechnology and its impact on HPC

(Total Contact Hours: 42)

3. Books Recommended:

1. Ananth Grama, Anshul Gupta, George Karypis, and Vipin Kumar, "Introduction to Parallel Computing", 2nd Ed., Addison-Welsey, 2004.
2. William James Dally and Brian Towles, "Principles and Practices on Interconnection Networks", 1st Ed., Morgan Kauffman, 2004.
3. GPU Gems 3 --- by Hubert Nguyen (Chapter 29 to Chapter 41)
4. James H. Laros III, Kevin Pedretti, Suzanne M. Kelly, Wei Shu, Kurt Ferreira, John Van Dyke, and Courtenay Vaughan, "Energy-Efficient High-performance Computing-Measurement and Tuning", 1st Ed., Springer, 2013
5. Oscar Montiel Ross and Roberto Sepúlveda Cruz, "High Performance Programming for Soft Computing", 1st Ed., CRC press, 2014

COMPUTER VISION

L	T	P	Credit
3	0	0	03

EC 364 **Scheme**

1. **Course Outcomes (COs):**

At the end of the course the students will be able to:

CO1	**Describe** shape analysis and Implement boundary tracking techniques.
CO2	**Apply** feature extraction methods for computer processing.
CO3	**Analyze** pattern recognition algorithms for real world problems.
CO4	**Evaluate** motion related techniques.
CO5	**Design** of face detection and recognition algorithms.

2. **Syllabus:**

- **CAMERAS** **(06 Hours)**
  Pinhole Cameras, Radiometry – Measuring Light: Light in Space, Light Surfaces, Important Special Cases, Sources, Shadows, And Shading: Qualitative Radiometry, Sources and Their Effects, Local Shading Models, Application: Photometric Stereo, Interreflections: Global Shading Models, Color: The Physics of Color, Human Color Perception, Representing Color, A Model for Image Color, Surface Color from Image Color, Two Views, Stereopsis: Reconstruction, Human Stereposis, Camera-Computer interface.

- **LOW-LEVEL PROCESSING** **(04 Hours)**
  Transformation: Orthogonal, Euclidean, Affine, Projective, etc; Fourier Transform, Convolution and Filtering, Image Enhancement, Restoration, Histogram Processing.

- **SEGMENTATION BY FITTING A MODEL** **(06 Hours)**
  The Hough Transform, Fitting Lines, Fitting Curves, Fitting as a Probabilistic Inference Problem, Robustness, Segmentation and Fitting Using Probabilistic Methods: Missing Data Problems, Fitting, and Segmentation, The EM Algorithm in Practice, Tracking With Linear Dynamic Models: Tracking as an Abstract Inference Problem, Linear Dynamic Models, Kalman Filtering, Data Association, Applications and Examples.

- **FEATURE EXTRACTION** **(08 Hours)**
  Edges - Canny, LOG, DOG; Line detectors (Hough Transform), Corners - Harris and Hessian Affine, Orientation Histogram, SIFT, SURF, HOG, GLOH, Scale-Space Analysis- Image Pyramids and Gaussian derivative , Gabor Filters and DWT.

- **PATTERN AND MOTION ANALYSIS** **(10 Hours)**
  Clustering: K-Means, K-Medoids, Mixture of Gaussians, Classification: Discriminant Function, Supervised, Un-supervised, Semi-supervised; Classifiers: Bayes, KNN.
  Background Subtraction and Modeling, Optical Flow, KLT, Spatio-Temporal Analysis, Dynamic Stereo; Motion parameter estimation.

- **APPLICATION USING OpenCV AND MATLAB** **(08 Hours)**
  Introduction to Robotic Operating System (ROS), Installation and tasting ROS camera drivers, ROS to OpenCV, Introduction to OpenCV image processing library and MATLAB programming, Finger print recognition, Face detection and recognition, Object tracking, medical Diagnosis etc

(Total Contact Hours: 42)

3. Books Recommended:

1. Richard Szeliski, "Computer Vision: Algorithms and Applications", Springer-Verlag London Limited 2011
2. D. A. Forsyth, J. Ponce, "Computer Vision: A Modern Approach", 2nd Ed., Pearson Learning 2015.
3. K.S.Fu., R.C. Gonzalez CSG. Lee, "Robotics Control sensing vision and Intelligence", McGraw Hill Education Pvt. Ltd. 2013.
4. E. Tresso and A. Verri, "Introductory Techniques for 3-D Computer Vision", Prentice-Hall, 1998.
5. Bradsky & Kaehler, "Learning Open CV", , O'Reilly;

4. Reference Book:

1. E. R. Davies: "Computer and Machine Vision – Theory", Algorithms and Practicalities, 4th Ed., Elsevier (Academic Press), 2013.

MEMS

L	T	P	Credit
3	0	0	03

EC 366 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	**Describe** different electrical and mechanical properties of material used for MEMS and then investigate the impact of strain on MEMS technology.
CO2	**Apply** the theory of thermal and electrostatic sensing & actuation.
CO3	**Analyze** the Piezo-electric properties of material for micro sensor design.
CO4	**Evaluate** different micromachining techniques for MEMS process.
CO5	**Investigate** the various opportunities and challenges in the emerging field of MEMS technology.

2. Syllabus:

- **OVERVIEW OF MEMS AND MICRO-FABRICATION** **(08 Hours)**
  Introduction to MEMS Development, Characteristics of MEMS, Microelectronics Integration, Micro Fabrication Flow and Frequent Processing Steps, Silicon-based MEMS Processes, Overview of Beyond Silicon Material for MEMS

- **ELECTRO-MECHANICAL THEORY OF MEMS MATERIAL** **(10 Hours)**
  Conductivity of Semiconductors, Crystal Plane and Orientation, Tensile Stress and Strain, Mechanical Properties of Silicon and Thin Films, Flexural Beam Bending Analysis Under Loading Conditions, Torsional Deflection, Intrinsic Stress, Dynamic System, Resonance and Quality Factor.

- **FUNDAMENTAL OF SENSING AND ACTUATION** **(10 Hours)**
  Electrostatic Sensing and Actuation, Theory and Application of Parallel Plate Capacitor, Overview and Application Thermal Sensing, Piezo-resistive Sensor Materials and Their Stress Analysis, Applications of Piezo-resistive Sensors.

- **BULK AND SURFACE MICROMACHINING TECHNIQUES** **(08 Hours)**
  Types of Etching Techniques (definition and overview), Wet Etching for Simple Structures of Silicon, Basic Surface Micromachining Process, Structural and Sacrificial Material.

- **ADVANCEMENT IN MEMS TECHNOLOGY** **(06 Hours)**
  LIGA Process, Wafer Bonding, Polymer MEMS, Micro-fluidics Applications.

(Total Contact Hours: 42)

3. Books Recommended:

1. Chang Liu, “Foundations of MEMS”, 2nd Ed., Pearson International, 2011.
2. Gaberiel M.Rebiz, “RF MEMS Theory, Design and Technology”, John Wiley & Sons, 2003.
3. Charles P. Poole, Frank J.Owens, “Introduction to nanotechnology” John Wiley & sons, 2003.
4. Julian W. Gardner, Vijay K Varadhan, “Microsensors, MEMS and Smart devices”, John Wiley & sons, 2001.
5. Veikko Lindroos, Markku Tilli, Ari Lehto and Teruaki Motooka, “Handbook of Silicon Based MEMS Materials and Technologies”, 1st Ed., William Andrew, 2010.

PROFESSIONAL ETHICS, ECONOMICS AND BUSINESS MANAGEMENT

L	T	P	Credit
3	1	0	04

HU 304 **Scheme**

1. **Course Outcomes (COs):**

At the end of the course the students will be able to:

CO1	**Identify** application of ethics in society and development of understanding regarding Professional ethical issues related to Electronics engineering
CO2	**Develop** managerial skills to become future engineering managers
CO3	**Develop** skills related to various functional areas of management (Marketing Management, Financial Management, Operations Management, Personnel Management etc.)
CO4	**Build** knowledge about modern management concepts (ERP, SCM, e-CRM, etc.)
CO5	**Develop** experiential learning through Management games, Case study discussion, Group discussion etc.
CO6	**Apply** knowledge of Economics and Business management aspects in Electronics engineering

2. **Syllabus:**

- **PROFESSIONAL ETHICS** **(12 Hours)**
  Introduction, Approaches to Ethics, Meaning of Ethics, Major attributes of Ethics, Business Ethics, Factors influencing Ethics, Importance of Ethics, Ethics in Management, Organizational Ethics, Ethical aspects in Marketing, Mass communication and Ethics - Television, Whistle blowing, Education – Ethics and New Professional, Intellectual Properties and Ethics, Introduction to Professional Ethics, Engineering Ethics, Ethical issues related to Electronics Engineering.

- **ECONOMICS** **(06 Hours)**
  Introduction To Economics, Micro & Macro Economics, Applications & Scopes Of Economics, Demand Analysis, Demand Forecasting, Factors Of Production, Types Of Cost, Market Structures, Break Even Analysis.

- **MANAGEMENT** **(08 Hours)**
  Introduction to Management, Features Of Management, Nature Of Management, Development of Management Thoughts – Scientific Management By Taylor & Contribution of Henry Fayol, Coordination & Functions Of Management, Centralization & Decentralization, Decision Making; Fundamentals of Planning; Objectives & MBO; Types of Business Organizations: Private Sector, Public Sector & Joint Sector; Organizational Behavior: Theories of Motivation, Individual & Group Behavior, Perception, Value, Attitude, Leadership.

- **FUNCTIONAL MANAGEMENT** **(12 Hours)**
  Marketing Management: Core Concepts Of Marketing, Marketing Mix (4p), Segmentation – Targeting – Positioning, Marketing Research, Marketing Information System, Concept of International Marketing, Difference Between Domestic Marketing & International Marketing; Operations Management: Introduction to Operations Management, Types of Operation Systems, Types of Layouts, Material Handling, Purchasing & Store System, Inventory Management; Personnel Management: Roles & Functions of Personnel Manager, Recruitment, Selection, Training, Industrial Dispute, Collective Bargaining; Financial Management: Goal of Financial Management, Key Activities In Financial Management, Organization of Financial Management, Financial Institutions, Financial Instruments, Sources of Finance.

- **MODERN MANAGEMENT ASPECTS** **(04 Hours)**
  Introduction To ERP, e – CRM, SCM, RE – Engineering, WTO, IPR Etc.
- **TUTORIAL** **(14 Hours)**

(Total Contact Hours: 56)

3. **Books Recommended:**

1. Balachandran V.and Chandrasekaran, Corporate Governance, Ethics and Social Responsibility, 2nd Ed., PHI, 2011.
2. Prasad L.M., Principles & Practice Of Management, 8th Ed., Sultan Chand & Sons, 2015.
3. Banga T. R. & Shrama S.C., Industrial Organisation & Engineering Economics, 25th Ed., Khanna Publishers, 2015.
4. Everett E. Adam, Ronald J. Ebert, Production and Operations Management, 5th Ed., Prentice Hall of India, 2012.
5. Kotler P., Keller K. L, Koshi A. & Jha M., 14th Ed., Marketing Management – A South Asian Perspective, Pearson, 2014.

4. **Reference Books:**

1. Tripathi P.C.,Personnel Management & Industrial Relations, 21st Ed., Sultan Chand & sons, 2013.
2. Chandra P., Financial Management, 9th Ed., Tata McGraw Hill, 2015.Crane A. & Matten D., Business Ethics: Managing Corporate Citizenship and Sustainability in the Age of Globalisation, Oxford University, 2010.
3. Fritzsche D. J., Business Ethics: a Global and Managerial Perspectives, McGraw Hill Irwin, Singapore, 2004.
4. Mandal S. K., Ethics in Business and Corporate Governance, Tata McGraw Hill, 2011.

Electronics Engineering Department

B. Tech. Electronics and Communication Engineering

Scheme

SEMESTER – VII

Sr. No.	Subject	Code	Scheme	Credit	Examination Scheme				
					Theory Marks	Tutorial Marks	Term work Marks	Practical Marks	Total Marks
1.	Core-14 – Microwave Engineering	EC 401	3-1-2	05	100	25	25	25	175
2.	Core-15 – VLSI Design	EC 403	3-1-2	05	100	25	25	25	175
3.	Core Elective-III	EC 4XX/ EC 6XX	3-0-0	03	100	-	-	-	100
4.	Core Elective-IV	EC 4XX/ EC 6XX	3-0-0	03	100	-	-	-	100
5.	Summer Training*	EC 405	0-0-0	02	-	-	25	25	50
6.	Project Preliminaries	EC 407	0-0-6	03	-	-	75	75	150
		Total	**12-2-10=24**	**21**	**400**	**50**	**150**	**150**	**750**

* Summer Training is to be organized during the summer vacation after 6th Semester.

List of Subjects for Core Elective III & IV

Sr. No.	Subject	Code	Scheme	Credit
1.	Error Control Coding	EC 409	3-0-0	03
2.	Optical Wireless Communication	EC 411	3-0-0	03
3.	Antenna Theory	EC 621	3-0-0	03
4.	Satellite Communication	EC 623	3-0-0	03
5.	Advanced Electronic Circuits	EC 625	3-0-0	03
6.	Deep Learning	EC 627	3-0-0	03
7.	Biomedical Instrumentation	EC 629	3-0-0	03
8.	Advanced Processer Architecture	EC 631	3-0-0	03
9.	Internet of Things	EC 633	3-0-0	03
10.	Robotics	EC 635	3-0-0	03
11.	Embedded Systems	EC 637	3-0-0	03

SEMESTER – VIII

Sr. No.	Subject	Code	Scheme	Credit	Examination Scheme				
					Theory Marks	Tutorial Marks	Term work Marks	Practical Marks	Total Marks
1.	Core Elective-V	EC 6XX	3-0-0	03	100	-	-	-	100
2.	Core Elective-VI	EC 6XX	3-0-0	03	100	-	-	-	100
3.	Core Elective-VII	EC 6XX	3-0-0	03	100	-	-	-	100
4.	Innovation, Incubation and Entrepreneurship	HU 410	3-0-0	03	100	-	-	-	100
5.	Project	EC 402	0-0-12	06	-	-	150	150	300
		Total	**12-0-12=24**	**18**	**400**	-	**150**	**150**	**700**

List of Subjects for Core Elective V, VI & VII

Sr. No.	Subject	Code	Scheme	Credit
1.	Biomedical Signal Processing	EC 622	3-0-0	03
2.	Ad-Hoc Networks	EC 624	3-0-0	03
3.	Nanoelectronics	EC 626	3-0-0	03
4.	VLSI Signal Processing	EC 628	3-0-0	03
5.	Microwave Integrated Circuits	EC 632	3-0-0	03
6.	MIMO Communication systems	EC 634	3-0-0	03
7.	Testing and Verification of VLSI Circuits	EC 636	3-0-0	03
8.	VLSI System Design	EC 638	3-0-0	03
9.	Optical Networks	EC 642	3-0-0	03
10.	Global Navigation Satellite System	EC 644	3-0-0	03
11.	Radar Systems	EC 646	3-0-0	03
12.	Estimation and Detection Theory	EC 648	3-0-0	03
13.	Speech Processing and Human-Machine Communication	EC 652	3-0-0	03
14.	Real Time Systems	EC 654	3-0-0	03
15.	Photonic Integrated Devices and Systems	EC 656	3-0-0	03
16.	Visible Light Communication	EC 658	3-0-0	03
17.	EM Interference and Compatibility	EC 662	3-0-0	03

Course	Semester	Credit
B. Tech. – I	Semester – I	24
	Semester – II	25
B. Tech. – II	Semester – III	22
	Semester – IV	23
B. Tech. – III	Semester – V	22
	Semester – VI	21
B. Tech. – IV	Semester – VII	21
	Semester – VIII	18
	Total UG Credit	**176**

MICROWAVE ENGINEERING

L	T	P	Credit
3	1	2	05

EC 401 **Scheme**

1. **Course Outcomes (COs):**

At the end of the course students will be able to:

CO1	**Explain** the working principle of waveguide based and microstrip based components, sources and their applications.
CO2	**Apply** the knowledge of transmission line theory to waveguide components, microstrip components and antennas.
CO3	**Analyze** the electric and magnetic field modes in microstrip based and waveguide based components in association with the communication systems.
CO4	**Evaluate** the different parameters of microwave communication system.
CO5	**Design** the matching networks, microstrip filters of different orders, waveguide based hybrid circuits and Microwave integrated circuits.

2. **Syllabus:**

- **INTRODUCTION** **(02 Hours)**
  Circuit-Field Relations, RF Behavior of Passive Components, Chip Components.

- **MICROWAVE WAVEGUIDES AND COMPONENTS** **(08 Hours)**
  Introduction, Rectangular Waveguides, Rectangular Cavity Resonators, Circular Waveguides, Microwave Hybrid Circuits: Waveguides Tees, Magic Tees, Directional Couplers, radiation from rectangular and circular apertures, Radiation from sectoral and pyramidal horns.

- **MICROWAVE NETWORK ANALYSIS AND IMPEDANCE MATCHING** **(06 Hours)**
  Basic Definitions, Interconnecting Networks, Network Properties And Application, ABCD and Scattering Parameters, Impedance Matching using Discrete Components, Microstrip Line Matching Networks.

- **POWER DIVIDERS AND DIRECTIONAL COUPLERS** **(07 Hours)**
  The T Junction Power Divider, The Wilkinson Power Divider, The Quadrature (90°) Hybrid, Coupled Line Directional Couplers, Ratrace and Hybrid Ring.

- **MICROWAVE FILTERS** **(06 Hours)**
  Basic Resonator and Filter Configurations, Periodic Structures, Filter Design by the Image Parameter Method, Special Filter Realizations, Stepped-Impedance Low-Pass Filters, Coupled Line Filters.

- **MICROWAVE DIODES AND TUBES** **(06 Hours)**
  GaAs FET, HEMT, Varactor diodes, PIN diodes, IMPATT, TRAPATT and BARITT, Microwave Tunnel Diodes, Gunn Diodes, Schottky Diodes and Detectors, Microwave Unipolar and Bipolar Transistor: physical structure, principle of operation, characteristics, Klystrons, Magnetrons and TWT.

- **MICROWAVE ANTENNAS** **(04 hours)**
  Fundamentals of Antenna, Antenna Arrays, Microstrip, Helical, Yagi-Uda, Log-Periodic and Reflector Antennas.

- **MICROWAVE COMMUNICATION SYSTEMS AND OTHER APPLICATIONS** **(03 hours)**
  Overview of Radar, Cellular Communication, Satellite Communication

- **TUTORIALS** **(14 Hours)**

(Total Contact Hours: 56)

3. **Practicals:**
   1. Introduction to Microwave Bench.
   2. To determine the frequency & wavelength in a rectangular wave-guide working on TE10 mode
   3. To obtain characteristics of Attenuator (Fixed and Variable type)
   4. To verify properties of Magic Tee
   5. To verify properties of Directional Coupler.
   6. To obtain characteristics of Microstrip Band Pass and Band Stop Filters.
   7. To obtain characteristics of Microstrip Power Divider.
   8. To plot Mode Characteristics of Reflex Klystron.
   9. To plot of V-I characteristics of Gunn Diode
   10. To verify properties of Resonant Cavity
   11. Study and analysis of EMI and EMC standards.
   12. Experiments on Microwave Measurements :
       Power measurements: Calorimeter method, Bolometer bridge method
       Measurement of Cavity Q, Measurement of S parameters of a Network.

4. **Books Recommended:**
   1. Ludwig Reinhold and Bretchko Pavel, "RF Circuits Design: Theory and Applications", 1st Ed., Pearson Education, Low Price ed., 2000.
   2. Liao Samuel Y., "Microwave Devices and Circuits", 3rd Ed., PHI, 2nd Reprint, 2006.
   3. Pozar M. David, "Microwave Engineering", John Wiley & Sons, Inc., 1999.
   4. C. A. Balanis, "Antenna Theory and Design", 4th Ed., John Wiley & Sons, 2016.
   5. Annapurna Das, Sisir K Das, "Microwave Engineering", 3rd Ed., Mc Graw Hill, Reprint 2017.

5. **Reference Book:**
   1. Kumar A., "Microwave Techniques: Transmission Line", 1st Ed., New Age International, 1998.

VLSI DESIGN

L	T	P	Credit
3	1	2	05

EC 403 **Scheme**

1. Course Outcomes (COs):

At the end of the course students will be able to:

CO1	**Describe** VLSI Design flow and circuit characterization for performance estimation.
CO2	**Demonstrate** dynamic Logic circuits.
CO3	**Compare** different semiconductor memories.
CO4	**Evaluate** the circuit performance using Logical efforts.
CO5	**Design** arithmetic building blocks (data-path) from the system's perspective along with the design of FSM (Control-path).

2. Syllabus:

- **INTRODUCTION OF VLSI DESIGN** **(06 Hours)**
  Historical Perspective, Design Hierarchy, Concepts of Regularity, Modularity and Locality, VLSI Design Styles, VLSI Design Flow, Semi Custom- Full Custom IC Design Flow, Data Path, Control Path Programmable Logic Array, CMOS and Bipolar Transistor Gate Arrays and Their Limitations, Standard Cells, FPGA/CPLD Architecture.

- **DYNAMIC LOGIC CIRCUITS** **(06 Hours)**
  Voltage Bootstrapping, Synchronous Dynamic Circuit Techniques, Dynamic and High Performance Dynamic CMOS Circuit, Dynamic Latches and Registers.

- **CIRCUIT CHARACTERIZATION FOR PERFORMANCE ESTIMATION** **(07 Hours)**
  Interconnect, Estimation of Interconnect Parasites, Delay Estimation, Logical Efforts and Transistor Sizing, Power Dissipation, Design Margin, Reliability.

- **SEMICONDUCTOR MEMORIES** **(08 Hours)**
  Type of Memories, design and analysis of ROM Cells, Static and Dynamic Read - Write Memories, Memory Peripheral Circuits, Power Dissipation in Memory, Flash Memory.

- **DESIGN OF ARITHMETIC BUILDING BLOCKS** **(10 Hours)**
  Data Path Operations: Adders, Shifter, Multiplier, Power and Speed Trade-off in Data-path Structures, Control Path and FSM.

- **INPUT-OUTPUT CIRCUITS** **(05 Hours)**
  ESD Protection, Input Circuits, Output Circuits, Pad Drivers and Protection Circuit, On-Chip Clock Generation/Distribution, Latch-up and its Prevention.

- **TUTORIALS** **(14 Hours)**

(Total Contact Hours: 56)

3. Practical:

1. Introduction to Verilog HDL and FPGA.
2. Implementation and Simulation of Logic Gate using Verilog HDL on FPGA
3. Design and Implementation of Half adder and Full Adder using Verilog HDL on FPGA.
4. Design and Implementation of Half subtractor and Full Subtractor using Verilog HDL on FPGA.
5. Design and Implementation of Ripple Carry Adder using Verilog HDL on FPGA.
6. Design and Implementation of Multiplexer using Verilog HDL on FPGA.
7. Design and Implementation of Flip-Flops using Verilog HDL on FPGA.
8. Design and Implementation of Registers using Verilog HDL on FPGA.
9. Design and Implementation of Four Bit Up-Down Counter using Verilog HDL on FPGA.
10. Design and Implementation of Array Building Blocks.

4. BOOKS RECOMMENDED:

1. Sung-Mo Kang and Leblebici Y., "CMOS Digital Integrated Circuits: Analysis and Design", 3rd Ed., Tata McGraw-Hill, 2003.
2. Rabaey Jan, Chandrakasan Anantha and Borivoje Nikolic, "Digital Integrated Circuits": A Design Perspective, Pearson Education, 2nd Ed., Second Impression, 2008.
3. Weste Neil H.E, Harris D. and Banerjee A., "CMOS VLSI Design: A Circuits and Systems Perspective", 3rd Ed., Pearson Education, 2002.
4. Samir Palnitkar, "Verilog Hdl"– 2nd Ed., Pearson, 2003.
5. Bhasker J., "A Verilog Hdl Primer", 3rd Ed., BS Publication, 2008.

5. Reference Book:

1. Pucknell D.A. and Eshraghian K., "Basic VLSI Design, 3rd Ed., Prentice Hall of India", 2003.

ERROR CONTROL CODING

L	T	P	Credit
3	0	0	03

EC 409 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	**Explain** various mathematical tools: groups and finite fields, Linear algebra in the development of codes and sequences.
CO2	**Demonstrate** various codes and application in Communication for error correction
CO3	**Compare** the strengths and weaknesses of various errors correcting code for a given application.
CO4	**Evaluate** the different error correcting codes in digital communication system.
CO5	**Develop** and model different error correcting codes for appraise of reaching data rate to Shannon limit.

2. Syllabus:

- **CHANNEL CAPACITY AND CODING** **(06 Hours)**
  Introduction, Channel Models, Channel Capacity, Channel Coding, Information Capacity Theorem, The Shannon Limit, Random Selection of Codes, Hamming Distance, Few Points Of Information Theory.

- **BLOCK CODES** **(05 Hours)**
  The Digital Communication Channel, Introduction to Block Codes, Single Parity Check Codes, Product Codes, Repetition Codes, Hamming Codes, Minimum Distance Of Block Codes, Soft - Decision Decoding, Automatic Repeat Request Schemes.

- **LINEAR CODES** **(05 Hours)**
  Definition of Linear Codes, Generator Matrices, The Standard Array, Parity - Check Matrices, Error Syndromes, Error Detection And Correction, Shortened And Extended Linear Codes.

- **CYCLIC CODES** **(06 Hours)**
  Definition Of Cyclic Codes, Polynomials, Generator Polynomials, Encoding Cyclic Codes, Decoding Cyclic Codes, Factors Of x^n+1, Parity-Check Polynomials, Dual Cyclic Codes, Generator And Parity-Check Matrices Of Cyclic Codes, Design of cyclic coder using LFSR.

- **BCH CODES** **(05 Hours)**
  Linear Algebra, Galois Field, Definition and Construction of Binary BCH Codes, Error Syndromes In Finite Fields, Decoding SEC and DEC, Reed-Solomon Codes.

- **CONVOLUTION CODES** **(06 Hours)**
  Convolution, Encoding Convolutional Codes, Generator Matrices for Convolutional Codes, Generator Polynomials For Convolutional Codes, Graphical Representation Of Convolutional Codes, The Viterbi Decoder, Minimum distance.

- **ADVANCE ERROR CONTROL CODING** **(09 Hours)**

  Concept Of Puncturing, Interlever, Turbocode, Trellis Coded Modulation (TCM), LDPC Codes, Applications of Error Control Coding.

(Total Contact Hours:42)

3. Books Recommended:

1. Gravano Salvatore, "Introduction to Error Control Codes", 1st Ed., Oxford University Press, 2007.
2. Shulin/ Daniel J.Costello Jr., "Error Control Coding, Prentice Hall series in computer applications in electrical engineering" 2nd Ed:, Series, 2005.
3. Bose Ranjan, "Information Theory, Coding and Cryptography", 1st Ed., Tata McGraw-Hill, 2007.
4. Moon Tood K., "Error Correction Coding - Mathematical Methods and Algorithms", 1st. Ed., Wiley- Interscience, 2006.
5. SklarBernard, "Digital Communications - Fundamentals and Applications", 2nd Ed., Pearson Education-LPE, 2009.

OPTICAL WIRELESS COMMUNICATION

L	T	P	Credit
3	0	0	03

EC 411 **Scheme**

1. **Course Outcomes (COs):**

At the end of the course the students will be able to:

CO1	**Describe** atmospheric channels for the intended terrestrial free space optical link.
CO2	**Apply** the concepts of OWC to calculate the system performance under background noise effects.
CO3	**Analyze** various modulation/demodulation techniques in designing of transmitter/receiver for OWC system.
CO4	**Evaluate** various detection techniques under various atmospheric conditions
CO5	**Design** the OWC system under different weather conditions.

2. **Syllabus:**

- **INTRODUCTION** **(06 Hours)**
  General introduction, optical channel - Beam divergence, atmospheric losses, weather condition influence, atmospheric turbulence effects viz., scintillation, beam wander, beam spreading, etc.

- **CHANNEL MODELLING** **(07 Hours)**
  Linear time invariant model, channel transfer function, optical transfer function, models of turbulence induced fading viz., lognormal, exponential, K distribution, I- distribution, gamma-gamma distribution, Optical wave models - Plane, spherical and Gaussian, range equation, transmitting and receiving antenna gains.

- **BACKGROUND NOISE EFFECTS** **(07 Hours)**
  Background noise source, detector FOV, diffraction limited FOV, spatial modes, background noise power calculation.

- **MODULATION TECHNIQUES** **(07 Hours)**
  Power efficiency, BW efficiency, bit versus symbol error rates, error rate evaluation for isochronous modulation schemes viz., M-PPM, OOK, mxnPAPM schemes, subcarrier modulation, an isochronous modulation schemes - DPPM, DHPIM, DAPPM, psd and bandwidth requirement.

- **DETECTION TECHNIQUES** **(08 Hours)**
  Photon counter, PIN/APD, PMT, coherent techniques viz., homodyne and heterodyne, bit error rate evaluation in presence of atmospheric turbulence, concept of adaptive threshold.

- **WEATHER IMPAIRMENTS** **(07 Hours)**
  Effect of turbulence and weather conditions viz., drizzle, haze fog on error performance and channel capacity, link availability.

(Total Contact Hours: 42)

3. Books Recommended:

1. Z. Ghassemlooy, W. Popoola, S. Rajbhandari, "Optical Wireless Communications", 1st Ed., CRC Press, 2013.
2. L. C. Andrews, R.L.Phillips, "Laser Beam Propagation through Random Media", 2nd Ed., SPIE Press, USA, 2005.
3. J. H. Franz, V. K. Jain, "Optical Communications: Components and Systems", 1st Ed., Narosa Publishing House, 2000.
4. D. Chadha, "Terrestrial Wireless Optical Communication", 1st Ed., Tata McGraw-Hill, 2012.
5. Ramaswami Rajiv and Sivarajan K. N., "Optical Networks A Practical Perspective", Elsevier, 3rd Ed., Morgan Kaufmann Publishers, 2009.

ANTENNA THEORY

L	T	P	Credit
3	0	0	03

EC 621 **Scheme**

1. Course Outcomes (COs):

At the end of the course students will be able to:

CO1	**Describe** the working principle of different antennas.
CO2	**Apply** the developed theories to model different radiating systems.
CO3	**Compare** the various antennas in terms of their design, functionality, use etc.
CO4	**Evaluate** the radiation and impedance characteristics of aperture, broadband, microstrip antennas and arrays.
CO5	**Design** suitable antennas and validate their performance for antenna arrays and smart antennas, mathematically analyze the types of antenna arrays.

2. Syllabus:

- **FUNDAMENTAL CONCEPTS** **(04 Hours)**
  Physical concept of radiation, Radiation pattern, Near- and Far-field regions, Reciprocity, Directivity and Gain, Effective Aperture, Polarization, Input Impedance, Efficiency, Friis transmission equation, Radiation integrals and Auxiliary Potential Functions.

- **RADIATION FROM WIRES AND LOOPS** **(06 Hours)**
  Infinitesimal dipole, Finite-length Dipole, Linear Elements near Conductors, Dipoles for Mobile Communication, Small Circular Loop Folded Dipole.

- **APERTURE ANTENNAS** **(08 Hours)**
  Huygens' Principle, Radiation from Rectangular and Circular Apertures, Design Considerations, Babinet's Principle, Radiation from Sectoral and Pyramidal Horns, Design Concepts.

- **REFLECTOR ANTENNAS** **(05 Hours)**
  Parabolic Reflector, Paraboloidal Reflector, Aperture Pattern of Large Circular Apertures with Uniform Illumination, Off axis operation of Paraboloidal Reflectors, Cassegrain feed system.

- **BROADBAND ANTENNAS** **(04 Hours)**
  Broadband concept, Log-periodic antennas, Frequency independent antennas.

- **MICROSTRIP ANTENNAS** **(06 Hours)**
  Basic characteristics of microstrip antennas, Feeding methods, Methods of Analysis, Design of Rectangular and Circular Patch Antennas.

- **ANTENNA ARRAYS** **(05 Hours)**
  Analysis of Uniformly Spaced Arrays with Uniform and Non-uniform Excitation amplitudes, Extension to planar arrays.

- **MODERN PRINTED ANTENNAS DESIGN TRENDS AND APPLICATIONS** **(04 Hours)**
  Substrate Integrated Waveguide (SIW) Antennas, Metamaterial based Antennas; Transmission-Line based Metamaterials in Antenna Engineering.

(Total Contact Hours: 42)

3. Books Recommended:

1. C. A. Balanis, "Antenna Theory and Design", 4th Ed., John Wiley & Sons., 2016.
2. J.D. Krauss, "Antennas for all Applications", 3rd Ed., Tata McGraw-Hill, 2008.
3. W. L. Stutzman, and G. A. Thiele, "Antenna Theory and Design", 2nd Ed., John Wiley & Sons, 1998.
4. R. S. Elliot, "Antenna Theory and Design", Revised edition, Wiley-IEEE Press., 2003.
5. R. E. Collin, "Antennas and Radio Wave Propagation", McGraw-Hill., 1985.

SATELLITE COMMUNICATION

L	T	P	Credit
3	0	0	03

EC 623 **Scheme**

1. **Course Outcomes (COs):**

At the end of the course the students will be able to:

CO1	**Describe** the basic concepts and terminology of Satellite Communication
CO2	**Classify** the various satellite subsystems and their functionality and able to Understand effects of Scintillation
CO3	**Demonstrate** Spread Spectrum Technology to develop a secured satellite communication link
CO4	**Analyze** the various multiple access schemes suitable for satellite link
CO5	**Evaluate** the importance of satellite communication used for different applications
CO6	**Design** of satellite link budget

2. **Syllabus:**

- **COMMUNICATION SATELLITE: ORBITAL MECHANICS** **(06 Hours)**
  Introduction to Orbital Parameters and Terminology, Types of Orbits, Coverage and Frequency Considerations, Delay and Throughput Consideration, System Consideration

- **SATELLITE SUBSYSTEMS** **(08 Hours)**
  Introduction to Subsystems, Attitude and Orbit Control System, TT&C, Power systems, Communication system, Satellite Antennas, Equipment Reliability, Space Qualification

- **SATELLITE LINK BUDGET** **(06 Hours)**
  Basic Link Analysis, System Noise Temperature and G/T ratio, Design of Downlink/ Uplink, Overall Satellite Link Design

- **MULTIPLE ACCESS SCHEMES** **(10 Hours)**
  TDMA Frame Structure, TDMA Burst Structure, TDMA Frame Efficiency, TDMA Super frame Structure, Frame Acquisition & Synchronization, Satellite Position Determination, Burst Time Plan, Control & Coordination By The Reference Station, TDMA Timing, TDMA Equipment, Advanced TDMA Satellite Systems, Introduction to FDMA, Inter-modulation and Calculation of C/N with Intermediation

- **SATELLITE SPREAD SPECTRUM COMMUNICATIONS** **(06 Hours)**
  Direct Sequence Spread Spectrum System, Direct Sequence Code Division Multiple Access, Frequency Hop Spread Spectrum Systems, Frequency Hop Code Division Multiple Access, Satellite On-Board Processing

- **ATMOSPHERIC CONTRINTS FOR SATELLITE COMMUNICATION** **(02 Hours)**
  Introduction to atmospheric constraints, ionospheric impact, tropospheric impact

- **SATELLITE SERVICES** **(04 Hours)**
  MSAT, VSAT, Radarsat, GPS, DTH, Satellite Phones

(Total Contact Hours: 42)

3. **Books Recommended:**

1. Pratt T. and Bostian C. W., “Satellite Communications”, 2nd Ed., John Wiley & Sons, 2003.
2. Tri T Ha, “Digital Satellite Communications”, 2nd Ed., McGraw-Hill, 1990.
3. Roddy Dennis, “Satellite Communications”, 3rd Ed., McGraw-Hill, 2001.
4. Nagaraja N.S., “Elements of Electronic Navigation”, 2nd Ed., TMH, 1990.
5. Varsha Agrawal Anil K. Maini, “Satellite Communications” Wiley, 2010.

ADVANCED ELECTRONIC CIRCUITS

L	T	P	Credit
3	0	0	03

EC 625 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	**Describe** the fundamental principles and applications of Linear and Switch Mode Power Supplies
CO2	**Discuss** the effect of static op-amp limitations and Illustrate its impact on various circuits.
CO3	**Implement** various waveform generation techniques
CO4	**Analyze** the concept of Switched capacitor and its applications in various circuit designs.
CO5	**Evaluate** analog multiplier circuit and its applications.
CO6	**Design** Linear and switching regulators according to specifications.

2. Syllabus:

- **LINEAR VOLTAGE REGULATOR** **(08 Hours)**
  Voltage References, Characteristics of Voltage Regulators, Line and Load Regulation, Series and Shunt Voltage Regulators, Protection Circuits, Low Dropout (LDO) Voltage Regulators, Adjustable Voltage Regulators, Voltage Regulator IC.

- **SWITCHING REGULATOR** **(10 Hours)**
  Choice of Switching Frequency, Operation and Design of Different types of Switching Regulators, Buck type, Boost type and Buck-Boost Type, Continuous and Discontinuous Mode, Study of PWM IC, Isolated Multi-Winding Switching Regulator, Push-Pull Configuration, Merits and Demerits of Switching Regulator.

- **STATIC OP-AMP LIMITATION** **(08 Hours)**
  Input Bias and Offset Currents, Low-Input-Bias-Current Op Amps, Input Offset Voltage, Low-Input-Offset-Voltage Op Amps, Input Offset Error and Compensation Techniques, Input Voltage Range/Output Voltage Swing, Maximum Ratings, Effect of offset voltage and bias current on various op-amp based circuits, Stability and compensation of Op-Amps.

- **FUNCTION GENERATORS** **(05 Hours)**
  Transfer Curve Synthesizer, Sine Wave Generation using an analog MUX, Waveform generation Techniques, PLL.

- **ANALOG MULTIPLIER** **(05 Hours)**
  Simple Multiplier using an Emitter Coupled Transistor Pair, Gilbert Multiplier Set, Complete Four Quadrants Analog Multiplier, IC Multiplier, Application of Analog Multiplier, Logarithmic and Antilog Amplifiers, Design issue with Log Amplifier.

- **SWITCHED CAPACITOR FILTER** **(06 Hours)**
  Switched Capacitor using a MOSFET, SC Integrator, Practical Limitation of SC Integrator, Switch Capacitor Filters, Universal SC Filters, and Gyrator Circuit.

(Total Contact Hours: 42)

3. **Books Recommended:**

1. Pressman Abraham I., "Switching Power Supply Design", McGraw-Hill, 2nd Ed., 2015.
2. Sergio Franco, "Design with Operational Amplifiers and Analog Integrated Circuits", McGraw-Hill, 4th Ed., Published: May 11, 2016.
3. K R Botkar, "Integrated Circuits", Khanna Publisher, 10th Ed., 1987
4. Flynn Whittington, "Switched Mode Power Supplies" Universities Press; 2nd Ed. 2009.
5. Salivahanan S., "Linear Integrated Circuits", Fourth Reprint, McGraw-Hill, 2010.

DEEP LEARNING

L	T	P	Credit
3	0	0	03

EC 627

Scheme

1. **Course Outcomes (COs):**

At the end of the course students will be able to:

CO1	**Describe** basic concepts of pattern classification , Neuron and Neural Network, and to analyze ANN learning.
CO2	**Demonstrate** different single layer/multiple layer Perception learning algorithms.
CO3	**Examine** concept of deep learning algorithms for various applications.
CO4	**Evaluate** the concept of optimizer and Network training.
CO5	**Design** of another class of layered networks using deep learning principles.

2. **Syllabus:**

- **INTRODUCTION** **(12 Hours)**
  Feature Descriptor, Bayesian Learning, Decision Surfaces, Linear Classifiers, Linear Machines with Hinge Loss, Support Vector Machine, Multiclass support Vector Machine, Maximum margin hyper planes: Rationale for Maximum Margin, Linear SVM: Separable Case: Linear Decision Boundary, Margin of a Linear Classifier, learning a Linear SVM model, Linear SVM: Non-separable Case, Nonlinear SVM: Attribute Transformation, Learning a Nonlinear SVM, Kernel Trick, Characteristics of SVM.

- **NEURAL NETWORK** **(08 Hours)**
  Multilayer Perceptron, Feed forward Neural networks, Gradient descent and the back propagation algorithm, Example of Back Propagation Learning, Non-Linear Functions, Unsupervised Learning with Deep Network, Autoencoder, Autoencoder vs PCA.

- **CONVOLUTIONAL NEURAL NETWORK (CNN)** **(08 Hours)**
  Convolution, Cross correlation, building blocks of CNN, MLP vs CNN, Different CNN architectures, Popular CNN model, Transfer Learning, Vanishing and Exploding Gradient, Recurrent Neural Networks.

- **OPTIMISER** **(03 Hours)**
  Gradient Descent, Batch Optimization, Mini-Batch Optimization, Momentum Optimizer; Momentum and Nesterov Accelerated Gradient (NAG) Optimiser, RMSProp, Adam.

- **REGULARIZATION FOR DEEP LEARNING** **(03 Hours)**
  Parameter norm penalties, Effective training in Deep Net-early stopping, Dropout, Batch Normalization, Instance Normalization, Group Normalization, Recent Trends in Deep Learning Architectures, Residual Network, Skip Connection Network, Fully Connected CNN etc.

- **APPLICATIONS AND EXAMPLES** **(08 Hours)**
  Classical Supervised Tasks with Deep Learning, Image Denoising, Semantic Segmentation, Object Detection, Image generation with Generative adversarial networks, video to text with LSTM models.

(Total Contact Hours:42)

3. Books Recommended:

1. Ian Goodfellow, YoshuaBenjio, Aaron Courville, "Deep Learning", The MIT Press, 2017.
2. Eugene Charniak , "Introduction to Deep Learning", The MIT Press, Hardcover, 2019.
3. Richard O. Duda, Peter E. Hart, David G. Stork ,Pattern Classification-, 2nd Ed., John Wiley & Sons Inc.Wiley; 2007.
4. Simon Haykins "Neural Network- A Comprehensive Foundation", 2nd Ed., Pearson Prentice Hall.
5. Zurada and Jacek M, "Introduction to Artificial Neural Systems", West Publishing Company.

4. Reference Book:

1. Christopher M. Bishop, "Pattern Recognition and Machine Learning", Springer; 2nd Ed., 2011.

BIOMEDICAL INSTRUMENTATION

L	T	P	Credit
3	0	0	03

EC 629 **Scheme**

1. **Course Outcomes (COs):**

At the end of the course the students will be able to:

CO1	**Describe** Model biological systems.
CO2	**Demonstrate** the principles of transducers in bio-instrumentation.
CO3	**Analyze** the ECG, EEG and EMG.
CO4	**Evaluate** bio medical signal parameters.
CO5	**Develop** pace makers, defibrillators, surgical instruments etc.

2. **Syllabus:**

- **ANATOMY AND PHYSIOLOGY** **(06 Hours)**
  Elementary Ideas of Cell Structure, Heart and Circulatory System, Control Nervous System, Musclo-Skeletal System, Respiratory System Body Temperature and Reproduction System.

- **CLASSIFICATION OF BIOMEDICAL EQUIPMENT** **(02 Hours)**
  Diagnostic, Therapeutic and Clinical Laboratory Equipment.

- **SAFETY ASPECT OF MEDICAL EQUIPMENT** **(02 Hours)**
  Gross Current, Micro Current Shock, Safety Standards Rays and Considerations, Safety Testing Instruments, Biological Effects of X-Rays and Precautions.

- **BIOELECTRIC SIGNALS AND THEIR RECORDING** **(08 Hours)**
  Bioelectric Signals (ECG, EMG, ECG, EOG & ERG) and Their Characteristics, Bio-Electrodes, Electrodes Tissue Interface, Contact Impedance, Effects of High Contact Impedance, Types of Electrodes, Electrodes for ECG, EEG and EMG.

- **TRANSDUCERS FOR BIOMEDICAL APPLICATION** **(10 Hours)**
  Resistive Transducers - Muscle Force and Stress (Strain Gauge), Spirometry, Humidity, (Gamstrers), Respiration (Thermistor), Inductive Transducers: Flow Measurements, Muscle Movement (LVDT), Capacitive Transducers: Heart Sound Measurement, Pulse Pick Up, Photoelectric Transducers, Pulse Transducers, Blood Pressure, Oxygen Analyses Piezoelectric Transducers: Pulse Pickup, Ultrasonic Blood Flowmeter, Chemcial Transducer: Ag-Agfallas (Electrodes, PH Electrode).

- **BIOELECTRIC SIGNAL RECORDING MACHINES** **(06 Hours)**
  Physiological Pre-Amplifier and Specialized Amplifiers, ECG Lead Systems Details of ECG, EMG and EEG Machines.

- **PATIENT MONITORING SYSTEM.** **(04 Hours)**
  Heart Rate Measurement, Pulse Rate Measurement, Respiration, Rate Measurement, Blood Pressure Measurement, Microprocessor Applications in Patient Monitoring.

- **DEFIBRILLATORS AND PACEMAKERS** **(04 Hours)**

  Rationale of using Defibrillators, Theory of Defibrillators Circuits, Types of Defibrillators, Safety issues in Defibrillators, Theory of Pacemakers, Types of Pacemakers, Pacemaker Circuit, Technical Specification of Pacemaker, Defibrillator and Pacemaker Simulators.

(Total Contact Hours: 42)

3. **Books Recommended:**

1. John. G. Webster,"Medical Instrumentation Application and Design", 4th Ed., John Wiley, 2015.
2. Goddes L. A. and Baker L. E., "Principles of Applied Biomedical Instrumentation", 3rd Ed., Wiley India Pvt Ltd; 2008.
3. Carr Joseph J. and Brown John M, "Biomedical Instrumentation and Measurement", 4th Ed., Pearson, 2001.
4. Cromwell, "Biomedical Instrumentation and Measurements ", 2nd Ed., Pearson Education India; 2015.
5. R.S. Khandpur, "Hand book of Medical Instruments", 3rd Ed., McGraw Hill Education, 2014.

ADVANCED PROCESSOR ARCHITECTURE

L	T	P	Credit
3	0	0	03

EC 631 **Scheme**

1. **Course Outcomes (COs):**

At the end of the course the students will be able to:

CO1	**Discuss** different processor architectures and system-level design processes.
CO2	**Demonstrate** the components and operation of a memory hierarchy and the range of performance issues influencing its design.
CO3	**Analyze** the organization and operation of current generation parallel computer systems, including multiprocessor and multicore systems.
CO4	**Evaluate** the principles of I/O in computer systems, including viable mechanisms for I/O and secondary storage organization.
CO5	**Develop** systems programming skills in the content of computer system design and organization.

2. **Syllabus:**

- **COMPUTER ABSTRACTIONS AND TECHNOLOGY** **(04 Hours)**
  Technologies for building processors and memory, Performance, Power wall, the switch from uniprocessors to Multiprocessors.

- **INSTRUCTION SET ARCHITECTURE OF 64-BIT RISC-V** **(08 Hours)**
  RISC-V addressing modes, instruction types, logical operations, instructions for making decisions, supporting procedures, RISC-V addressing for Wide Immediate and addresses, parallelism and instructions, comparison with MIPS and x86 Architectures.

- **PIPELINING** **(10 Hours)**
  An overview of pipelining, pipelined data-path and control, Data hazards: Forwarding versus Control, Control hazards, Exceptions, Parallelism via instructions, Real stuff: ARM Cortex-A53 and Intel Core i7 Pipelines, Case study: ILP and matrix multiply.

- **PARALLEL PROCESSORS** **(12 Hours)**
  Parallel programs, Flynn's taxonomy, Hardware multithreading, multicore and shared memory multiprocessors, Graphics processing units, Clusters and message passing multiprocessors, Multiprocessor networks, Benchmarking of Intel Core i7 960 and NVIDA Tesla GPU, Case study: Multiprocessors and matrix multiply, Cache coherence, Advanced Cache optimizations, Real stuff: The ARM Cortex-A53 and Intel Core i7 memory hierarchy, Case study: Cache blocking and matrix multiply.

- **STORAGE AND INTERCONNECTION** **(08 Hours)**
  The basic principles of interconnection network design, On-Chip Interconnection Network, Router Architecture, Network interface design, Case Study: NoC

(Total Contact Hours: 42)

3. **Books Recommended:**

1. David A. Patterson, John L. Hennessy, "Computer Organization and Design: The Hardware Software Interface [RISC-V Edition]", The Morgan Kaufmann Series in Computer Architecture and Design, 2017
2. John L Hennessy, "Computer architecture: a quantitative approach", 6th Ed., Morgan Kaufmann Publishers, 2019
3. Leander Seidlitz, "RISC-V ISA Extension for Control Flow Integrity", Technische Universität München, 2019
4. Andrew Waterman, KrsteAsanović, The RISC-V Instruction Set Manual: Volume I: User-Level ISA, riscv.org, 2017
5. Andrew Waterman, KrsteAsanović, The RISC-V Instruction Set Manual: Volume II: Privileged Architecture, riscv.org, 2017

4. **Reference Book:**

1. William James Dally, Brian Patrick Towles, "Principles and Practices of Interconnection Networks", Morgan Kaufmann, Year: 2004

INTERNET OF THINGS

L	T	P	Credit
3	0	0	03

EC 633 **Scheme**

1. **Course Outcomes (COs):**

At the end of the course the students will be able to:

CO1	**Describe** sensor data available on the Internet for analysis and visualization.
CO2	**Demonstrate** basic measurement tools to determine the real-time performance of packet-based networks.
CO3	**Examine** how to communicate with other mobile devices using various communication platforms such as Bluetooth and Wi-Fi.
CO4	**Evaluate** trade-offs in interconnected wireless embedded sensor networks.
CO5	**Create** end-to-end IoT applications, working as a team.

2. **Syllabus:**

- **INTRODUCTION TO IOT** **(06 Hours)**
  IOT Architecture, Major components of IoT, IoT enabling technologies, IoT Standards, IoT Entities, IOT Software Development Platforms (Python/C/C++), Sensors, Actuators, Gateways, Cloud, Mobile/Web Applications

- **MACHINE-TO-MACHINE COMMUNICATIONS** **(08 Hours)**
  Wired Communication Protocols, Role of M2M in IoT, Machine-to-Machine Communication: MQTT/MQTT-SN,COAP

- **INTEROPERABILITY IN IOT** **(04 Hours)**
  Linux-based Edge Device—Raspberry Pi, Integration of Sensors and Actuators with Arduino, RaspberriPi, Python programming.

- **NETWORKING IN IOT** **(08 Hours)**
  Real-time networking, Soft and real time, quality of service/information, resource reservation and scheduling, and performance measurements, Introduction to SDN, SDN for IoT

- **COMPUTING IN IOT** **(08 Hours)**
  Data Handling and Analytics,Cloud Computing, Sensor-Cloud, Fog Computing, IoT Security

- **IOT EXAMPLES** **(08 Hours)**
  IoT System in a Laboratory, Industrial IoT as Managed Service,Smart Cities and Smart Homes, Connected Vehicles, Smart Grid .

(Total Contact Hours: 42)

3. Books Recommended:

1. Pethuru Raj and Anupama C. Raman, "The Internet of Things: Enabling Technologies, Platforms, and Use Cases", 1st Ed., CRC Press, 2017.
2. ArshdeepBahga and Vijay Madisetti, "Internet of Things: A Hands-on Approach", 1st Ed., Universities Press, x 2014.
3. Jan Holler, Vlasios Tsiatsis, Catherine Mulligan, Stefan Avesand, Stamatis Karnouskos and David Boyle, “From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence”, 1st Ed., Academic Press, 2014.
4. Rahul Dubey, “An Introduction to Internet of Things: Connecting Devices, Edge Gateway, and Cloud with Applications”, 1st Ed., 2019.
5. Brian Russell and Drew Van Duren, “Practical Internet of Things Security”, Packt Publishing, 2016.

ROBOTICS

L	T	P	Credit
3	0	0	03

EC 635

Scheme

1. **Course Outcomes (COs):**

At the end of the course the students will be able to:

CO1	**Describe** application and specification of various robots , robot kinematics and control
CO2	**Apply** localization and mapping algorithms for robots.
CO3	**Experiment** mapping and navigation for algorithms robots
CO4	**Evaluate** different planning and navigation for algorithms robots
CO5	**Design** robots for the given specification.

2. **Syllabus:**

- **INTRODUCTION** **(04 Hours)**
  History of Robotics-Present status and future trends, Needs of Robots, Applications, Examples and Specification of Service, Field, Non Conventional Industrial Robots

- **ROBOT KINEMATICS** **(04 Hours)**
  Fundamentals of Rigid transform, Kinematics of Mechanics, Orientation and Angular velocity, Kinematic models of Sensors, Transform Graphs and Pose networks, Quaternions.

- **ROBOT CONTROL** **(06 Hours)**
  Classical Control, State Space control, Optimal and model predictive control, Intelligent control

- **LOCALIZATION AND MAPPING** **(10 Hours)**
  Introduction, Bayes filter, Kalman Filter, Extended Kalman Filter, Information Filter, Histogram Filter, Particle Filter, Challenges of Localization, Map Representation, Probabilistic Map based Localization, Monte carlo localization, Landmark based navigation, Globally unique localization, Positioning beacon systems, Route based localization Mapping, Metrical maps, Grid maps, Sector maps, Hybrid Maps, SLAM.

- **PLANNING AND NAVIGATION** **(10 Hours)**
  Introduction, Path planning overview, Representation of Search and Global path planning (Sequential motion planning), Real time Global Motion Planning (Depth limited approaches, Anytime approaches, Plan repair approaches-D* Algorithm, Hierarchical planning)

- **MOBILE ROBOTICS** **(08 Hours)**
  Mobile Robot hardware, Non visual/Visual sensors and related algorithms, System Control, Robot collectives, Mobile robots in practise (Flying Robots, Underwater robots, Micro/nano robots, modular robots).

(Total Contact Hours: 42)

3. Books Recommended:

1. Sebastian Thrun, Wolfram Burgard, Dieter Fox, "Probabilistic Robotics", 1st Ed., MIT Press, 2005.
2. Kevin M. Lynch and Frank C. Park, "Modern Robotics: Mechanics, Planning, and Control", 1st Ed., Cambridge University Press, 2017.
3. Alonzo Kelly, "Mobile Robotics: Mathematics, Models, and Methods", 1st Ed., Cambridge University Press, 2013.
4. Bruno Siciliano and Oussama Khatib, eds. "Springer Handbook of Robotics", 2nd Edition, Springer, 2018
5. Howie Choset, Kevin LynchSeth Hutchinson, George Kantor, Wolfram Burgard, Lydia Kavraki, and Sebastian Thrun, "Principles of Robot Motion-Theory, Algorithms, and Implementation", MIT Press, Cambridge, 2005.

EMBEDDED SYSTEMS

L	T	P	Credit
3	0	0	03

EC 637 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	**Describe** ARM processor, its modes, exception handling, instruction pipelining and basic programming
CO2	**Implement** Assembly and C language programming for ARM Cortex-M.
CO3	**Analyze** 32-bit ARM microcontroller architecture, External Memory, Counters & Timers, Serial Data Input/Output and Interrupts. Design for interfacing Keys, LED/LCD Displays, ADC And DAC
CO4	**Evaluate** concepts of RTOS and its functionalities.
CO5	**Design** a typical cost-effective real-world embedded system with appropriate hardware components and software algorithms

2. Syllabus:

- **OVERVIEW OF EMBEDDED SYSTEMS** **(06 Hours)**
  Embedded Vs General computing system, Classification of Embedded systems, Major applications, Quality Attributes of Embedded Systems, Typical components, Embedded software development, Embedded OS, RISC Vs CISC Architectures

- **ARM CORTEX M3/M4 ARCHITECTURE** **(10 Hours)**
  Overview of ARM Cortex family, Operation modes and states, Registers, Special Registers, Floating point Registers, Application program status registers, Memory system and MPU, Exception and interrupts, System control block, OS support features

- **PROGRAMMING CORTEX M3/M4IN ASSEMBLY/C** **(12 Hours)**
  Assembly Instructions: Data Processing, SIMD and saturating, Multiply and MAC, Packing and unpacking, Floating point, Data conversion, Bit field processing, Compare and Test, Branching, Sleep mode, Memory barrier and other instructions, Assembly and Embedded C programming examples

- **PERIPHERAL INTERFACING** **(06 Hours)**
  Serial Communication interfacing such as USB, RS485, SPI, I2C, CAN and Ethernet, Motor control with PWM

- **APPLICATION PROGRAMMING OF CORTEX M3/M4** **(08 Hours)**
  Writing optimized ARM assembly/C code, Exception and fault handling routines, Handling floating point operations, Programming for DSP applications (such as Biquad filter, FIR filter, IIR filter, DFT, FFT etc.)

(Total Contact Hours: 42)

3. Books Recommended:

1. Joseph Yiu, "A definitive guide to the ARM-Cortex M3 and Cortex-M4 Processors", 3rd Ed., Newnes, 2013.
2. ShibuK.V., "Introduction to Embedded Systems", 1st Ed., TMH 2009.
3. Y. Zhu, "Embedded Systems with Arm Cortex-M3 Microcontrollers in Assembly Language and C" E-Man Press LLC, 2014.
4. A.N.Sloss, D.Symes and C. Wright, "ARM System Developer's Guide: Designing and Optimizing System Software", Elsevier, 2004.
5. ARM Cortex M4 Technical Reference Manual.

BIOMEDICAL SIGNAL PROCESSING

L	T	P	Credit
3	0	0	03

EC 622 **Scheme**

1. **Course Outcomes (COs):**

At the end of the course the students will be able to:

CO1	**Describe** physical, electrical and mathematical models for the origin of bioelectrical signals in the cell, and their conduction in nerves and in tissue.
CO2	**Explain** modeling of biomedical systems.
CO3	**Analyze** ECG and EEG signal with characteristic feature points.
CO4	**Evaluate** different methods for signal processing of the ECG, the EEG and the EMG, with respect to time- and frequency domain analysis.
CO5	**Design** different filters for biomedical signals.

2. **Syllabus:**

- **INTRODUCTION** **(06 Hours)**
  Short introduction- Discrete time systems and signals; Z-transform, Difference equation, Preliminaries, Biomedical signal origin & dynamics (ECG), Biomedical signal origin & dynamics (EEG, EMG etc.)

- **FILTERING FOR REMOVAL OF ARTIFACTS** **(06 Hours)**
  Statistical Preliminaries, Time domain filtering (Synchronized Averaging, Moving Average), Time domain filtering (Moving Average Filter to Integration, Derivative-based operator), Frequency Domain Filtering (Notch Filter), Optimal Filtering: The Weiner, Optimal Filtering: The Weiner Filter, Adaptive Filtering, Selecting Appropriate Filter.

- **EVENT DETECTION & WAVEFORM ANALYSIS** **(08 Hours)**
  Example events (viz. P, QRS and T wave in ECG), Derivative based Approaches for QRS Detection Pan Tompkins Algorithm for QRS Detection, Dicrotic Notch Detection Correlation Analysis of EEG Signal, Illustrations of problem with case studies, Morphological Analysis of ECG, Correlation coefficient, The Minimum phase correspondent, Signal length, Envelop Extraction, Amplitude demodulation, The Envelogram, Analysis of activity, Root Mean Square value, Zero-crossing rate, Turns Count, Form factor.

- **FREQUENCY-DOMAIN ANALYSIS** **(06 Hours)**
  Periodogram, Averaged Periodogram, Blackman-Tukey Spectral Estimator, Daniell's Spectral Estimator, Measures derived from PSD.

- **MODELLING OF BIOMEDICAL SYSTEMS** **(06 Hours)**
  Motor unit firing pattern, Cardiac rhythm, Formants and pitch of speech, Point process, Parametric system modelling, Autoregressive model, Autocorrelation method, Application to random signals, Computation of model parameters, Levinson-Durbin algorithm, Computation of gain factor, Covariance method, Spectral matching and parameterization, Model order selection, Relation between AR and Cepstral coefficients, ARMA model, Sequential estimation of poles and zeros.

- **FILTER DESIGN FOR BIO MEDICAL SIGNALS** **(10 Hours)**
  Design derivative-based filter, Design Butterworth high pass filter, Design Wiener filter, Implement the Pan-Tompkins method for QRS detection.Use cross-correlation to detect alpha rhythm, Design a matched filter, Pan-Tompkins method for QRS detection and the Lehner and Rangayyan method to detect dicrotic notch, Half wave and full wave rectification, RMS value calculation, Turns count calculation, RMS, Turns count and Zero-crossing rate calculations ,Derive the Envelogram, RR interval and Form Factor calculations, Power spectrum calculations using different windows, Mean frequency and variance of PSD, Compute PSDs of Voiced, Unvoiced and Silent portion of sound signal, Compute mean frequency of PSDs and ratio of energies, Study the changes in the PSDs by varying window width, number of segments averaged, and type of the window used.

(Total Contact Hours: 42)

3. Books Recommended:

1. R M Rangayyan "Biomedical Signal Analysis: A case Based Approach", 1st Ed., IEEE Press, John Wiley & Sons. Inc, 2002.
2. Willis J. Tompkins "Biomedical Digital Signal Processing", 2nd Ed., EEE, PHI, 2004.
3. D C Reddy "Biomedical Signal Processing: Principles and Techniques", 10th Reprint, Tata McGraw-Hill Publishing Co. Ltd, 2011.
4. J G Webster "Medical Instrumentation: Application & Design", 4th Ed., John Wiley & Sons Inc., 2009.
5. C Raja Rao, S K Guha "Principles of Medical Electronics and Biomedical Instrumentation", 2nd Ed., Universities Press, 2001.

4. Reference Books:

1. A V Oppenheim and RW Shafer "Discrete-time Signal Processing", 3rd Ed., Pearson Education, 2010.
2. Steven M. Kay, "Modern spectral estimation theory and application ", 1st Ed., Pearson India; 2009.

AD-HOC NETWORKS

L	T	P	Credit
3	0	0	03

EC 624 **Scheme**

1. **Course Outcomes (COs):**

At the end of the course the students will be able to:

CO1	**Describe** the basic knowledge of architecture, issues, protocols of Mobile Adhoc Networks and the standard Adhoc networks-Bluetooth, WiFi, WiMAX, WSN etc.
CO2	**Apply** protocols and techniques in MANETs, developing algorithms for recent standard Adhoc networks overcoming the constraints
CO3	**Analyze** Wireless Sensor Network Architecture.
CO4	**Evaluate** various techniques and protocols/algorithms, case study and problem solving as per given data.
CO5	**Design** of Wireless Sensor Network for IoT application.

2. **Syllabus:**

- **INTRODUCTION** **(04 Hours)**
  Introduction To Generations In Wireless Systems, Introduction To Mobile Ad-Hoc Networks (MANETS), Classification Of Mobile Data Networks, MANET issues, Wireless Channel Related Issues

- **MAC LAYER ISSUES OF ADHOC NETWORKS** **(04 Hours)**
  CSMA with Hidden and Exposed Terminal Issues, MACA and MACAW protocols

- **NETWORK LAYER ISSUES IN ADHOC NETWORKS** **(06 Hours)**
  Challenges, Proactive and Reactive Algorithms, Limitations of Bellman Ford Algorithm, DSDV, WRP, CGSR protocols, DSR, AODV, Location aided, hybrid protocols, multicast protocols

- **TRANSPORT LAYER ISSUES** **(06 Hours)**
  Challenges, data flow control mechanisms, congestion control protocols, security aspects

- **BLUETOOTH** **(04 Hours)**
  Bluetooth Network Structure: Piconet&Scatternet, Bluetooth Specifications, Bluetooth Protocol Stack, Bluetooth Media Access Control Consideration, Asynchronous Connectionless And Synchronous Connection Oriented Communication Link, Modified Bluetooth

- **WIFI - IEEE802.11 STANDARDS** **(04 Hours)**
  Various 802.11 Protocols (a to s), WiFi Architecture, Security Enhancement, QoS Enhancement, Physical & MAC Layer Aspects Of 802.11 a,b,g,n; WiFi MAC: Point Coordinate Function, Distributed Coordinate Function, Hybrid Coordinate Function

- **WiMAX - IEEE802.16 STANDARDS** **(04 Hours)**

Various 802.16 (a to e) Protocols, WiMAX Air Interface / Physical Layer, WiMAX Architecture, WiMAX Protocol Architecture, WiMAX And WiFi Interworking, WiMAX Mode: TDD And FDD, QoS In WiMAX

- **WIRELESS SENSOR NETWORK** **(06 Hours)**
  Sensor node architecture, Sensor Network architecture, Zigbee IEEE 802.15.4, Mobile Computing Aspects, Introduction to IoT

- **UWB** **(02 Hours)**
  UWB Air Interface

- **IEEE802.20 AND BEYOND** **(02 Hours)**

(Total Contact Hours: 42)

3. Books Recommended:

1. Toh C. K. "Ad-hoc Mobile Wireless Networks-Protocol and Systems", LPE, 2nd Ed., Pearson Education, 2009.
2. William C.Y. Lee, "Wireless& Cellular Telecommunication", 3rd Ed., McGraw-Hill, 2005.
3. Upena Dalal, "Wireless Communication", 1st Ed., Oxford University, 2009.
4. Vijay K. Garg, "Wireless Network Evolution 2G to 3G", 2nd Ed., Pearson Education, 2004.
5. C. Siva Rama Murthy, B. S. manoj, "Adhoc Wireless Networks-Architectures and Protocols", 1st Ed., Pearson, 2007.

NANOELECTRONICS

L	T	P	Credit
3	0	0	03

EC 626 **Scheme**

1. Course Outcomes (COs):

At the end of the course, students will be able to:

CO1	**Describe** various carrier transport mechanisms, properties of semiconductor materials, and novel devices using mathematical equations.
CO2	**Demonstrate** physics needed for special classes of nanoelectronic devices and their applications.
CO3	**Analyze** nanoelectronic devices and their suitability in the semiconductor industry.
CO4	**Evaluate** the technological, economical and social impact of nanostructuring processes, small devices and systems.
CO5	**Develop** novel devices, processes and applications based on them.

2. Syllabus:

- **FUNDAMENTALS OF NANOSCALE PHYSICS** **(12 Hours)**
  Top-Down and Bottom-Up Approach, Potential of Nanotechnology and Nanoelectronics, Classical Particles, Quantum Mechanics of Electrons, Free and Confined Electrons, Quantum Structures

- **BAND THEORY OF SOLIDS** **(08 Hours)**
  Electrons in Periodic Potential, Kronig-Penney Model of Band Structure, Band Theory of Solids, Graphene and Carbon Nanotubes.

- **SINGLE, FEW AND MANY ELECTRONS PHENOMENA** **(11 Hours)**
  Tunnel Junctions, Applications of Tunneling, Coulomb Blockade and Single Electron Transistor, Particle Statistics, Density of States.

- **QUANTUM STRUCTURES** **(11 Hours)**
  Quantum Wells, Quantum Wires and Quantum Dots, Ballistic Transport and Spin Transport.

(Total Contact Hours: 42)

3. Books Recommended:

1. Hanson, G. W., “Fundamentals of Nanoelectronics”, 1st Ed., Pearson Education, 2009.
2. Rogers, Pennathur and Adams, “Nanotechnology: Understanding Small Systems”, CRC Press, Tayler and Francis Group, 2008.
3. Mahalik N. P., “Micromanufacturing and Nanotechnology”, Springer, 2006.
4. Kohler and Fritzsche, “Nanotechnology: An Introduction To Nanostructuring Techniques”, 1st Edition, 1st Reprint, Wiley-VCH, 2004.
5. Fahrner W. R. (Ed),“Nanotechnology And Nanoelectronics: Materials, Devices, Measurement Techniques”, Springer Publications, 2005.

4. Reference Book:

1. Kumar Vijay, “Nanosilicon”, 1st Ed., Elsevier Ltd., 2008.

VLSI SIGNAL PROCESSING

L	T	P	Credit
3	0	0	03

EC 628 **Scheme**

1. **Course Outcomes (COs):**

At the end of the course the students will be able to:

CO1	**Describe** DSP algorithms using data flow graphs and various VLSI architectures for signal processing.
CO2	**Apply** fast convolution methods for optimization.
CO3	**Analyze** critical path algorithm and strength reduction.
CO4	**Evaluate** signal processing architectures based on area and power.
CO5	**Design** VLSI architectures for the signal processing based on specifications.

2. **Syllabus:**

- **DSP CONCEPTS** **(10 Hours)**
  Linear system theory, DFT, FFT, DCT realization of digital filters. Typical DSP algorithms, DSP applications, Data flow graph presentation of DSP algorithm.

- **ARCHITECTURAL ISSUES** **(12 Hours)**
  Binary Adders, Binary multipliers, Multiply Accumulator (MAC) and Sum of Product (SOP). Pipelining and Parallel Processing, Retiming, Unfolding, Folding, Register Minimization Technique and Systolic architecture design, Coordic Architecture, Distributed Arithmetic Architecture

- **FAST CONVOLUTION** **(10 Hours)**
  Cook-Toom algorithm modified Cook-Toom algorithm, Winograd algorithm, modified Winograd algorithm, Algorithmic strength reduction in filters and transforms, DCT and inverse DCT, parallel FIR filters.

- **POWER ANALYSIS IN DSP SYSTEMS** **(10 Hours)**
  Scaling versus power consumption, power analysis, power reduction techniques, power estimation techniques, low power IIR filter design, Low power CMOS lattice IIR filter.

(Total Contact Hours: 42)

3. **Books Recommended:**

1. Keshap K. Parhi, “VLSI Digital Signal Processing Systems, Design and Implementation”, 1st Ed., John Wiley, 2007.
2. Keshab K. Parhi and Takao Nishitani, Marcel Dekker “Digital Signal Processing for Multimedia Systems”, 1st Ed., CRC Press, 1999.
3. U. Meyer-Baese, “Digital Signal processing with Field Programmable Arrays”, 3rd Ed., Springer, 2007.
4. V. K. Madisetti, “VLSI Digital Signal Processors: An Introduction to Rapid Prototyping and Design Synthesis”, IEEE Press, New York, 1995.
5. S. Y. Kung, H. J. Whitehouse, “VLSI and Modern Signal Processing”, 1st Ed., Prentice Hall, 1985.

MICROWAVE INTEGRATED CIRCUITS

L	T	P	Credit
3	0	0	03

EC 632 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	**Describe** the Microstrip lines, slot lines, co-planar line, and Microwave and millimeter wave circuit.
CO2	**Implement** the models for passive components, active device and impedance matching network.
CO3	**Analyze** the design and stability of microwave integrated circuits, Substrate Integrated Waveguide, Metamaterial-Based Compact Microwave and Millimetre Wave Circuit.
CO4	**Evaluate** the parameter of passive microwave components, active device and impedance matching network.
CO5	**Develop** an ability to evaluate the performance of microwave integrated circuits by using different measurements and testing techniques.

2. Syllabus:

- **INTRODUCTION TO MICROWAVE INTEGRATED CIRCUITS** **(03 Hours)**
  Introduction to Monolithic Microwave Integrated Circuits (MMICs), their advantages over discrete circuits, MMIC fabrication techniques, Thick and Thin film technologies and materials, encapsulation and mounting of active devices, Microstrips on semiconductor substrates.

- **MICRO-STRIP LINES** **(03 Hours)**
  Planar transmission lines for MICs. Method of Conformal transformation for microstrip analysis, concept of effective dielectric constant, Effective dielectric constant for microstrip, Losses in Microstrip.

- **SLOT LINES** **(04 Hours)**
  Slot Line Approximate analysis and field distribution, Transverse resonance method and evaluation of slot line impedance, comparison with Microstrip line.

- **FINE LINES AND COPLANAR LINES** **(03 Hours)**
  Fin lines & Coplanar Lines. Introduction, Analysis of Fin lines by Transverse Resonance Method, Conductor loss in Fin lines. Introduction to coplanar wave guide and coplanar strips.

- **LUMPED ELEMENTS FOR MICS** **(04 Hours)**
  Use of Lumped Elements, Capacitive elements, Inductive elements and Resistive elements

- **MATCHING AND BIASING NETWORKS** **(03 Hours)**
  Impedance Matching using Discrete Components, Microstrip Line Matching Networks

- **FUNDAMENTALSOF CMOS TRANSISTORS FOR RFIC DESIGN** **(04 Hours)**
  MOSFET Basics, MOSFET Models, Fundamentals of Stability, Determination of Stable and Unstable Regions, Stability Consideration for N-Port Circuits, Noise Figure Circles, Constant VSWR Circles. Broadband, High Power and Multistage Amplifiers, Low Noise Amplifier Design.

- **MICROWAVE IC DESIGN AND MEASUREMENT TECHNIQUES** **(03 Hours)**
  MIC Measurement, Testing and Applications: MIC measurement system, measurement techniques – S parameter measurement, noise measurement, MIC applications.

- **SUBSTRATE INTEGRATED CIRCUITS** **(07 Hours)**
  Substrate Integrated Waveguide, Substrate Integrated Image Guide, Substrate Integrated Non-radiative Dielectric Guide, Substrate Integrated Feeding Network, Substrate Integrated Divider, Substrate Integrated Phase Shifter, Substrate Integrated Coupler, Substrate Integrated Circuit–Related Transition.

- **METAMATERIAL-BASED COMPACT MICROWAVE AND MILLIMETRE WAVE CIRCUIT DESIGN** **(08 Hours)**
  Designs of True-Time-Delay Lines and Phase Shifters based on CRLH TL Unit Cells, Perfect Metamaterial Absorbers in Microwave and Terahertz Bands, Metamaterial-Based Compact Filter Design, Magnetically Tunable Unidirectional Electromagnetic Devices Based on Magnetic Surface Plasmon, Compact Coplanar Waveguide Metamaterial-Inspired Lines and its use in Highly Selective and Tunable Bandpass Filters.

3. **Books Recommended:**

   1. K.C. gupat, “Microwave Integrated Circuits”, 1st Ed., Wiley eastern Pvt. Ltd., 1975.
   2. K.C. Gupta, R. Garg, I. J. Bahl, “Microstrip Lines and Slot Lines”, 1st Ed., Artech House.
   3. T. H. Lee, “The Design of CMOS radio Frequency Integrated Circuits”, 2nd Ed., Cambridge, 2004.
   4. Xun-Ya Jiang, “Metamaterials” 1st Ed., Intech, 2012.
   5. Yu Jian Cheng, “Substrate Integrated Antennas and Arrays”, 1st Ed., CRC Press, 2016.

4. **Reference Books:**

   1. Bharathi Bhat, Shiban Koul, “Stripline-like transmission Lines for Microwave Integrated Ciruits”, 1st Ed., New Age International (P) Ltd. Publishers, 2007
   2. Ricardo Marques, Ferran Martin, Mario Sorolla, “Materials with Negative Parameters”, 1st Ed., Wiley Interscience, 2001.
   3. David M. Pozar, “Microwave Engineering”, 4th Ed., John Wiley & Sons, 2011.

MIMO COMMUNICATION SYSTEMS

L	T	P	Credit
3	0	0	03

EC 634

Scheme

1. **Course Outcomes (COs):**

At the end of the students will be able to:

CO1	**Describe** basic terminologies associated with multiantenna / MIMO communication systems with perception of capacity, gain, coding and detection techniques.
CO2	**Implement** different MIMO channels analytically for scenarios like CSIR, CSIT etc
CO3	**Analyze** BER, SER performance analysis of MIMO systems, space-time codes with baseband signal processing aspects also to analyze the capacity of various MIMO systems
CO4	**Evaluate** the performances of different space time codes, MIMO detection techniques like ML, ZF, MMSE etc.
CO5	**Develop** new capacity improving technique, Low complexity receiver design for MIMO with better link performance

2. **Syllabus:**

- **INTRODUCTION TO MULTI ANTENNA SYSTEM** **(10 Hours)**
  Introduction to wireless communication systems and wireless Channels, Performance in fading Wireless channels, Classical and generalized fading distributions, Error/Outage Probabilities over fading channels, Need for MIMO Systems, Multiple antennas in wireless Communication, Benefits of MIMO technology, Basic Building Block, Diversity gain, multiplexing gain, A fundamental Trade-off,MIMO in wireless networks, MIMO communication in wireless standards, Analytical MIMO channel models

- **MIMO CHANNEL CAPACITY** **(08 Hours)**
  Power allocation in MIMO system: Uniform power allocation, Adaptive power allocation, Near optimal power allocation,
  Channel Capacity of simplified MIMO channels: capacity of deterministic MIMO channel, capacity of random MIMO channel, Ergodic and outage capacity of i.i.d. Rayleigh fading MIMO channel, separately correlated Rayleigh fading MIMO channel and keyhole Rayleigh fading MIMO channel

- **INTRODUCTION TO SPACE-TIME CODING** **(04 Hours)**
  Sources and types of diversity, analysis under Rayleigh fading, performance of different diversity schemes, Space-Time Coded Systems, Performance Analysis of Space-Time Codes, Space-Time Code Design Criteria

- **SPACE TIME BLOCK AND TRELLIS CODES** **(08 Hours)**
  Alamouti Space-Time Code, SER analysis for Alamouti space time code over fading channels, Space time block codes, space time trellis codes, performance analysis of space time codes over separately correlated MIMO channel, Performance analysis.Space – time codes with no CSI

- **SPACE TIME CODING FOR FREQUENCY SELECTIVE FADING CHANNELS** **(04 Hours)**
  Frequency-selective channels – Capacity and Information rates of MIMO FS fading channels, Space - time coding and Channel detection for MIMO FS channels, MIMO OFDM systems.

- **INTRODUCTION TO MIMO DETECTION TECHNIQUES** **(04 Hours)**
  Maximum likelihood (ML) detector, Linear suboptimal detectors: Zero forcing detector, MMSE detector, Successive Interference Cancellation (SIC), Sphere decoding

- **ADVANCE TOPICS IN MIMO WIRELESS COMMUNICATION** **(04 Hours)**
  Space time block coded spatial modulation, MIMO based cooperative communication, Large scale MIMO systems, MIMO cognitive radios

(Total Contact Hours: 42)

3. **Books Recommended:**

1. Rakesh Singh Kshetrimayum, "Fundamentals of MIMO Wireless Communications", 1st Ed., Cambridge University Press 2017.
2. Mohinder Jankiraman, "Space Time Codes and MIMO Systems", Har/Cdr Ed., Artech house London, Ed. 2004
3. Branka Vucetic, Jinhong Yuan, "Space Time Coding", 1st Ed., John Wiley & Sons Ltd, 2003
4. Paulraj, R. Nabar and D. Gore, "Introduction to Space-Time Wireless Communications", 1st Ed., Cambridge University Press 2008
5. Tolga m. Duman, Ali Ghrayeb, "Coding for MIMO Communication Systems", 1st Ed., John Wiley & Sons Ltd., 2007

TESTING & VERIFICATION OF VLSI CIRCUITS

L	T	P	Credit
3	0	0	03

EC 636 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	**Describe** the test patterns required to detect faults in a circuit and testability.
CO2	**Apply** methods/techniques to improve the testability of digital circuits.
CO3	**Analyze** Logic BIST circuits.
CO4	**Evaluate** the formal verification techniques.

2. Syllabus:

- **INTRODUCTION** **(12 Hours)**
  Scope of Testing and Verification in VLSI Design Process, Issues in Test and Verification of Complex Chips, Yield modeling, defects, fault models.

- **VLSI TESTING FAULT MODELS** **(15 Hours)**
  Fundamentals Of Automatic Test Pattern Generation: Combinational and sequential circuits, Design For Testability: Scan Design, Delay Fault Testing, Delay Fault Testing, BIST, Memory Test, Test Interface And Boundary Scan, System Testing and Test For SOC

- **VERIFICATION** **(15 Hours)**
  Basics of design verification, simulation based verification, Hardware emulation, Formal verification: Basics of equivalence checking and model checking, Timing verification.

(Total Contact Hours: 42)

3. Books Recommended:

1. Bushnell M. and Agrawal V. D., "Essentials Of Electronic Testing For Digital, Memory And Mixed-Signal VLSI Circuits", 1st Indian Reprint Edition, Springer India, 2015.
2. Abramovici M., Breuer M. A. and Friedman A. D.,"Digital Systems Testing And Testable Design", , 1st Ed., Jaico Publishing House 2001.
3. Kropf T., "Introduction to Formal Hardware Verification", 1st Ed., Springer Verlag, 2010.
4. William K. C. Lam, "Hardware Design Verification: Simulation and Formal Method-Based Approaches" 1st Ed., Prentice Hall, 2005.
5. Stroud, "A Designer's Guide to Built-in Self-Test", Springer, 2002 Edition, 2006.

VLSI SYSTEM DESIGN

L	T	P	Credit
3	0	0	3

EC 638 **Scheme**

1. **Course Outcomes (COs):**

At the end of the course students will be able to:

CO1	**Describe** systems levels issues related to interconnect and its solution.
CO2	**Apply** the system decompositions in data path and control path.
CO3	**Analysis** of sequential logic circuit.
CO4	**Evaluate** various Timing issues and its solutions.
CO5	**Design** sequential logic circuit and testing.

2. **Syllabus:**

- **INTERCONNECT** **(12 Hours)**
  The Wire, Interconnect Parameter, Electrical And Spice Wire Model, RLC Parasitic, Signal Integrity And High Speed Behavior Of Interconnects: Ringing, Cross Talk And Ground Bounce. Layout Strategies At IC And Board Level For Local And Global Signals, Power Supply Decoupling, Advance Interconnect Techniques. Clocking strategy

- **SYSTEM HARDWARE DECOMPOSITION** **(10 Hours)**
  VLSI Design Flow, Mapping Algorithms into architectures, Data Path And Control Path, Register Transfer Level Description, Control Path Decomposition (Interfacing With FSM), Pitfalls of Decomposition, Critical Path and worst case timing analysis, Control Flow And Data Flow Pipelines, Communication Between Subsystems, Control Dead Locks. Concept of hierarchical system design; Data-path element: Data-path design philosophies, fast adder, multiplier, driver etc. Timing And Control Shared Memory Data Hazards And Consistency, Mutual Exclusion.

- **DESIGNING OF SEQUENTIAL LOGIC CIRCUIT** **(10 Hours)**
  Timing classification; Synchronous design; Self-timed circuit design; Clock Synthesis and Synchronization: Synchronizers; Arbiters; Clock Synthesis; PLLs; Clock generation; Clock distribution; Synchronous Vs Asynchronous Design, Static And Dynamic Latches And Registers, Design And Optimization Of Pipelined Stages, Timing Issues In Digital Circuits, Handling Multiple Clock Domains, Interface Between Synchronous And Asynchronous Blocks, Set-Up And Hold Time Violation, Concept Of Meta-Stability.

- **DESIGN FOR TEST** **(10 Hours)**
  Introduction, Test Procedure, Issucs In Design For Testability, Ad-Hoc Testing, Scan-Based Test, Boundary Scan Design, Built-In-Self Test (BIST), Test Pattern Generation, Fault Models, Automatic Test Pattern Generation (ATPG), Variability Analysis.

(Total Contact Hours: 42)

3. Books Recommended:

1. Rabaey Jan M., Chandrakasan Anantha and Borivoje Nikolic, "Digital Integrated Circuits (Design Perspective)", 2nd Ed., Prentice Hall of India, 2016 (Reprint).
2. Neil H. E. Weste, David. Harris and Ayan Banerjee,, "CMOS VLSI Design", 3rd Ed., Pearson Education, 2006
3. Smith M. J. S., "Application Specific Integrated Circuits", 1st Ed., Addison Wesley, 1999.
4. Dally W. J. and Poulton J. W., "Digital System Engineering", 1st Ed., Cambridge University Press, 1998.
5. Hall S. H., Hall G. W. and McCall J. A., "High Speed Digital System Design", 1st Ed., John Wiley & Sons, 2000.

4. Reference Books:

1. Bakoglu H. B., "Circuit Interconnect and Packaging For VLSI", 1st Ed., Addison-Wesley, 1990.
2. Laung-Terng Wang, Cheng-Wen Wu and Xiaoqing Wen, "VLSI Test principles And Architectures Design For Testability", 1st Ed., Morgan Kaufmann Publishers, 2006.

OPTICAL NETWORKS

L	T	P	Credit
3	0	0	03

EC 642 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	**Classify** the architectures of client layers of optical layer, frame structures and protocols.
CO2	**Interpret** PON and FSO technologies and their components to compute range budget for these networks.
CO3	**Compare** the wavelength routing algorithms, wavelength conversion techniques and predict protection and restoration techniques for optical networks.
CO4	**Evaluate** various network control and management methods in optical networks.
CO5	**Analyze** OTDM, Optical AND gates, OPS, Optical PLL, Tunable delays for future optical networks.

2. Syllabus:

- **INTRODUCTION** **(04 Hours)**
  Network terminologies, OSI model, Telecommunications Network Architecture, Services: Circuit Switching, and Packet Switching, Multiplexing Techniques, Second-Generation Optical Networks, The Optical Layer, Transparency and Network Evolution, WDM Networking Evolution, Point-to-Point WDM Systems, Wavelength Add/Drop Multiplexer (WADM), Fiber and Wavelength Cross connects, Broadcast-and-Select Networks, Wavelength-Routed (Wide-Area) Optical Network, WDM Economics.

- **OPTICAL METRO AND TRANSPORT NETWORKS** **(06 Hours)**
  Client Layers of the Optical Layer, SONET/SDH, Multiplexing, SONET/SDH Layers, Optical Transport Network, ATM, FDDI, Ethernet, IP, OTN.

- **OPTICAL ACCESS NETWORKS** **(06 Hours)**
  Fibber to the Curb (FTTC), PON Evolution, PON Technologies, OLT, Splitters, ONU, PON Range Budget, TPON, GPON, WDM PON and other Networks, Free Space optics, and Free Space Optical Networks.

- **WAVELENGTH ROUTED OPTICAL NETWORKS** **(07 Hours)**
  Optical Routers and Optical Switches, Wavelength continuity constraint, Basics of Wavelength Conversion, Wavelength Conversion Techniques, Optoelectronic Approach, Optical Gating, Interferometric Technique, Wave Mixing, Converter Switches.

- **NETWORK SURVIVABILITY** **(07 Hours)**
  Basic Concepts, Protection and Restoration, Protection in SONET/SDH, Point-to-Point Links, Ring Interconnection Protection in the Client Layers: Resilient Packet Rings, Ethernet, MPLS, IP etc., Optical Layer Protection Schemes, GMPLS Protection.

- **NETWORK CONTROL AND MANAGEMENT** **(05 Hours)**
  Basic Functions of Network Control and Management, Dynamic Routing and Wavelength Assignment, Fixed Routing and Fixed-Alternate-Path Routing, Adaptive Routing Based on Global Information, Adaptive Routing Based on Neighborhood Information, Adaptive Routing Based on Local Information, various resource reservation techniques and fault management.

- **FUTURE OPTICAL NETWORKS** **(07 Hours)**
  Photonic Packet Switching (OPS) Optical Time Division Multiplexing (OTDM), Bit Interleaving, Packet Interleaving, Optical AND Gates, Synchronization, Tunable Delays, Optical Phase Lock Loop, Optical Packet Switching (OPS) and Optical Burst Switching.

(Total Contact Hours: 42)

3. <u>Books Recommended:</u>

1. Rajiv Ramaswami, Kumar Sivarajan, Galen Sasaki, “Optical Networks: A Practical Perspective”, 3rd Ed., Morgan Kaufmann, November 27, 2009.
2. Biswanath Mukherjee, “Optical WDM Networks”, 1st Ed., Springer; 2006.
3. Uyless Black, “Optical Networks: Third Generation Transport Systems”, Prentice Hall PTR, 1st Ed., February 26, 2002.
4. HemaniKaushal , V.K. Jain , SubratKar, “Free Space Optical Communication”, 1st Ed., Springer, 2017.
5. C. S. Murthy & M. Gurusamy, “WDM Optical Networks”, 1st Ed., PHI, 2002.

GLOBAL NAVIGATION SATELLITE SYSTEM

L	T	P	Credit
3	0	0	03

EC 644 **Scheme**

1. **Course Outcomes (COs):**

At the end of the course students will be able to:

CO1	**Classify** global as well regional navigation systems.
CO2	**Apply** knowledge of different signal structures of diverse navigation systems.
CO3	**Analyze** position of GNSS receiver using acquisition and tracking.
CO4	**Evaluate** various GNSS positioning techniques.
CO5	**Design** societal application using GNSS.

2. **Syllabus:**

- **GNSS OVERVIEW** **(04 Hours)**
  Introduction to GNSS systems, GNSS Architecture, Augmentation System

- **SATELLITE NAVIGATION SYSTEMS** **(08 Hours)**
  Global Navigation systems: GPS, GLONASS, GALILEO, Beidou Regional Navigation systems : QZSS, IRNSS/NavIC

- **SATELLITE SIGNAL CHARACTERISTICS: GPS/GNSS** **(08 Hours)**
  Common components of any GNSS Signal, Modulation Techniques, Multiple Accessing Techniques , CDMA-Code Division Multiple Access, FDMA-Frequency Division Multiple Access, Signal structure of different GNSS systems

- **SATELLITE SIGNAL ACQUISITION, TRACKING AND DATA DEMODULATION** **(08 Hours)**
  Introduction of Acquisition, Acquisition Methods, Serial Search in time domain, Parallel Search in frequency domain, Tracking, Navigation Data Decoding

- **GNSS POSITIONING TECHNIQUES** **(10 Hours)**
  code based positioning, phase based positioning , Single Point Positioning, Differential positioning, Precise Point Positioning, RTK

- **APPLICATIONS OF GNSS** **(04 Hours)**
  Aviation Ground-based Augmentation, Marine Navigation, Space Navigation, Vehicle Navigation, Precision Agriculture, Military Applications, Geodesy, Surveying and Mapping, Atmospheric and Ionospheric Science

(Total Contact Hours: 42)

3. Books Recommended:

1. Elliott_D._Kaplan, "Christopher_Hegarty Understanding GPS Principles and Applications", 3rd Ed., Archtech House, Artech House, 2017.
2. Pratap Misra, "Per Enge - Global Positioning System_ Signals, Measurements, and Performance", 1st Ed., Ganga-Jamuna Press, 2006.
3. Kai Borre,_Dennis M. Akos, Nicolaj Bertelsen, "A Software-Defined GPS and Galileo Receiver: A Single-Frequency Approach", 1st Ed., Peterson, 2007.
4. Scott Madry, "Global Navigation Satellite Systems and Their Applications", Springer series 10058, 2015.
5. Teunissen, Montenbruck, "Handbook of Global Navigation Satellite Systems", 1st Ed., Springer-Verlag, 2017.

RADAR SYSTEMS

L	T	P	Credit
3	0	0	03

EC 646 **Scheme**

1. Course Outcomes (COs):

At the end of the course students will be able to:

CO1	**Classify** various components and various antenna mechanism used for radar technology.
CO2	**Apply** specific use of technology for various requirements.
CO3	**Analyze** the working of different schemes of RADAR.
CO4	**Evaluate** the RADAR technology performance in different environments.
CO5	**Design** radar transmitter and receiver system.

2. Syllabus:

- **INTRODUCTION** **(05 Hours)**
  Radar Block Diagram, Radar Equation, Detection of Signal in Noise, Receiver Noise and S/N Ratio, Transmitter Power, Pulse Repetition Frequency and Range Ambiguities, Beam Shapes, Introduction to Doppler Effect, CW and FMCW RADAR

- **MTI AND PULSE DOPPLER RADAR** **(05 Hours)**
  Introduction To MTI And Doppler Radar, Delay Line Cancellers, Staggered PRFs, Digital MTI Processing, Moving Target Indicator, Limitation to MTI Performance, Pulse Doppler Radar.

- **TRACKING RADAR** **(03 Hours)**
  Tracking With Radar, Monopulse Tracking, Conical Scan And Sequential Lobing, Limitation To Tracking Accuracy, Tracking In Range and Acquisition.

- **INFORMATION FROM RADAR SIGNALS** **(05 Hours)**
  Basic Radar Measurements, Theoretical Accuracy Of Radar Measurements, Ambiguity Diagram, Pulse Compression, Target Recognition.

- **RADAR CLUTTER** **(10 Hours)**
  Introduction, Surface Clutter Radar Equation, Land Clutter, Sea Clutter, Weather Effects, Detection Of Targets In Clutter.

- **RADAR ANTENNA** **(08 Hours)**
  Functions Of Radar Antenna, Reflector Antennas, Electronically Steered Phased Array Antennas, Frequency Scan Arrays, Cosecant Squared Antenna Pattern, Effects of Errors on Radiation Pattern, Radomes.

- **OTHER RADARS TOPICS** **(06 Hours)**
  Synthetic Aperture RADAR, Air-Surveillance RADAR, Optical RADAR.

Total Contact Hours: 42)

3. Books Recommended:

1. Sklonik Merrill, “Introduction to Radar Systems”, 3rd Ed., Tata McGraw-Hill, 2001.
2. Nagaraja N. S., “Elements of Electronics Navigation”, 2nd Ed., Tata McGraw-Hill, 1996.
3. Hannen-Toomay, “Principles of Radar”, 3rd Ed., PHI-NEW DELHI, 2010.
4. Mark A. Richards, William A. Holm, James A. Scheer, “Principles of Modern Radar: Basic Principles (Radar, Sonar and Navigation)”, Sci Tech Publishing Inc; 2010.
5. Mark A. Richards, “Fundamentals of Radar Signal Processing”, 2nd Ed., McGraw-Hill Education, 2014.

ESTIMATION AND DETECTION THEORY

L	T	P	Credit
3	0	0	03

EC 648 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	**Describe** random variables, random processes and the basic concepts of signal detection and estimation.
CO2	**Apply** detection and estimation algorithms for problems.
CO3	**Analyze** performance of different detection and estimation algorithms.
CO4	**Evaluate** performance of detection and estimation algorithms.
CO5	**Design** detector and estimator for the problems of interest.

2. Syllabus:

- **INTRODUCTION** **(02 Hours)**
  Recap of probability theory, random variable and random process, Summery of important PDFs

- **STATISTICAL DETECTION THEORY** **(04 Hours)**
  Neyman –Pearson Theorem, Receiver Operating Characteristics, Irrelevant Data, Minimum Probability of Error, Bayes Risk, Multiple Hypotheses Testing

- **DETECTION OF DETERMINISTIC SIGNAL** **(05 Hours)**
  Matched Filters, Generalized Matched Filters, Multiple Signals, Linear Model, Signal Processing Example

- **DETECTION OF RANDOM SIGNAL** **(05 Hours)**
  Estimator-Correlator, Linear Model, Estimator-Correlator for Large Data Records, General Gaussian Detection, Signal Processing Example

- **COMPOSITE HYPOTHESES TESTING** **(04 Hours)**
  Approaches: Bayesian Approach, Generalized Likelihood Ratio Test, Performance of GLRT for Large Data Records, Locally Most Powerful Detectors, , Multiple Hypotheses Testing

- **MINIMUM VARIANCE UNBIASED ESTIMATION** **(04 Hours)**
  Unbiased Estimators, Minimum Variance Criteria, Existence of the Minimum Variance Unbiased Estimator, Finding the Minimum Variance Unbiased Estimator, Extension to a Vector Parameter

- **CRAMER-RAO LOWER BOUND** **(06 Hours)**
  Estimator Accuracy Considerations, Cramer-Rao Lower Bound, General CRLB for Signals in White Gaussian Noise, Transformation of Parameters, Extension to a Vector Parameter, Vector Parameter CRLB for Transformations, CRLB for the General Gaussian Case, Signal Processing Examples

- **MAXIMUM LIKELIHOOD ESTIMATION** **(06 Hours)**
  Finding the MLE, Properties of the MLE, MLE for Transformed Parameters, Numerical Determination of the MLE, Extension to a Vector Parameter, Signal Processing Examples

- **LEAST SQUARES** **(06 Hours)**
  The Least Squares Approach, Linear Least Squares, Geometrical Interpretations, Order-Recursive Least Squares, Sequential Least Squares, Constrained Least Squares, Signal Processing Examples

(Total Contact Hours: 42)

3. Books Recommended:

1. Steven M. Key, "Fundamentals of Statistical Signal Processing (Volume II): Detection Theory", 1st Ed., Prentice Hall PTR, 1998.
2. Steven M. Key, "Fundamentals of Statistical Signal Processing (Volume I): Estimation Theory", 1st Ed., Prentice Hall PTR, 1993.
3. H. V. Poor, "An Introduction to Signal Detection and Estimation", 2nd Ed., Springer, 1998.
4. H. L. Van Trees, "Detection, Estimation and Modulation Theory: Part I", 2nd Ed., John Wiley, NY, 2016.
5. H. L. Van Trees, "Detection, Estimation and Modulation Theory: Part II", 2nd Ed., John Wiley, NY, 2016.

4. Reference Book:

1. H. L. Van Trees, "Detection, Estimation and Modulation Theory: Part III", 2nd Ed., John Wiley, NY, 2016.

SPEECH PROCESSING AND HUMAN-MACHINE COMMUNICATION

L	T	P	Credit
3	0	0	03

EC 652 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	**Describe** the fundamentals of speech and the speech production system.
CO2	**Apply** algorithm to extract different speech parameters.
CO3	**Analyze** different TTS models.
CO4	**Evaluate** an appropriate statistical speech model for a given application.
CO5	**Design** a speech recognition system.

2. Syllabus:

- **INTRODUCTION** **(04 Hours)**
  Application of speech processing; Speech signal representation and measurement; Stationary and non-stationary analysis of speech

- **SPEECH PRODUCTION AND PERCEPTION** **(06 Hours)**
  Speech production mechanism; Speech production model; Speech perception; Classification of speech sounds: voiced, unvoiced, silence, vowel, semi-vowel, consonants, diphthongs, nasal, fricative, affricative, stops etc.

- **ANALYSIS OF SPEECH SIGNAL** **(10 Hours)**
  Short-term processing, Time domain analysis: short-time energy, short-time autocorrelation, short-time zero crossing; Frequency domain analysis; Short-term Fourier transform (STFT); Filter-bank analysis; Spectrogram analysis; Cepstrum analysis; Pitch estimation: autocorrelation based, cepstrum based and LP analysis based; Formant estimation

- **LINEAR PREDICTION ANALYSIS** **(10 Hours)**
  All pole model; Pole zero model; Autocorrelation and covariance method; Levinson-Durbin algorithm; Inverse filtering; LP residual; Pitch frequency and formant frequency analysis using LP analysis, Comparison of LP model with non-linear speech production models

- **TEXT-TO-SPEECH SYNTHESIS** **(06 Hours)**
  Components of TTS, Speech synthesis methods: Concatenative and waveform based; Intelligibility and naturalness of synthesized speech; Applications and present status; WORLD vocoder

- **AUTOMATIC SPEECH RECOGNITION** **(06 Hours)**
  Statistical and machine learning Approaches; Acoustic models; Language models

(Total Contact Hours: 42)

3. **Books Recommended:**

1. L. R. Rabiner and R. W. Schafer, "Digital Processing of Speech Signals", 1st Ed., Pearson Education India, 2003.
2. J. Benetsy, M. M. Sondhi and Y. Huang, "Springer Handbook of Speech Processing", 1st Ed., Springer Verlag, 2008.
3. J. R. Deller, Jr., J. H. L. Hansen and J. G. Proakis "Discrete-Time Processing of Speech Signals", Wiley- IEEE Press, IEEE Edition, NY, USA, 1999.
4. D. O'Shaughnessy, "Speech Communications: Human and Machine", 2nd Ed., University Press, 2005.
5. Thomas F Quatieri, "Discrete-Time Speech Signal Processing – Principles and Practice", 1st Ed., Pearson Education, 2004.

REAL TIME SYSTEMS

L	T	P	Credit
3	0	0	03

EC 654 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	**Describe** the foundation for programming languages developed for real time programming.
CO2	**Apply** real time operating systems and their functions.
CO3	**Analyze** the real time network.
CO4	**Evaluate** the real time systems with regard to keeping time and resource restrictions.
CO5	**Design** real time applications with RTOS.

2. Syllabus:

- **INTRODUCTION TO REAL-TIME SYSTEMS** **(10 Hours)**
  Hard Versus Soft Real Time Systems, Reference Models of Real Time Systems, Operating System Services, I/O Subsystems, Network Operations Systems, Real Time Embedded Systems, Operating Systems Interrupt Routines in RTOS Environments, RTOS Task Scheduling Models, Interrupt Latency And Response Time, Standardization Of RTOS

- **REAL-TIME SCHEDULING AND SCHEDULABILITY ANALYSIS** **(09 Hours)**
  Task, Process And Threads, Commonly Used Approaches To Real Time Scheduling, Clock-Driven Scheduling, Priority Driven Scheduling Of Periodic Tasks, Hybrid Schedules, Event Driven Schedules, Earliest Dead Line First (EDF) Scheduling, Rate Monotonic Algorithm (RMA), Real Time Embedded Operating Systems: Standard & Perspective, Real Time Operating Systems: Scheduling Resource Management Aspects,Quasi-Static Determining Bounds On Execution Times

- **INTER-PROCESS COMMUNICATION AND SYNCHRONIZATION OF PROCESSES,TASKS AND THREADS** **(05 Hours)**
  Multiple Process in An Application, Data Sharing By Multiple Tasks And Routines Inter Process Communication

- **REAL-TIME OPERATING SYSTEMS** **(12 Hours)**
  Handling Resources Sharing and Dependencies Among Real Time Tasks, Resource Sharing Among real Time tasks, Priority Inversion, Priority Inheritance Protocol (PIP), Highest Locker Protocol (HLP), Priority Ceiling Protocol (PCP), Different Types of Priority Inversion Under PCP, Important Features of PCP, Handling Task Dependencies, Real time communication, Real time systems for multiprocessor systems, Real-time databases.

- **COMMERCIAL REAL TIME OPERATING SYSTEMS** **(06 Hours)**
  Time Services, Unix As Real Time OS, Non-Primitive Kernel, Dynamic Priority Levels, Unix Based Real Time OS, Extension to the Traditional Unix Kernal, Host Target Approach, Preemption Point Approach, RT Linux, Windows CE as Real Time OS, Real Time POSIX Standard, MC/OS-II

(Total Contact Hours: 42)

3. Books Recommended:

1. Rajib Mall, "Real Time Systems Theory and Practice", 1st Ed., Pearson Education, 2007.
2. Wayne Wolf, "Computers as Components: Principles of Embedded Computing System Design", 2nd Ed., Morgan Kaufman, 2008.
3. Liu Jane, "Real-time Systems", 1st Ed., PHI, 2000.
4. Albert M. K. Cheng, "REAL-TIME SYSTEMS Scheduling, Analysis, and Verification", 1st Ed., Wiley Interscience, 2002.
5. Richard Zurawski, "Embedded Systems Handbook", 1st Ed., CRC Taylor Francis, 2006.

PHOTONIC INTEGRATED DEVICES AND SYSTEMS

L	T	P	Credit
3	0	0	03

EC 656 **Scheme**

1. **Course Outcomes (COs):**

At the end of the course the students will be able to:

CO1	**Describe** the working and construction of various Acoustic optic devices and their fabrication.
CO2	**Apply** the concept of the optical waveguides to analyze different coupling methods.
CO3	**Analyze** the advanced optical sources and detectors, OIC and monolithic systems.
CO4	**Evaluate** the parameters for optical sensors for different types of measurements
CO5	**Design** Bio photonic applications of micro and Nano photonics.

2. **Syllabus:**

- **OPTICAL WAVEGUIDE THEORY** **(07 Hours)**
  Planar waveguides: Step-index and graded-index waveguides, guided and radiation modes. Strip and channel waveguides, anisotropic waveguides, segmented waveguide; electro-optic and acousto-optic waveguide devices.

- **ACOUSTO OPTIC DEVICES AND FABRICATION** **(08 Hours)**
  Directional couplers, optical switch; phase and amplitude modulators, filters, etc. junction, power splitters, Arrayed waveguide devices, fiber pig tailing, Fabrication of integrated optical waveguides and devices

- **WAVEGUIDE CHARATERIZATION** **(07 Hours)**
  Waveguide characterization, end-fire and prism coupling; grating and tapered couplers, nonlinear effects in integrated optical waveguides.

- **NEW MATERIALS AND PROCESS TECHNOLOGIES** **(07 Hours)**
  New materials and process technologies for optical device fabrication, advanced optical sources & detectors, amplifiers, their reliability issues, Optical integrated circuits, hybrid & monolithic systems, optical inter-connects, materials and processing for OEIC.

- **OPTICAL SENSORS** **(07 Hours)**
  Optical sensors intrinsic & extrinsic, principles of pressure, temperature, displacement and velocity measurements

- **ADVANCED TOPICS MICRO AND NANOPHOTONICS** **(06 hours)**
  Photonic crystals and MOEMS, Bio-photonic applications, recent developments in PICs.

(Total Contact Hours: 42)

3. **Books Recommended:**

1. Robert Hansberger, "Integrated optics: Theory and technology" 6th Ed., Springer, 2009.
2. T. Tamir, "Guided wave opto-electronics", 2nd Ed., Springer Verilag, 1990.
3. H. Nishihara, M. Haruna, and T. Suhara, "Optical Integrated Circuits", 1st Ed., McGraw-Hill Professional, 1989.
4. Yariv, A., & Yeh, P. "Photonics: Optical Electronics in Modern Communications", 6th Ed., Oxford university Press (2006).
5. C. R. Pollock and M. Lip Son, "Integrated Photonics", 1st Ed., Kluwer Pub., 2003.

VISIBLE LIGHT COMMUNICATION

L	T	P	Credit
3	0	0	03

EC 658 **Scheme**

1. **Course Outcomes (COs):**

At the end of the course the students will be able to:

CO1	**Classify** performance improvement techniques and light positioning in visible light communication.
CO2	**Demonstrate** the synchronization issues in VLC and the positioning system.
CO3	**Apply** the visible light communication (VLC) with various modulation techniques in Li-Fi systems.
CO4	**Evaluate** VLC link design parameters.
CO5	**Design** an image sensor based VLC system.

2. **Syllabus:**

- **MODULATION TECHNIQUES** **(08 Hours)**
  Introduction – Inverse source coding in dimmable VLC – ISC for NRK-OOK – ISC for M-ary PAM – Comparison with respect to dimming capacity – Multi-level transmission scheme – Asymptotic performance – Colour intensity modulation for muli-coloured VLC – colour space and signal space.

- **PERFORMANCE ENHANCEMENT TECHNIQUES AND LIGHT POSITIOING** **(08 Hours)**
  Introduction - Performance improvement of VLC systems by tilting the receiver plane – performance improvement of VLC systems by arranging LED lamps – Dimming technique and its performance in VLC systems. Indoor positioning and merits of using light – Positioning algorithms – challenges and solutions.

- **VISIBLE LIGHT POSITIONG AND COMMUNICATION AND SYNCHRONIZATION ISSUES IN VLC** **(09 Hours)**
  Introduction – Indoor light positioning systems based on visible light communication and imaging sensors. Outdoor light positioning systems based on LED traffic lights and photodiodes. VLC modulation methods in the time domain – Bit error rate calculation – Effects of synchronization time offset on IPPM BER.

- **IMAGE SENSORS BASED VLC AND STANDARD FOR VLC** **(09 Hours)**
  Overview – Image sensors – Image sensor as a VLC receiver – Design of an image sensor based VLC system – Massively parallel visible light transmission – Accurate sensor pose estimation – Application of Image sensor based communication. Scope of VLC standard – VLC modulation standard – VLC data transmission standard – VLC illumination standard.

- **APPLICATIONS** **(08 Hours)**
  Visible light communication for vehicular networking – Smart phone camera based visible light communication – Li-Fi – High-speed visible light communication - Visible light communication: Opportunities, challenges and path to market.

(Total Contact Hours: 42)

3. Books Recommended:

1. Zabih Ghassemlooy, Luis Nero Alves, Stanislav Zvanovec, Mohammad-Ali Khalighi, “Visible Light Communication: Theory and Applications”, 1st Ed., CRC press, 2017.
2. Shlomi Arnon, “Visible light Communication”, 1st Ed., Cambridge University Press, 2015.
3. H. Franz, V. K.Jain, “Optical Communications: Components and Systems”, Narosa Publishing House, 2000.
4. T. L. Singhal, "Optical Fiber Communications: Principles and Applications", 1st Ed., Cambridge, 2015.
5. Ramaswami Rajiv and Sivarajan K. N., "Optical Networks A Practical Perspective", 3rd Ed., Elsevier, Morgan Kaufmann Publishers, 2009.

EM INTERFERENCE AND COMPATIBILITY

L	T	P	Credit
3	0	0	03

EC 662 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	**Classify** the different standards for EMC.
CO2	**Implement** the environments of radiation and conduction interference and methods to counter it.
CO3	**Analyze** the hazards of cross talk interference and model the methods to avoid it.
CO4	**Evaluate** the utility of different EMC methods in different environments.
CO5	**Design** a system for EMC.

2. Syllabus:

- **INTRODUCTION** **(04 Hours)**
  History of EMI/EMC, Analysis of EMI, Types of noise and interference, Electromagnetic Compatibility, Benefits of good EMC design, EMC regulations (Government, Commercial And Military), Examples of EMC related problems.

- **EMC REQUIREMENTS FOR ELECTRONIC SYSTEMS** **(05 Hours)**
  Radiated emission limits for Class A, Class B, FCC And CISPR, Measurement Of Emissions for Verification of Compliance, Radiated Emission and Susceptibility, Conducted Emissions and Susceptibility, Typical Product Emissions, Additional Product Requirements, Design Constraints for Products, Advantages of EMC Design.

- **CONDUCTED EMISSION AND SUSCEPTIBILITY** **(07 Hours)**
  Measurement Of Conducted Emission: LISN, Common and Differential Mode Currents, Power Supply Filters, Basic Properties of Filters, a Generic Topology, Effect of Filter Elements on Common and Differential Mode Currents, Separation of Conducted Emissions In to Common And Differential Mode Components For Diagnostic Purpose, Power Supplies: Linear and SMPS, Effect of Power Supply Components on Conducted Emissions, Power Supply and Filter Placement, Conducted Susceptibility.

- **RADIATED EMISSION AND SUSCEPTIBILITY** **(07 Hours)**
  Simple Emission Models for Wires And PCB Lands: Differential Mode Versus Common Mode Currents, Differential Mode Current Emission Model, Common Mode Current Emission Model, Current Probes, Simple Susceptibility Models for Wires And PCB Lands: Shielded Cables and Surface Transfer Impedance.

- **CROSS TALK** **(10 Hours)**
  Three Conductor Transmission Lines and Crosstalk, Transmission Line Equations for Lossless Lines, The Per Unit Length Parameters: Homogeneous versus Inhomogeneous Media, Wide Separation Approximation for Wires, Numerical Methods for Other Structures, The Inductive-Capacitive Coupling Approximation Model: Frequency Domain Inductive-Capacitive Coupling Model, Time Domain Inductive-Capacitive Coupling Model, Lumped Circuit Approximate Models, Shielded Wires, Inductive and Capacitive Coupling, Effect of Shield Grounding, Effect of Pigtails, Effects of Multiple Shields, MTL Model Predictions, Twisted Wires, Inductive and Capacitive Coupling, Effects of Twist, Effects of Balancing.

- **SHIELDING** **(05 Hours)**
  Shielding Effectiveness, Far Field Sources, Exact Solution, Approximate Solution, Near Field Sources: Near Field versus Far Field, Electric Sources, Magnetic Sources, Low Frequency, Magnetic Fielding Shielding, Effect of Apertures.
- **SYSTEM DESIGN FOR EMC** **(04 Hours)**
  Shielding and Grounding, PCB Design, System Configuration and Design, Electrostatic Discharge, Diagnostic Tools.

3. Books Recommended:

1. Paul Clayton, Introduction to Electromagnetic Compatibility, 2nd Ed., Wiley Interscience, 2006.
2. Ott H. W., Noise Reduction Techniques in Electronic Systems, 2nd Ed., Wiley Interscience, 1988.
3. Goedbloed, Electromagnetic Compatibility, 1st English Language Ed., Prentice Hall, 1993.
4. Kaiser K. L., Electromagnetic Shielding, 1st Ed., CRC Press, 2006.
5. V. Prasad Kodali, Engineering Electromagnetic Compatibility, Principles, Measurement and Technologies, IEEE Press, 1996.

4. Reference Book:

1. Michel Mardiguian,"EMI Troubleshooting Techniques", 1st Ed., McGraw-Hill Professional, 1999.

INNOVATION, INCUBATION AND ENTREPRENEURSHIP

L	T	P	Credit
3	0	0	03

HU 410 **Scheme**

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	**Explain** the concepts of Entrepreneurship
CO2	**Develop** skills related to various functional areas of management (Marketing Management, Financial Management, Operations Management, Personnel Management etc.)
CO3	**Develop** skills related to Project Planning and Business Plan development
CO4	**Demonstrate** the concept of Innovation, Intellectual Property Rights (IPR) and Technology Business incubation
CO5	**Build** knowledge about Sources of Information and Support for Entrepreneurship
CO6	**Develop** Entrepreneurial Culture

2. Syllabus:

- **CONCEPTS OF ENTREPRENEURSHIP** **(10 Hours)**
  Scope of Entrepreneurship, Definitions of Entrepreneurship and Entrepreneur, Characteristics of an Entrepreneur, Entrepreneurial Development models and Theories, Entrepreneurs Vs Managers Classification of Entrepreneurs; Major types of Entrepreneurship – Techno Entrepreneurship, Women Entrepreneurship, Social Entrepreneurship, Intrapreneurship (Corporate entrepreneurship), Rural Entrepreneurship, Family Business etc.; Problems for Small Scale Enterprises and Industrial Sickness; Entrepreneurial Trait Tests; Entrepreneurial Environment – Political, Legal, Technological, Natural, Economic, Socio – Cultural etc. ; Motivation; Business Opportunity Identification

- **FUNCTIONAL MANAGEMENT AREA IN ENTREPRENEURSHIP** **(12 Hours)**
  Marketing Management: Basic concepts of Marketing, Development of Marketing Strategy and Marketing plan, Online Marketing, New Product Development Strategy
  Operations Management: Basic concepts of Operations management, Location problem, Development of Operations strategy and plan
  Personnel Management: Main operative functions of a Personnel Manager, Development of H R strategy and plan
  Financial Management: Basics of Financial Management, Ratio Analysis, Capital Budgeting, Working Capital Management, Cash Flow Statement, Break Even Analysis

- **PROJECT PLANNING** **(06 Hours)**
  Product Development – Stages in Product Development; Feasibility analysis – Technical, Market, Economic, Financial etc.; Project report; Project appraisal; Setting up an Industrial unit – procedure and formalities in setting up an Industrial unit; Business Plan Development

- **PROTECTION OF INNOVATION THROUGH IPR** **(04 Hours)**
  Introduction to Intellectual Property Rights – IPR, Patents, Trademarks, Copy Rights

- **INNOVATION AND INCUBATION** **(06 Hours)**
  Innovation and Entrepreneurship, Creativity, Green Technology Innovations, Grassroots Innovations, Issues and Challenges in Commercialization of Technology Innovations, Introduction to Technology Business Incubations, Process of Technology Business Incubation

- **SOURCES OF INFORMATION AND SUPPORT FOR ENTREPRENEURSHIP** **(04 Hours)**
  State level Institutions, Central Level institutions and other agencies

(Total Contact Hours: 42)

3. Books Recommended

1. Desai Vasant, Dynamics of Entrepreneurial Development and Management, 6th Revised Ed., Himalaya Publishing House, India, 2011.
2. Charantimath P. M., Entrepreneurial Development and Small Business Enterprises, 3rd Ed., Pearson Education, 2018.
3. Holt David H., Entrepreneurship: New Venture Creation, Pearson Education, 2016.
4. Chandra P., Projects: Planning, Analysis, Selection, Financing, Implementation and Review, 9th Ed., Tata McGraw Hill, 2019.
5. Banga T. R. &Shrama S.C., Industrial Organisation & Engineering Economics, 25th Ed., Khanna Publishers, 2015.

4. Reference Books:

1. Prasad L.M., Principles & Practice Of Management, 8th Ed., Sultan Chand & Sons, 2015.
2. Everett E. Adam, Ronald J. Ebert, Production and Operations Management, 5th Ed., Prentice Hall of India, 2012.
3. Kotler P., Keller K. L, Koshi A.& Jha M., Marketing Management – A South Asian Perspective, 14th Ed., Pearson, 2014.
4. Tripathi P.C., Personnel Management & Industrial Relations, 21st Ed., Sultan Chand & sons, 2013.
5. Chandra P., Financial Management, 9th Ed., Tata McGraw Hill, 2015.

INNOVATION, INCUBATION AND ENTREPRENEURSHIP

L	T	P	Credit
3	0	0	03

HU 483 **Scheme**

1. **Course Outcomes (COs):**

At the end of the course the students will be able to:

CO1	**Explain** the concepts of Entrepreneurship
CO2	**Develop** skills related to various functional areas of management (Marketing Management, Financial Management, Operations Management, Personnel Management etc.)
CO3	**Develop** skills related to Project Planning and Business Plan development
CO4	**Demonstrate** the concept of Innovation, Intellectual Property Rights (IPR) and Technology Business incubation
CO5	**Build** knowledge about Sources of Information and Support for Entrepreneurship
CO6	**Develop** Entrepreneurial Culture

2. **Syllabus:**

- **CONCEPTS OF ENTREPRENEURSHIP** **(10 Hours)**
  Scope of Entrepreneurship, Definitions of Entrepreneurship and Entrepreneur, Characteristics of an Entrepreneur, Entrepreneurial Development models and Theories, Entrepreneurs Vs Managers Classification of Entrepreneurs; Major types of Entrepreneurship – Techno Entrepreneurship, Women Entrepreneurship, Social Entrepreneurship, Intrapreneurship (Corporate entrepreneurship), Rural Entrepreneurship, Family Business etc.; Problems for Small Scale Enterprises and Industrial Sickness; Entrepreneurial Trait Tests; Entrepreneurial Environment – Political, Legal, Technological, Natural, Economic, Socio – Cultural etc. ; Motivation; Business Opportunity Identification

- **FUNCTIONAL MANAGEMENT AREA IN ENTREPRENEURSHIP** **(12 Hours)**
  Marketing Management: Basic concepts of Marketing, Development of Marketing Strategy and Marketing plan, Online Marketing, New Product Development Strategy
  Operations Management: Basic concepts of Operations management, Location problem, Development of Operations strategy and plan
  Personnel Management: Main operative functions of a Personnel Manager, Development of H R strategy and plan
  Financial Management: Basics of Financial Management, Ratio Analysis, Capital Budgeting, Working Capital Management, Cash Flow Statement, Break Even Analysis

- **PROJECT PLANNING** **(06 Hours)**
  Product Development – Stages in Product Development; Feasibility analysis – Technical, Market, Economic, Financial etc.; Project report; Project appraisal; Setting up an Industrial unit – procedure and formalities in setting up an Industrial unit; Business Plan Development

- **PROTECTION OF INNOVATION THROUGH IPR** **(04 Hours)**
  Introduction to Intellectual Property Rights – IPR, Patents, Trademarks, Copy Rights

- **INNOVATION AND INCUBATION** **(06 Hours)**
  Innovation and Entrepreneurship, Creativity, Green Technology Innovations, Grassroots Innovations, Issues and Challenges in Commercialization of Technology Innovations, Introduction to Technology Business Incubations, Process of Technology Business Incubation

- **SOURCES OF INFORMATION AND SUPPORT FOR ENTREPRENEURSHIP** **(04 Hours)**
  State level Institutions, Central Level institutions and other agencies

(Total Contact Hours: 42)

3. Books Recommended

1. Desai Vasant, Dynamics of Entrepreneurial Development and Management, 6th Revised Ed., Himalaya Publishing House, India, 2011.
2. Charantimath P. M., Entrepreneurial Development and Small Business Enterprises, 3rd Ed., Pearson Education, 2018.
3. Holt David H., Entrepreneurship: New Venture Creation, Pearson Education, 2016.
4. Chandra P., Projects: Planning, Analysis, Selection, Financing, Implementation and Review, 9th Ed., Tata McGraw Hill, 2019.
5. Banga T. R. &Shrama S.C., Industrial Organisation & Engineering Economics, 25th Ed., Khanna Publishers, 2015.

4. Addition Recommended

1. Prasad L.M., Principles & Practice Of Management, 8th Ed., Sultan Chand & Sons, 2015.
2. Everett E. Adam, Ronald J. Ebert, Production and Operations Management, 5th Ed., Prentice Hall of India, 2012.
3. Kotler P., Keller K. L, Koshi A.& Jha M., Marketing Management – A South Asian Perspective, 14th Ed., Pearson, 2014.
4. Tripathi P.C., Personnel Management & Industrial Relations, 21st Ed., Sultan Chand & sons, 2013.
5. Chandra P., Financial Management, 9th Ed., Tata McGraw Hill, 2015.

Revised Syllabus for B. Tech. IInd to B. Tech. IVth year
Mechanical Engineering Department

Teaching Scheme: B. Tech. (Mechanical Engineering) II Year

SEMESTER - III

Sr. No.	Subject	Code	Scheme	Exam Scheme				Total	Credit
				Theory		Tuto.	Pract.		
				Hrs.	Marks	Marks	Marks		
1.	Mathematics - III	MA219	3 – 1 – 0	3	100	25	-	125	04
2.	Engineering Thermodynamics	ME201	4 – 1 – 0	3	100	25	-	125	05
3.	Theory of Machines	ME203	3 – 1 – 2	3	100	25	50	175	05
4.	Metallurgy	ME205	3 – 0 – 2	3	100	-	50	150	04
5.	Measurement and Instrumentation	ME207	3 – 1 – 2	3	100	25	50	175	05
		Total	16 – 4 – 6	15	500	100	150	750	23

21|07|2020

Engineering Mathematics-III

MA219

L	T	P	Credit
3	1	0	04

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1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	understand the concept of convergence and divergence of infinite series
CO2	expand the periodic functions in the form of Fourier series along with different cases
CO3	obtain Fourier integral from Fourier series and understand the concept of integral transforms with their applications
CO4	aware the methods to obtain the solution of certain partial differential equations
CO5	understand the fundamental of numerical methods and apply in engineering problems

2. Syllabus

- **INFINITE SERIES** **(06 Hours)**
  Introduction, positive term series, comparison test, Cauchy's root test, D'Alembert's test, Raabe's test, Logarithmic test, Integral test, Gauss's test, Series with arbitrary terms, Rearrangement of terms.

- **FOURIER SERIES** **(06 Hours)**
  Definition, Fourier series with arbitrary period, in particular periodic function with period 2π. Fourier series of even and odd function, Half range Fourier series.

- **FOURIER INTEGRAL AND FOURIER TRANSFORMS** **(07 Hours)**
  Fourier Integral theorem, Fourier sine and cosine integral complex form of integral, Inversion formula for Fourier transforms, Fourier transforms of the derivative of a function.

- **PARTIAL DIFFERENTIAL EQUATION** **(08 Hours)**
  Second order PDE of Mathematical Physics (Heat, wave and Laplace equation, one dimensional with standard boundary conditions, solution by separation of variable method using Fourier series, Solution by separation of variables & transformation techniques.

- **SOLUTION OF ORDINARY DIFFERENITAL EQUATIONS** **(07 Hours)**
  Introduction to initial and boundary value problem, Euler's method, Runge-Kutta method, Taylor's series method, Predictor-Corrector method. Shooting method for boundary value problems and eigen value problem.

- **FINITE DIFFERENCE METHOD** **(08 Hours)**
  Introduction to finite difference method. Approximation to derivatives and boundary conditions of different kinds. Finite difference method to boundary value problems. Explicit and implicit Finite difference method for parabolic PDEs in one dimension with different boundary conditions. Approximation to ∇^2, Five point formula for Laplace and Poisson equation.

(Total Lecture Hours: 42)

21/07/2020

3. Books Recommended:

1. E. Kreyszig, Advanced Engineering Mathematics, 10th Edition, John Wiley, 2011.
2. C. R. Wylie, Advanced Engineering Mathematics, 6th Edition, McGraw Hill Education, 1995.
3. P. V. O'Neil, Advanced Engineering Mathematics, 7th Edition, Cengage, 2012.
4. M. D. Greenberg, Advanced Engineering Mathematics, 2nd Edition, Pearson Education, 2002.
5. B. V. Ramana, Higher Engineering Mathematics, 1st Edition, McGraw-Hill, New Delhi, 2010.

Further Reading:

1. S.S. Chapra and R.P. Canale, Numerical Methods for Engineers, 7th Edition, McGraw Hill International Edition, 2015.
2. K.S. Rao, Numerical Methods for Scientists and Engineers, 3rd Edition, Prentice-Hall India, 2007.

21/07/2020

Engineering Thermodynamics

L	T	P	Credit
4	1	0	05

ME201

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1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Relate the thermodynamic laws to engineering systems and processes.
CO2	Solve thermodynamic problems using Mollier diagram, steam and gas tables/charts.
CO3	Apply the second law of thermodynamics and entropy concepts in analyzing performance of heat pump and refrigerator
CO4	Explain the method of improving performance of a system by reducing irreversibility.
CO5	Analyse performance of various steam power cycle in context to power plant.
CO6	Classify various steam generators

2. Syllabus

- **INTRODUCTION** **(02 Hours)**
- **PROPERTIES OF PURE SUBSTANCE** **(08 Hours)**
  Definition of pure substance, Phases of a pure substance, P-V-T behavior of a pure substance, Critical & triple point of a pure substance, Mollier diagram, steam table & dryness fraction of steam, Measurement of dryness fraction of steam.
- **PROPERTIES OF GAS AND GAS MIXTURE** **(05 Hours)**
  Equation of state for ideal gas, Change in entropy, internal energy, enthalpy of gas in various thermodynamics processes, Dalton's law of partial pressure & properties of gas mixture.
- **SECOND LAW OF THERMODYNAMICS** **(07 Hours)**
  Statements of second law of thermodynamics. - The Carnot cycle & Carnot's theorem, Corollary of Carnot's theorem, Efficiency of reversible engine, Causes of irreversibility, C.O.P. of heat pump & refrigerator.
- **ENTROPY** **(08 Hours)**
  Inequality of Clausius theorem, Entropy as a property, Change in entropy in reversible and irreversible processes, Principle of increase of entropy, Entropy change of an ideal gas in various thermodynamics processes, Second law of thermodynamics for steady flow process & its application
- **AVAILABILITY AND IRREVERSIBILITY** **(10 Hours)**
  Basic concepts, Available and unavailable energy for a cycle, Different form of Exergy, Exergy balance for closed system and open system, Decrease of Exergy principle, Difference between first law & second law efficiency, Second law efficiency for steady flow devices.
- **THERMODYNAMIC RELATIONS & EQUILIBRIUM** **(08 Hours)**
  The Maxwell relations, Clausis –clapeyron equation, Joule –Thomson coefficient, Relationships involving specific heats, enthalpy, entropy.

21\03\2020

- **STEAM GENERATIORS** **(08 Hours)**

  Types of steam generators like natural circulation and forced circulation. Heat recovery steam generators (HRSG) with LP and HP evaporators, economizers, super heaters and air preheaters. High pressure boilers such as La Mont, Loeffler, Benson, Schmidt, Velox Boiler. Performance of boilers.

(Total Lecture Hours: 56)

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3. Books Recommended:

1. W. Van, R.E. Sonnetag and C. Borgnakke, Fundamental of Classical Thermodynamics, John Wiley & sons, 2005.
2. P K Nag, Engineering Thermodynamics, McGraw Hill Education Private Limited, 2013.
3. Y.A. Cengel and M.A. Boles, Thermodynamics, Tata McGraw Hill, 2004.
4. C.P. Kothandaraman, P.R. Khajuria and S. Domkundrar, A Course in Thermal Engineering, Dhanpat Rai & Sons,2004.
5. P.L. Ballaney, Thermal Engineering, Khanna Publishers, 2000.

21\07\2020

Theory of Machines

L	T	P	Credit
3	1	2	05

ME203

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1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Calculate the degree of freedom of mechanisms.
CO2	Apply the kinematic analyses in existing or real life mechanisms.
CO3	Analyze the kinematic requirements and shape of the cam and follower mechanism.
CO4	Analyze the given gears and gear trains for specific applications.
CO5	Calculate the required length and size of the belt, rope and chain drives considering required power transmission and centrifugal effect

2. Syllabus

- **MACHINES AND MECHANISMS** **(06 Hours)**
  Introduction, Mechanism and machine, Rigid and resistant body, Link, Kinematic pair, Types of motion, Degrees of freedom (mobility), Classification of kinematic pairs, Kinematic chain, Linkage, Mechanisms, Kinematic inversion, Inversions of slider crank chain, Double slider-crank chain

- **VELOCITY ANALYSIS** **(08 Hours)**
  Trace the Loci of points in simple mechanisms, Absolute and Relative motions, Vectors, Addition and Subtraction of vectors, Motion of a link, Angular velocity, Rotation of a rigid body, Translation and rotation of a rigid body, Velocity analysis of mechanisms by relative velocity method (graphical), Instantaneous centre, Kennedy's Theorem, Locating I- centres, Velocity analysis by instantaneous centers, Centrode.

- **ACCELERATION ANALYSIS** **(09Hours)**
  Definition of acceleration, Angular acceleration, A general case of acceleration, Radial and transverse components of acceleration, The coriolis component of acceleration, Acceleration analysis of mechanisms, Acceleration diagrams, Coriolis Acceleration component, Kinematic analysis of mechanisms with computer assisted software: Modeling and assembly of the linkages, joints and constraints, motion animation of the mechanism, Kinematic analysis of the existing or real life mechanism.

- **BELTS, ROPES AND CHAINS** **(06 Hours)**
  Introduction, Belt and rope drives, Open and crossed belt drives, Velocity ratio, Slip, Materials for belt and ropes, Law of belting, Length of belt, Ratio of friction tensions, Power transmitted, Centrifugal effect on belts, Maximum power transmitted by a belt, Initial tension, Creep, Chains, Cha in length, Angular speed ratio, Classification of chains

- **GEARS AND GEAR TRAINS** **(07 Hours)**
  Introduction, Classification of gears, Gear terminology, Law of gearing, Velocity of sliding, Forms of teeth, Cycloidal profile teeth, Involute profile Teeth, Comparison of cycloidal and involute tooth forms, Birth of contact, Arc of contact, number of pairs of teeth in contact, Interference in involute gears, Minimum number of teeth, Interference between rack and pinion, Undercutting, Introduction

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to helical, Spiral, Worm, Worm gear and bevel gears. Types of Gear trains. Kinematic analysis of gear trains, Differential of an Automobile.

- **CAMS** **(06 Hours)**
  Introduction, Types of cams, Types of followers, Cam terminology, Displacement diagrams, Motions of the follower, Graphical construction of cam profile.

(Total Lecture Hours: 42)

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3. Practicals:

1. To study and demonstrate various types of mechanisms and their inversions.
2. To draw velocity diagram of a mechanisms using instantaneous centre method.
3. To draw velocity and acceleration diagrams for mechanisms.
4. To draw velocity and acceleration diagram of a mechanism involving coriolis component of acceleration.
5. Kinematic analysis of existing or real life mechanisms with computer assisted software – I
6. Kinematic analysis of existing or real life mechanisms with computer assisted software – II
7. To study and demonstrate various types of cams and followers.
8. To draw the layout of cam profile for a reciprocating radial knife edge follower to provide constant velocity to the follower
9. To draw the layout of cam profile for an offset reciprocating roller follower to provide constant acceleration and retardation motion to the follower
10. To draw the layout cam profile for a flat faced reciprocating follower to provide SHM motion to the follower
11. To draw the layout of cam profile for an oscillating follower to provide cycloidal motion to the follower

4. Books Recommended:

1. S. S. Rattan, Theory of machines. Tata McGraw-Hill Education, 2014.
2. J. J. Uicker, G. R. Pennock and J.E. Shigley, Theory of Machines and Mechanisms, 3 rd Edition, Oxford University Press, 2011.
3. J.S., Rao and R.V. Dukkipati, Mechanism and Machine Theory, New edge international publishers, 2007.
4. A. Ghosh, and A.K. Mallik, Theory of mechanisms and machines, Affiliated East-West Press Private Limited, 2002.
5. A. G. Ambekar, Mechanism and Machine Theory, Prentice Hall of India Private Limited, 2007.

21\07\2020

Metallurgy

ME205

L	T	P	Credit
3	0	2	04

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Describe the importance of metallurgical industries and explain the basic principles of metallography and extraction of metallic elements.
CO2	Explain the microstructure of ferrous and non-ferrous alloys and correlate the same with their properties and applications.
CO3	Analyze solidification mechanisms of metals and apply the same for control of structure of engineering products
CO4	Describe strengthening mechanisms of metallic materials, and explain the elastic/plastic deformation of metallic materials.
CO5	Explain the phase-equilibria in binary alloys and analyze phase diagrams for binary alloys.
CO6	Explain the principle, procedure and application of heat-treatments of ferrous and non-ferrous alloys.
CO7	Explain the principles, procedures, advantages and limitations of non-destructive testing techniques.

2. Syllabus:

- **INTRODUCTION AND SCOPE** **(04 Hours)**
  Various fields of metallurgical engineering, Status of metallurgical industry in India, Sources of metals, Basic outline of the principles of production of iron and steel, copper, aluminum. Basic concepts of metallography.

- **STRUCTURE-PROPERTY CORRELATIONSHIP IN METALS** **(06 Hours)**
  Ferrous: Allotropic forms of Iron, Wrought Iron, Cast Irons - Grey, White, Malleable and Spheroidal Graphite, Steel - Plain carbon steel, Alloying of steels, Stainless steels, Tool steels, Maraging steels.
  Non-ferrous: Copper & Copper alloys - Brass, Bronze, Cupro-Nickel; Aluminum and Aluminum alloys, Titanium alloys, Nickel based super alloys.

- **SOLIDIFICATION OF METALS** **(04 Hours)**
  Solidification of pure metals, Nucleation, Growth, Applications of controlled Nucleation & controlled growth.

- **DEFORMATION OF METALS** **(06 Hours)**
  Elastic & plastic deformation of metals, Strengthening mechanisms, Importance of grain size, directional properties, Recovery, Recrystallization and grain growth

- **EQUILIBRIUM PHASE DIAGRAMS** **(08 Hours)**
  Objectives & classification, Basic terms - system, phases & structural constituent, Phase systems - Isomorphous, Eutectic. Eutectoid, Peritectic. Interpretation of phase diagrams - Lever rule, Gibb's phase rule, Equilibrium phase diagram of Fe-Fe_3C system, Equilibrium phase diagrams of non-ferrous alloys.

21/07/2020

- **HEAT TREATMENT** **(08 Hours)**
  Purpose, Definition and Classification of heat-treatment processes for steels, Heat treatments for bulk materials - Annealing, Normalizing, Hardening, Tempering, Isothermal cooling transformation diagram (ICT/TTT) and Continuous cooling transformation (CCT) diagrams for steels, Various surface hardening heat-treatment of steels; Heat-treatment of Al alloys - Solution treatment, Solution quenching & Precipitation hardening.

- **NON-DESTRUCTIVE TESTING TECHNIQUES** **(06 Hours)**
  Importance, principle, procedure, equipments, advantages & limitations of various non-destructive techniques - visual inspection, radiography, ultrasonic testing, magnetic particle inspection, liquid penetrant inspection, eddy current testing

(Total Lecture Hours: 42)

3. Practicals:

1. To study construction and working of metallurgical microscope.
2. To preparation specimen for microscopic observation
3. To study structure, properties and applications of ferrous alloys.
4. To study $Fe\text{-}Fe_3C$ equilibrium phase diagram and its applications.
5. To Study structure, properties and applications of non-ferrous alloys.
6. To study T-T-T & C-C-T diagram of steels.
7. To estimate effect of severity of quenching media in hardening heat-treatment of steels.
8. To determine hardenablility of steel using Jominy end quench test.

4. Books Recommended:

1. R. Balasubramanian, Callister's Materials Science and Engineering, John Wiley & Sons, 2014.
2. D. R. Askland, P. P. Fulay, W. J. Wright, The Science and Engineering of Materials, Cengage Learning, 2015.
3. S. H. Avner, Introduction to Physical Metallurgy, McGraw-Hill, 2017.
4. O. P. Khanna, A Text book of Materials Science And Metallurgy, Dhanpat Rai Publications.
5. W. Smith, J. Hashemi, R. Prakash, Materials Science & Engineering, McGraw Hill, 2014.

21\07\2020

Measurements And Instrumentation

ME207

L	T	P	Credit
3	1	2	04

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1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Draw block diagram of different measurement instruments.
CO2	Describe basic concepts of mechanical measurement, errors in measurements and uncertainty.
CO3	Identify the type of measurement instruments and their relevant specification etc. which can be used in a particular process parameter measurement selection.
CO4	Explain the theory of stress & strain, force and torque measurements.
CO5	Explain control systems used in industry.
CO6	Analyze and characterize the behavior of a control system in terms of different system and performance parameters.

2. Syllabus

- **BASIC CONCEPTS & IMPORTANCE OF MEASUREMENTS:** **(07 hours)**
  Aim of measurement, methods of measurement, generalized measurement systems, Instruments & its classifications, performance characteristics of instruments, Statistic & dynamic characteristics, analysis of experimental data, Regression analysis, correlation, estimation of uncertainty and presentation of data, design of experiments, Errors in measurements.

- **TEMPERATURE MEASUREMENTS:** **(06 Hours)**
  Temperature scales, Ideal gas, Temperature measuring devices, Thermometer, Bi- metallic strip, Electrical resistance thermometer, Thermistors and thermocouples, Laws of thermocouples and their applications, Construction and calibration of thermocouples, Radiation pyrometers, total radiation pyrometers

- **PRESSURE MEASUREMENT:** **(07 hours)**
  Definition of pressure, Units, Types of pressure measurement devices, Manometers, Dead weight tester, Bourdon tube pressure gauge, Diaphragms and bellows, Low pressure measurement, Mcleod gauge, Pirani thermal conductivity gauge, Knudsen gauge, Ionization gauge, Piezo electric transducer Selection of pressure measuring devices for specific applications, Calibration of pressure measuring devices.

- **FLOW MEASUREMENTS:** **(07 hours)**
  Types of flow measuring devices, Constructional features, Obstruction meters like orifice, Venturi nozzle and their calibration, Flow measurement by drag effects (rotameter), Pitot tube, Hot wire anemometers, Magnetic flow Meters, Flow visualization Techniques, Shadowgraph, Interferometer, Laser Doppler, Ultra sonic flow meter.

- **MEASUREMENT OF FORCE, TORQUE AND STRAIN:** **(6 hours)**
  load cells, cantilever beams, proving rings, differential transformers. Measurement of torque: Torque measurement on rotating shaft, Proney brake and eddy current dynamometer. Measurement of strain:

Mechanical strain gauges, electrical strain gauges, strain gauge: materials, gauge factors, theory of strain gauges and method of measurement, Rosettes, bridge arrangement, temperature compensation.

- **DISPLACEMENT, VELOCITY, SPEED AND ACCELERATION MEASUREMENTS: (5 hours)**
  Working principal of Resistive Potentiometer, Linear variable differential transducers, Electro Magnetic Transducers, Mechanical, Electrical and Photoelectric Tachometers, Piezoelectric Accelerometer, Seismic Accelerometer.

- **CONTROL SYSTEMS: (04 hours)**
  Basic concepts of control systems, classifications of control system, close loop control systems, open loop control system, automatic control systems, servo mechanism, regulator, representation through model, analogous system, block diagram, mathematical block diagram, signal flow graph, time response of control systems stability, frequency response, Industrial controllers pneumatic and hydraulic control systems, micro controller

(Total Lecture Hours: 42)

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3. Practicals:

1. To calibrate the thermocouples.
2. To demonstrate temperature by using RTD & thermistor
3. To determine the fluid flow velocity through orifice meter, venturimeter,
4. To determine the fluid flow velocity through rotameter and magnetic flow meter.
5. To demonstrate temperature of forceby using strain gauge.
6. To demonstrate temperature pressure measurement through dead weight tester.
7. To demonstrate temperature measurements of speed of machine elements.
8. To demonstrate temperature measurement of temperature by using optical pyrometer.

4. Books Recommended:

1. O. E. Doeblin and D. N. Manik, Measurements System, 7th Edition, McGraw Hill, 2019
2. Richard S. Figiliola,Theory and Design for Mechanical Measurements; 6thEdition, Wiley India, 2015
3. D. S. Kumar, Mechanical Measurement and control,5th edition, Metropolitan Book Co. (P) Ltd., (2015)
4. A. K. Sawhney and Puneet Sawhney, A Course in Mechanical Measurements and Instrumentation and Control, Dhanpat Rai & Co., 2017
5. R. K. Rajput, Mechanical Measurements and Instrumentation, Kataria and sons, 2013

21\07\2020

Teaching Scheme: B. Tech. (Mechanical Engineering) II Year

SEMESTER - IV

Sr. No.	Subject	Code	Scheme	Exam Scheme				Total	Credit
				Theory		Tuto.	Pract.		
				Hrs.	Marks	Marks	Marks		
1.	Fluid Mechanics	ME202	3 – 1 – 2	3	100	25	50	175	05
2.	Heat Transfer	ME204	3 – 1 – 2	3	100	25	50	175	05
3.	Machine Design and Drawing	ME206	4 – 0 – 4	3	100	-	100	200	06
4.	Dynamics of Machines	ME208	3 – 1 – 2	3	100	25	50	175	05
5.	Industrial Engineering	ME212	3 – 0 – 0	3	100	-	-	100	03
		Total	16 – 3 – 10	15	500	75	250	825	24

21/07/2020

Fluid Mechanics

ME202

L	T	P	Credit
3	1	2	05

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1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Predict the performance of prototype using dimensionless numbers.
CO2	Apply continuity equation in Cartesian and cylindrical coordinate system.
CO3	Compute local velocity and acceleration of complex fluid flow domain.
CO4	Solve fluid dynamic problems applying Navier-Stoke's equation and its reduced form
CO5	Evaluate fluid flow properties for laminar/turbulent flow through pipes and parallel plates
CO6	Design piping system for water distribution

2. Syllabus

- **FLUID KINEMATICS** **(12 Hours)**
  Velocity Field, Steady and unsteady Flows, One, Two and Three Dimensional Flows, Uniform and non-uniform flows, Steam Lines and Stream Tubes, Path Lines and Streak Lines, Euler and Lagrangian Methods, Substantial Derivative and Acceleration, Translation, Rotation and Deformations, Vorticity , Rotational and Irrotational flows, Circulation, Velocity Potential function, Equation of Continuity in differential form for Cartesian and cylindrical coordinate system, Equation of Stream Line, Discharge in Terms of Steam Function, Stream Function and Velocity Potential function, Laplace Equation in terms of Stream Function and Velocity Potential function, Boundary Conditions, Flow Nets, Differential and Integral Approach Applied to Conservation of Mass, Momentum and Energy Principles..

- **FLUID DYNAMICS** **(10 Hours)**
  Newton's Laws of Motion, Reynold's Transport Theorem, Euler's Equation, Bernoulli's Equation, Flow Through Confined Passages, Navier-Stokes Equation, Exact solution of Navier-Stokes Equation for simple flows. Vortex flow, Free vortex flow and forced vortex flow.

- **DIMENSIONAL ANALYSIS** **(04 Hours)**
  Dimensions, Dimensional Homogeneity, Buckingham-π Theorem, Dimensional Grouping, Non - Dimensional Numbers, Geometrical, Kinematics and Dynamic Similarity.

- **LAMINAR AND TURBULENT FLOWS** **(06 Hours)**
  Concepts of Laminar an Turbulent Flows, Laminar Flow Through Round Pipes, Laminar Flow between Parallel Plates for Moving and Stationary plates, Measurement of Viscosity. Concept of Eddy Viscosity, Prandtle's Mixing Length Theory, Viscous Sub layer, Smooth and Rough Pipe s, Nickuradse Experiment, Moody's Chart.

- **PIPE SYSTEMS** **(05 Hours)**
  Major and Minor losses in pipes, Losses in Fittings, Power Transmission Through Pipes, Pipes connected in Series and Parallel, Branched Pipes, Total Energy line and Hydraulic Gradient Lines. Water distribution system.

- **BOUNDARY LAYER THEORY** **(05 Hours)**

21/07/2020

Concept of Boundary Layer, Boundary Layer over Flat Plates and Tubes, Boundary Layer Parameters, Boundary Layer Thickness, Momentum Thickness, Displacement Thickness, Von - Karman Momentum Integral Equation, Boundary Layer Separation and Control, Concept of Drag, Streamlined and Bluff Bodies.

(Total Lecture Hours: 42)

3. Practicals:

1. Flow of an Incompressible Fluid through an Orifice meter and its calibration for measurement of discharge.
2. Flow of an Incompressible Fluid through a Nozzle meter and its calibration it for measurement of discharge.
3. Flow of an Incompressible Fluid through a Venturi Meter and its Calibration for measurement of discharge.
4. Flow of an Incompressible Fluid through a Centrifugal Head Meter and its Calibration for measurement of discharge.
5. Forced Vortex flow of water in the vessel.
6. Variation of friction factor with Reynolds number for Laminar flow through circular pipe
7. Variation of friction factor with Reynolds number for Turbulent flow through circular pipe
8. Determination of the velocity distribution in circular pipe.
9. Study of types of Pipes, Pipe symbols, Pipe Fittings and Valves.

4. Books Recommended:

1. F. M. White, Fluids Mechanics, McGraw -Hill Inc., 2015.
2. V. L. Streeter, E. B. Wylie, Fluid Mechanics, McGraw -Hill Book Co. Inc., 2001.
3. A. K. Mohanty, Fluid Mechanics, Prentice -Hall India Private Ltd., 2004.
4. J. F. Douglas, J. M. Gasiorek, J. A. Swaffield, Fluid Mechanics, Pearson Education Pvt. Ltd., 2001.
5. S. K. Som, G. Biswas, Introduction to Fluid Mechanics and Fluid Machines, Tata McGraw Hill Co. Pvt. Ltd., 2017.

21/07/2020

Heat Transfer

ME204

L	T	P	Credit
3	1	2	05

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1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Apply appropriate mode of heat transfer while analysing complex engineering problems.
CO2	Compute steady state and transient heat conduction problems in slab, cylindrical and spherical systems.
CO3	Explore various Nusselt number correlations for forced and free convection systems.
CO4	Calculate surface to surface radiative heat transfer in engineering systems.
CO5	Investigate the performance of heat exchanger using LMTD and NTU-effectiveness methods.

2. Syllabus

- **INTRODUCTION** **(01 Hours)**
  Modes of heat transfer, conduction, convection and radiation.

- **CONDUCTION** **(14 Hours)**
  Fourier's law. General three-dimensional heat conduction equation in Cartesian, cylindrical and spherical co -ordinates. One-dimensional steady conduction through plane wall, cylinder and sphere. Contact Resistance. Critical radius of insulation. Heat source systems in plane wall and cylinder. Heat conduction through extended surface. Effectiveness and fin efficiency. Derivation of governing differential equation (GDE) for pin fin. Solution GDE of pin fin subjected to different boundary conditions. Heat flow rate from finned system. One-dimensional unsteady state heat conduction. Lumped heat capacity analysis. Analysis of system with considerable temperature gradient. Heisler and Grober charts.

- **CONVECTION** **(14 Hours)**
  Forced Convection: Governing Differential Equation, Dimensionless number and their physical significance, Internal forced convection, External forced convection, Flow over tube banks, Reynolds analogy and Colburn analogy. Free Convection: Governing Differential Equation, Dimensionless number and their physical significance, Empirical relations for plate and cylinder and their use. Combined natural and forced convection. Fundamentals of boiling & condensation heat transfer.

- **RADIATION** **(07 Hours)**
  Thermal radiation, monochromatic and total emissive power. Basic laws of radiation. Radiation shape factors, black and grey surfaces, heat transfer in presence of re-radiating surfaces.

- **HEAT EXCHANGERS** **(06 Hours)**
  Basic types of heat exchangers, fouling factors, LMTD, Effectiveness – NTU methods of design.

(Total Lecture Hours: 42)

21/07/2020

3. Practicals:

1. To calibrate copper constantan of thermocouple.
2. To plot temperature distribution and analyse heat transfer through composite wall.
3. To determine thermal conductivity of insulating powder.
4. To find and compare heat transfer coefficient in natural convection
5. To assess emissivity of circular surface
6. To determine and compare heat transfer coefficient in internal forced convection phenomena.
7. To compute Stefan Boltzmen constant value
8. To determine pin-fin efficiency in natural and forced convection.
9. To calculate the overall heat transfer coefficient in shell and tube heat exchanger.

4. Books Recommended:

1. S. P. Sukhatme, Heat Transfer, Universities Press, 20012.
2. J. P. Holman, Heat Transfer, McGraw Hill, 2017.
3. Y. A. Cengel, A. J.Ghajar, Heat and Mass Transfer, McGraw Hill, 2017.
4. N. V. Suryanarayana, Engineering Heat Transfer, Penram International Publishing, 2015.
5. R. C. Sachdeva, Fundamentals of Heat and Mass Transfer, New Age International Publications, 2012.

21/07/2020

Machine Design and Drawing

ME206

L	T	P	Credit
4	0	4	06

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1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Describe the theories of stress and strain
CO2	Explain the basic principles of machine design and drawing considerations.
CO3	Design machine elements for dynamic considerations.
CO4	Design screws, fasteners, riveted, bolted and welded joints.
CO5	Design mechanical springs, shafts and shaft components

2. Syllabus

- **THEORIES OF STRESS AND STRAIN** **(10 Hours)**
  Concept of stress and strain and their relationships, equilibrium equations, strain displacement relation, simple beams, bending moments, shear forces and stresses in beams. torsion, energy methods.

- **COMBINE LOADING AND THEORIES OF FAILURE** **(10 Hours)**
  Combined stresses, mohr's circle diagram for stress and strain rosettes. theories of failure, stresses in thin and thick cylinders.

- **DESIGN CONSIDERATIONS** **(05 Hours)**
  Introduction to design procedure, design requirements and material selection, review of force analysis concepts, factor of safety concepts, concept and mitigation of stress concentration.

- **DYNAMIC LOADING** **(05 Hours)**
  Cyclic loading, endurance limit, fatigue and thermal stresses, creep.

- **DESIGN OF MECHANICAL ELEMENTS**
  Screws, Fasteners, and Design of Joints **(12 Hours)**
  Threaded fasteners and power screws, design of welded, riveted and bolted joints, knuckle and cotter joints.
  Shafts and Shaft Components **(07 Hours)**
  Design of keys, splines, shafts and shaft couplings.
  Mechanical Springs **(07 Hours)**
  Stresses in helical springs, curvature effect, deflection of helical springs, spring materials, helical compression spring design for static service, fatigue loading, extension and leaf springs.

(Total Lecture Hours: 56)

21/07/2020

3. Practicals:

Machine Drawing Practice

1. DETACHABLE FASTENERS: Specifications of screw threads and threaded fasteners, foundation bolts; shaft couplings, knuckle and cotter joints.
2. PERMANENT FASTENINGS: Rivets and riveted joints, types of welds and welded joints, and representation of welds on drawings.
3. ASSEMBLY DRAWINGS: Review of sheet preparation: boundary lines, zones, title block, revision panel, parts list, numbering of components and associated detail drawings; assembly drawing practices, exposure to CAD software.
4. COMPONENTS DRAWING: Use of tolerances, tolerance dimensioning, general tolerances; Surface quality symbols: Terminology and representation on drawings, correlation of tolerances and surface quality with manufacturing techniques, detail drawing practices: I.C. Engine parts, boiler mounting accessories.

4. Books Recommended:

1. S. P. Timoshenko and D. H. Young, Elements of Strength of Materials, 5th Edition, East-West Press Pvt. Ltd., 2009.
2. R. G. Budynas and K. Nisbett, Shigley's Mechanical Engineering Design, 11th Edition, McGraw Hill, 2020.
3. V. B. Bhandari, Design of Machine Elements, 4th Edition, Tata McGraw Hill, 2016.
4. R. L. Norton, Machine Design, 5th Edition, Pearson Education India Ltd., 2014.
5. N. D. Bhatt and V. M. Panchal, Machine Drawing, 48th Edition, Charotar Publishing House, 2013.

21/07/2020

Dynamics of Machines

ME208

L	T	P	Credit
3	1	2	05

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1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Understand the conditions of the static equilibrium and free body diagrams and analyse different types of governors.
CO2	Apply the knowledge of static and dynamic force analysis in existing mechanisms
CO3	Apply the concept of balancing for rotating and reciprocating unbalanced masses
CO4	Analyze the stability of automobile, naval ship and other related devices considering gyroscopic effect.
CO5	Design and analysis of the flywheel considering turning moment diagram,

2. Syllabus

- **INTRODUCTION** **(09 Hours)**
  Forces, couples, conditions of static equilibrium, free body diagrams, analysis of mechanisms, spur gears, worm gears.

- **STATIC AND DYNAMIC FORCE ANALYSIS** **(11 Hours)**
  Inertia forces, analysis of a floating link, rotation, method of virtual work. Dynamic analysis of Four-link mechanism, combined static and inertia force analysis of different mechanisms, Turning moment diagrams, fluctuation of speed and energy, flywheels, Inertia force analysis of simple mechanisms.

- **BALANCING** **(09Hours)**
  Introduction, static balancing, dynamic balancing of several masses in different planes. Balancing of inline engines, V-engines, radial engines, balancing machines.

- **GOVERNORS** **(08 Hours)**
  Introduction, types of governors, sensitiveness of a governor, hunting, isochronisms, stability, effort and power of a governor, controlling force.

- **GYROSCOPE** **(05 Hours)**
  Angular velocity, angular acceleration, gyroscopic couple, gyroscopic effect on naval ships, stability of an automobile, stability of a two wheel vehicle.

(Total Lecture Hours: 42)

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3. Practicals:

1. To determine mass moment of inertia of connecting rod by compound pendulum mentioned.
2. To determine mass moment of inertia of connecting rod by bifiller method.
3. To determine mass moment of inertia of connecting rod by trifiller method.

4. To balance multi-rotor system by experimental and validation with analytical and graphical method.
5. To prepare the performance characteristic curves on Porter governor.
6. To prepare the performance characteristic curves on Proell governor.
7. To prepare the performance characteristic curves on Watt governor.
8. To find the gyroscopic couple acting on rotating disc.

4. Books Recommended:

1. S. S. Rattan, Theory of Machines, McGraw Hill Education (India) Private Limited, 2009.
2. J.E. Shigley, J. J. Uicker and G. R. Pennock, Theory of Machines and Mechanisms, 3 rd Edition, Oxford University Press, 2005.
3. R. S. Khurmi and J. K. Gupta, Theory of Machines, S. Chand and Company Ltd., 2003.
4. J.S. Rao, and R.V. Dukkipati, Mechanism and Machine Theory, Wiley Eastern Ltd.,1989
5. A. Ghosh and A. K. Malick, Theory of Mechanisms and Machines, 3^{rd} Edition, East West Press Pvt. Ltd., 2000.

21/07/2020

Industrial Engineering

ME212

L	T	P	Credit
3	0	0	03

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Explain the basics of industrial engineering, identify the factors influencing productivity and evaluate the productivity.
CO2	Apply the tools of method study and time study for creating the improved process and timing for doing a job.
CO3	Explain and analyse the factors affecting the plant layout and location decisions.
CO4	Apply qualitative and quantitative techniques for solving the problems of forecasting.
CO5	Apply deterministic and probabilistic inventory control models for evaluating the inventory level.
CO6	Explain the production systems and functions of production planning and control.

2. Syllabus

- **INDUSTRIAL ENGINEERING AND PRODUCTIVITY** **(04 Hours)**
  Introduction, history, objectives, organization structure, scope, Productivity, factors influencing productivity, Productivity measurement, causes of low productivity and techniques of their elimination, Introduction to advance industrial engineering techniques.
- **WORK STUDY AND ERGONOMICS** **(10 Hours)**
  History, Scope, Objectives, Overview, Method study Objectives and procedure, Micro motion study, Method study tools, Time study procedure, Performance rating, Allowances, Predetermined Motion Time Systems (PMTS), Work Sampling, Ergonomics, Work science, Design factors, Effect of environment, Man-Machine System, Workload and Fatigues.
- **PLANT LOCATION AND LAYOUT** **(07 Hours)**
  Factors affecting location decisions, Methods of evaluating location alternative, Layout types, Work cells, Repetitive and product oriented layout, Computerized layout design procedure
- **FORECASTING** **(06 Hours)**
  Steps, qualitative and quantitative approaches, Monitoring and controlling forecast, Forecasting in service sector
- **INVENTORY CONTROL** **(07 Hours)**
  Managing inventory, Inventory models for independent demand, Probabilistic models and safety stock, Single period model, Fixed period model
- **PRODUCTION PLANNING AND CONTROL (PPC)** **(04 Hours)**
  Production Systems, Job, Batch, Mass and Continuous production system, Objectives of PPC, Functions of PPC

21\07\2020

- **HUMAN RESOURCE MANAGEMENT** **(04 Hours)**

Functions of Human Resource Manager, Training and development, Job evaluation and Merit rating, Wage and Wage Incentives, Grievance handling, Discipline and welfare

(Total Lecture Hours: 42)

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3. Books Recommended:

1. J. Heizer, B. Render, C. Munson, and A.Sachan, Operations Management, 12th Edition, Pearson Education, 2017.
2. E. S. Buffa and R. K. Sarin, Modern Production/ Operations Management, 8th Edition, John Wiley & Sons, 1987.
3. S. Eilon, Elements of Production Planning and Control, 3rd Edition, Universal Publishing Corporation, 1991.
4. N.V. S. Raju, Industrial Engineering and Management, 1st Edition, Cengage Learning, 2013.
5. M. Mahajan, Industrial Engineering and Production Management, 1st Edition, Dhanpat Rai & Co. (P) Limited, 2015.

21/07/2020

Teaching Scheme: B. Tech. (Mechanical Engineering) III Year

SEMESTER - V

Sr. No.	Subject	Code	Scheme	Exam Scheme				Total	Credit
				Theory		Tuto.	Pract.		
				Hrs.	Marks	Marks	Marks		
1.	**Fluid Machines**	ME301	4 – 0 – 2	3	100	-	50	150	05
2.	**Design of Machine Components**	ME303	3 – 1 – 2	3	100	25	50	175	05
3.	**Machining Processes**	ME305	3 – 1 – 2	3	100	25	50	175	05
4.	**Institute Elective –1**	ME3XX	3 – 0 – 0	3	100	-	00	100	03
5.	**Core Elective – 1**	ME3AA	3 – 0 – 0	3	100	-	-	100	03
6.	**Seminar**	ME307	0 – 0 – 2	0	-	-	50	50	01
		Total	16 – 2 – 8	15	500	50	200	750	22

Institute Elective – 1 (ME3XX)

1. Plastic and Ceramics: ME361
2. Theory and Application of Fluid Machinery*: ME363
3. Mechatronics: ME365
4. Control System: ME367
5. Engineering Estimation and Costing: ME369

*Except MED students

Core Elective – 1 (ME3AA)

1. Computational Fluid Dynamics: M321
2. Maintenance & Safety Engineering:ME323
3. Powder Processing Techniques: ME325
4. Mechanics of Materials: ME327
5. Additive Manufacturing Process:ME329

21/07/2020

Fluid Machines

ME301

L	T	P	Credit
4	0	2	05

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1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Illustrate selection and application of various hydraulic and steam turbines
CO2	Explain the working principles of hydraulic pumps, and predict performance curves
CO3	Describe the working principles of steam power cycles
CO4	Explain working principles of steam nozzle
CO5	Explore various steam condenser, and cooling towers
CO6	Describe basic principles of pumps, fans, blowers and compressors

2. Syllabus

- **FUNDAMENTALS OF FLUID MACHINES** **(04 Hours)**
  Classification of fluid machines, Impulse momentum principle, Basic equation of energy transfer in a fluid machines.

- **HYDRAULIC TURBINES** **(12 Hours)**
  Classification, Pelton, Francis, Kaplan, Propeller turbines, Velocity triangles, power and efficiency calculations, draft tube, cavitation, Thoma's cavitation factors

- **HYDRAULIC PUMPS** **(12 Hours)**
  Classification of different type of pump, principle of dynamic action & positive displacement type of pump, various parts of centrifugal pump & their function, theoretical analysis of energy transfer between fluid & rotor, losses, various efficiencies of the pump, performance characteristics, matching of pump & system characteristics, model analysis of centrifugal pump & specific speed, cavitation in pump & maximum suction lift.

- **STEAM POWER CYCLES** **(05 Hours)**
  Simple steam power cycle, Rankine cycle, Rankine cycle efficiency, Comparison of Rankine & Carnot cycles. Reheat cycle, Regenerative cycle, Reheat -regenerative cycle, Cogeneration.

- **STEAM NOZZLES** **(05 Hours)**
  Introduction, Types of Nozzles, Flow of steam through nozzles, Expansion of steam considering friction, Nozzle efficiency, Super-saturated flow through nozzle, Examples.

- **STEAM TURBINES** **(08 Hours)**
  Introduction of steam and water turbine, Classification and general constructional features, Compounding of turbine. Impulse Turbine: Working principle, Forces on blades, Velocity diagrams, efficiency of multi stage turbine, Specific speed and performance characteristic curves for water turbine. Impulse Reaction Turbine: Working principle, Degree of reaction, Parson's reaction turbine, height of blade, Cavitation and performance characteristic curves for water turbine.

- **STEAM CONDENSOR AND COOLING TOWER** **(04 Hours)**

21/07

Introduction, Elements of steam condensing plant, Types of steam condensers, Thermodynamic analysis of condenser, Cooling towers.

- **FANS, BLOWERS AND COMPRESSORS** **(06 Hours)**
  Construction and classification, governing equation, losses, performance curves, Positive displacement, Centrifugal and axial flow compressor, Components & their functions, velocity triangle, Performance, Slip factor, pre whirl, Choking, Surging & stalling, Degree of reaction.

(Total Lecture Hours: 56)

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3. Practicals:

1. Study of Modern Steam Power Plant.
2. Estimation of power output & efficiency of a steam turbine.
3. Study of condenser and cooling tower.
4. Impact of jet on vanes.
5. Performance test on gear pump.
6. Performance test on jet pump.
7. Performance test on centrifugal pump.
8. Study and performance of water turbines.
9. Study of compressors.

4. Books Recommended:

1. S. Domkundwar, C.P. Kothandaraman and A.V. Domkundwar, A Course in Thermal Engineering, Dhanpat Rai and Co, 2018
2. J. Lal, Hydraulic Machines including Fluidics, Dhanpat Rai & Co, 2016.
3. S. K. Som, G. Biswas, S. Chakraborty, Introduction to Fluid Mechanics and Fluid Machines, McGraw Hill, 2017
4. P.K. Nag, Power Plant Engineering, Tata McGraw Hill Publications, 2017
5. S.M.Yahya, Turbines, Compressors and Fans, Tata McGraw Hill, 2017.

Design of Machine Components

ME303

L	T	P	Credit
3	1	2	05

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1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Apply the statistical considerations in machine design.
CO2	Design and analysis of power transmission elements.
CO3	Design of different types of clutches and brakes.
CO4	Design of different types of bearings and I. C. Engine components.
CO5	Design of miscellaneous machine elements.

2. Syllabus

- **STATISTICAL CONSIDERATIONS IN MACHINE DESIGN** **(03 Hours)**
  Probabilistic approach to design, statistical analysis of tolerances, reliability, statistical factor of safety, MTBF, reliability of systems in series and parallel.

- **DESIGN OF POWER TRANSMISSION ELEMENTS** **(17 Hours)**
  Design of belt drives, selection of flat and V- belts, design of pulleys and flywheels, design of gear drives – spur, helical, bevel and worm gear drives, design of single and multistage speed reducers. Design of gear boxes: Types of gear boxes, design of machine tool gear boxes using preferred numbers.

- **DESIGN OF CLUTCHES AND BRAKES** **(05 Hours)**
  Types of clutches, design of single and multiple plate clutches, cone and centrifugal clutch, design of block brake, pivoted shoe brake, long shoe brake, internal shoe brake, simple and differential band brake.

- **DESIGN OF BEARINGS** **(08 Hours)**
  Design of hydrodynamic journal bearings, classification, material selection, Sommerfeld number and use of charts for the estimation of minimum film thickness, temperature rise, flow quantity etc. design of pressure fed and self-contained bearings, rolling contact bearings, classification, selection factors affecting bearing life, bearing assembly and lubrication.

- **MISCELLANEOUS MACHINE ELEMENTS** **(05 Hours)**
  Selection of steel wire rope for hoists and cranes, crane hooks, design of pressure vessels: thin and thick cylinder, stresses and types of failures.

- **DESIGN OF I.C. ENGINE COMPONENTS** **(04 Hours)**
  Piston, cylinder and connecting rod.

(Total Lecture Hours: 42)

21/07/2020

3. Practicals:

1. Drawing of involute gear profile.
2. Design of spur gear.
3. Design of helical gear.
4. Design of journal bearing.
5. Design of two stage speed reducer gear box with its kinematic arrangement.
6. Design and drawing of automobile clutch of any of the following:
    a. Plate clutch,
    b. Centrifugal clutch,
    c. Multi-plate clutch.
7. Design and drawing of the any of the brake from following:
    a. External expanding brake,
    b. Internal expanding brake,
    c. Differential band brake.
8. Design and drawing of hook block.
9. Selection and mounting of rolling element bearing.
10. Design of bevel gear.

4. Books Recommended:

1. R. G. Budynas and K. Nisbett, Shigley's Mechanical Engineering Design, 11th Edition, McGraw Hill, 2020.
2. V. B. Bhandari, Design of Machine Elements, 4th Edition, Tata McGraw Hill, 2016.
3. R. L. Norton, Machine Design, 5th Edition, Pearson Education India Ltd., 2014.
4. M. F. Spotts, Design of Machine Elements, Pearson Education India Ltd., 2004.
5. R. C. Juvinall and K. M. Marshek, Fundamentals of Machine Component Design, 6th Edition, Wiley, 2017.

21/08/2020

Machining Processes

ME305

L	T	P	Credit
3	1	2	05

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1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain mechanics of chip formation and types of chips.
CO2	Explain relationship between chip formation and generation of stress, strain, force and wear.
CO3	Describe conventional machining processes, geometry of cutting tools, and mechanism of conventional machine tools.
CO4	Select machining process(es), cutting tool(s) and machine tool(s) to produce a given part.
CO5	Calculate machining time incurred in machining a part if machining parameters and part dimensions are given.
CO6	Explain working principle and machine setup of unconventional machining processes.

2. Syllabus

- **MECHANICS OF MACHINING** **(10 Hours)**
  Mechanism of chip formation, types of chips, chip breakers, Marchant circle diagram, cutting forces and power, tool wear and tool life; machinability; economics of machining; cutting tool materials; types of tools.

- **CONVENTIONAL MACHINING PROCESSES** **(16 Hours)**
  Introduction to Turning, shaping, planning, milling, drilling, broaching processes; types of machines and operations; different mechanisms on the machine; tool and work holding devices; special attachments; capstan and turret machine; automats; machining time calculations.

- **FINISHING PROCESSES** **(06 Hours)**
  Introduction to grinding, types of machines and operations, dressing and trueing, glazing, designating system, selection of grinding wheel, lapping, honing, super finishing processes.

- **THREAD AND GEAR MANUFACTURING PROCESSES** **(05 Hours)**
  Thread manufacturing by thread milling and thread grinding. Gear milling, hobbing and finishing.

- **INTRODUCTION TO UNCONVENTIONAL MACHINING PROCESSES** **(05 Hours)**

(Total Lecture Hours: 42 Hours)

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3. Practicals:

1. Machining Practices on lathe for step turning, taper turning, grooving, thread cutting operations.
2. Machining practices on shaping and drilling machine.
3. Machining practices on milling machine to cut spur or helical gear.

4. Calculation of shear plane angle under different machining conditions.
5. Measurement of chip tool interface temperature under different machining conditions.
6. Grinding Practice of single point cutting tool and measure tool angles.
7. Demonstration of Capstan lathe.
8. Demonstration of EDM process.

4. Books Recommended:

1. H.M.T., Production Technology, Tata McGraw-Hill Education, 2004.
2. S. K. Hajra Choudhury, Element of Workshop Technology, Vol. 2, 14th Edition, Media Promoters and publishers Pvt., 2010.
3. V. K. Jain, Advanced machining processes. Allied publishers, 2009.
4. A. B. Chattopadhyay, Machining and Machine Tools, 2nd Edition, John Wiley & Sons, 2017.
5. S. Kalpakjian, S. R. Schmid, Manufacturing Engineering and Technology, 7th Edition, Pearson, 2018

21/07/2020

Plastics and Ceramics

ME361

L	T	P	Credit
3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Describe fundamentals of plastic and ceramic materials.
CO2	Identify the importance of manufacturing processes used to manufacture plastic and ceramic products.
CO3	Establish design guidelines and testing associated with production of plastic products.
CO4	Analyze plastic recycling and waste management practices.
CO5	Distinguish sintering mechanisms considered for ceramic materials.
CO6	Compile properties of various plastic and ceramic materials and its comparison with other classes of materials.

2. Syllabus

- **INTRODUCTION** **(06 Hours)**
  Classification of materials, history of plastic materials, comparison of plastics with other engineering materials. Classification of plastics, thermoplastic, thermoset plastics, elastomers and polymers. Polymer structures, polymerization, properties of polymers, additive methods to modify polymers. National and International organizations dealing with plastic materials.

- **PROCESSING OF PLASTICS** **(10 Hours)**
  Injection molding, extrusion molding, blow molding, rotational molding, vacuum molding, thermoforming, compression molding, resin transfer molding, calendaring process, etc. Secondary processes for plastics i.e. machining, joining, painting, etc. Defects during processing of plastic products.

- **DESIGN AND TESTING OF PLASTICS PRODUCTS** **(06 Hours)**
  Commodity plastics, engineering plastics, speciality plastics. Design guidelines for products, design guidelines for various processes, importance of mold making. Concept of testing, specification and standards. Overview of various tests, significance of important thermal and mechanical properties of plastic materials.

- **PLASTICS RECYCLING AND WASTE MANAGEMENT** **(05 Hours)**
  Applicability and statistics of plastics in various sectors. Issues and challenges with plastics. Impact of plastics on environment and its remedies. Utility of plastics wastes, waste management practices, plastic recycling processes. Case studies for recycling and waste management.

- **CERAMIC MATERIALS** **(06 Hours)**
  Introduction to ceramic materials, history of ceramic materials, comparison of ceramics with other engineering materials. National and International organizations dealing with ceramics. Atomic bonding and crystal structures in ceramics, traditional and engineering ceramics, classification of ceramics based on properties and applications. Factors affecting properties of ceramics.

- **PROCESSING OF CERAMICS** **(09 Hours)**
  Material selection. Powder making processes. Processing of ceramic materials i.e. slip casting process, ceramic injection molding, tape casting process, etc. Significance of sintering in

ceramics, sintering mechanisms, stages during sintering, Importance of phase equilibrium diagrams, Gibbs phase rule, silica phase diagram, phase diagrams for other ceramics.

(Total Lecture Hours: 42)

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3. Books Recommended:

1. T. L. Szabo, Plastics – Inside Out, 3rd Edition, Elsevier Butterworth-Heinemann, 2005.
2. R. J. Crawford and P. J. Martin, Plastics Engineering, 4th Edition, Elsevier Butterworth-Heinemann, 2020.
3. J. R. Fried, Polymer Science and Technology, 3rd Edition, Prentice Hall, 2014.
4. M.W. Barsoum, Fundamentals of Ceramics, 2nd Edition, CRC Press, 2019.
5. M. N. Rahaman, Ceramic Processing and Sintering, 2nd Edition, CRC Press, 2003.

21/07/2020

Theory and Applications of Fluid Machinery

ME363

L	T	P	Credit
3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Classify fluid machines and explain the concept and performance parameters of fluid machines
CO2	Explain the construction and working of fan and blowers and select the appropriate machines for different applications
CO3	Identify types of compressors, calculate various performance parameters and analyze the performance characteristics
CO4	Compare the working of different types of pumps and evaluate the performance of pumps, Select the appropriate pump for suitable application
CO5	Classify hydraulic turbines, investigate velocity triangles and analyze the function of various components and cavitation phenomena
CO6	Identify measuring and performance parameters, Calculate the performance parameters, Evaluate the performance of fluid machines

2. Syllabus

- **INTRODUCTION TO FLUID MACHINES** **(08 Hours)**
  Classification of fluid machines: Positive displacement type and dynamic type machinery; Impulse type and reaction type machinery; reciprocating, radial, mixed and axial flow machines, Basic fluid mechanics of fluid machines, The torque momentum and head momentum equations; one dimensional theory and its limitations, specific work and its representation on T-s and h-s diagrams; losses and efficiencies; energy transfer in fluid machines

- **FANS AND BLOWER** **(06 Hours)**
  Classification and Construction; performance analysis: Power required, pressure rise, efficiency calculations; characteristic curves and selection, fan drives and fan noise. Applications in boilers, cooling towers, and other industrial applications

- **COMPRESSORS** **(06 Hours)**
  Centrifugal Compressors: Construction and working, Types, performance: work done and pressure rise; Slip; Compressibility effects; Surging and choking of compressors; Compressor characteristics and applications.
  Axial Flow Compressors:. Working, performance parameters: Stage pressure rise; polytrophic efficiency, degree of reaction; Surging and stalling of compressors; Compressor performance and characteristic curves, Off design performance and applications.

- **PUMPS** **(08 Hours)**
  Main elements and their functions, Various types and classification, Pressure changes in a pump - suction, delivery and manometric heads, head-capacity relationships, losses, pump output and efficiency, Minimum starting speed, Priming and priming devices, Multistage pumps - series and parallel arrangement; submersible pumps, Axial and mixed flow pumps: Construction and operation, NPSH and cavitation in pump.

21/07/2020

- **HYDRAULIC TURBINES** **(08 Hours)**
  Classification, Pelton, Francis, Kaplan, Propeller turbines, Velocity triangles, power and efficiency calculations, draft tube, cavitation, Thoma's cavitation factors

- **PERFORMANCE CHARACTERISTICS OF FLUID MACHINES** **(06 Hours)**
  Pressure, temperature, velocity, head, capacity, and power measurement, model testing, similarity laws, unit quantities, specific quantities, main operating and constant efficiency curve.

(Total Lecture Hours: 42)

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3. Books Recommended:

1. S. R. Gorla Rama, A.A. Khan, Turbomachinery Design and Theory, CRC Press- Taylor and Francis Group, 2011.
2. S. Ramachandran, R. Devaraj, Y.V.S. Karthick, Fluid Machinery, Airwalk Publications, 2017.
3. S.M.Yahya, Turbines, Compressors and Fans, Tata McGraw Hill, 2017.
4. A.T. Sayers, Hydraulic and compressible flow turbomachines. McGraw-Hill Publishing Co., 1990.
5. V. Kadambi and M. Prasad, An introduction to energy conversion, New Age International Private Limited, 2011.

21/07/2020

Mechatronics

ME365

L	T	P	Credit
3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the basic elements of mechatronics system.
CO2	Analyze the functioning of sensors, transducers and actuators.
CO3	Analyze and evaluate the electronic elements such as digital circuits, AD convertors, etc.
CO4	Explain the basics of PLC programming
CO5	Develop a mechatronic system using the gained knowledge.

2. Syllabus

- **INTRODUCTION TO MECHATRONICS** **(01 Hour)**
- **MECHATRONIC SYSTEM ELEMENTS** **(04 Hours)**
  Measurement system, Control system, Microprocessor based controllers & its applications, other applications with mechatronic approach, Building blocks of mechatronic system.
- **SENSORS & TRANSDUCERS** **(09 Hours)**
  Classification, Performance terminologies, Displacement, Position & proximity sensors, Photo detectors, Optical encoders, Pneumatic sensor, Hall effect sensor, Velocity & motion sensors: Incremental encoder, Tachogenerator, Piezo electric sensors, Tactile sensors, Flow & temperature sensors: Ultrasonic sensors, Light sensors, Selection of sensors, Interference & noise in measurement.
- **ACTUATION SYSTEMS** **(10 Hours)**
  Pneumatic & hydraulic actuation systems: System configuration, Control System & its elements, Linear actuators, Rotary actuators. Mechanical actuation: System types & its configuration, fixed ratio type, Invariant motion profile type, variator etc. Electrical actuation system types & configurations, Mechanical switches, Solid state switches, Solenoids.
- **DIGITAL CIRCUITS** **(08 Hours)**
  Boolean algebra combinational circuits. (Adders, Subtractors, encoders, decoders, multiplexers, de – multiplexers, memory units: RAM, ROM, EPROM etc.), Sequential circuits (Latches, Flip-flops, Counters, Registers).
- **ANALOG SIGNAL PROCESSING** **(06 Hours)**
  Amplifiers, Operational amplifiers, Ideal model for operational amplification, Inverting amplifier, Non-inverting amplifier, Summer, Difference amplifier, Instrumentation amplifier, Integrator, Differentiator, Sample & hold circuit, Comparator, Basics of filters, Types of filters, Introduction to A/D and D/A converters.
- **ELECTRONIC SYSTEM DESIGN** **(04 Hours)**
  Introduction to MPU & MCU, Assembly programming, Interfacing, Introduction to PLC & basics of PLC programming.

(Total Lecture Hours: 42)

2\08\2020

3. Books Recommended:

1. D. Shetty, A. R. Kolk, Mechatronic System Design, 2nd Edition, PWS Publicity Boston, 2010.
2. W. Bolton, Mechatronics, 4th Edition, Pearson Education (India), 2011.
3. HMT Ltd., Mechatronics, 1st Edition, Tata McGraw Hill Publication, 2002
4. D. Necsulescu, Mechatronics, Pearson Education (Singapore), 2002.
5. M. Mano, Digital Logic & Computer Design, 4th Edition, Pearson, 2016.

21/08/2020

Control Systems

ME367

L	T	P	Credit
3	0	0	03

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1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the theory and applications of control systems and draw block diagrams techniques, signal flow graphs of linear systems and their controlling actions.
CO2	Apply the knowledge of control systems components for hydraulic and pneumatic applications.
CO3	Apply the concept of standard test signals and transient response of first and second order systems, evaluate the sources of static and dynamic error constant.
CO4	Analyze the stability criteria for frequency response.
CO5	Analyze the behavior of closed loop systems using tools such as root locus, Routh Hurwitz, Bode, Nyquist, and Matlab.
CO6	Describe the control system design, Fuzzy logic, fuzzy set and fuzzy control, PLC

2. Syllabus

- **BASIC COMPONENTS OF CONTROL SYSTEM** **(08 Hours)**
  Open loop and Closed loop system – Automatic Control System. Mathematical Modeling, Analogous Models – Mathematical modelling of fluid system and thermal systems – Transfer Function – Block diagram reduction Techniques, signal flow graphs.

- **REPRESENTATION OF PHYSICAL SYSTEM** **(06 Hours)**
  Linear approximation of nonlinear System – position Control system – Stepper motor – Hydraulic systems – pneumatic systems – Inertial navigation system – Applications.

- **MODES OF CONTROLS** **(06 Hours)**
  Proportional, Integral, Derivative – proportional plus integral – proportional plus Derivative–proportional Plus integral plus derivative controls – examples from Mechanical system.

- **TIME DOMAIN ANALYSIS OF CONTROL SYSTEMS** **(08 Hours)**
  Classifications of time response, systems time response, analysis of steady state error, Standard test signals and transient response of first and second order systems. Sources of errors, static and dynamic error constants, Routh Hurwitz Stability Criteria.

- **FREQUENCY RESPONSE** **(06 Hours)**
  Bode Plot – Polar Plot. Stability Analysis – Relative stability

- **DESIGN PRINCIPLES** **(08 Hours)**
  An outline of Control System Design - Control of the A/F ratio in an Automotive Engine – Control of Read/Write Head Assembly of a Hard Disk. Introduction to Fuzzy logic – Fuzzy set – Fuzzy Control – PLC

(Total Lecture Hours: 42)

21/07/2020

3. Books Recommended:

1. G. F. Franklin, Feedback control of Dynamic Systems, 7th Edition, Pearson Education Asia, 2014
2. I. J. Nagrath and M.Gopal, Control System Engineering, 6th Edition, New Age International Pvt Ltd, 2018
3. K. Ogata, Modern Control Engineering, 5th Edition, Pearson Education India, 2015.
4. F. H. Raven, Automatic Control Engineering, 5th Edition, McGraw Hill, 1995
5. J. W. Webb & R. A. Reis, Programmable Logic Controllers: Principles and Applications, 5th Ed, PHI Learning, New Delhi, 2002
6. S. Gosh, Theory & application of control systems, Person Education, 2010

21/08/2020

Engineering Estimation and Costing

ME369

L	T	P	Credit
3	0	0	03

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1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Analyze the concept of estimation for various industrial applications..
CO2	Analyze the concept of cost accounting and control.
CO2	Apply engineering economics and analyze the breakeven point for single and multiple product production cases.
CO3	Demonstrate the effects of depreciation and replacement policy in engineering economic analysis problems.
CO4	Explain the concepts of financial management and accounting.

2. Syllabus

- **ESTIMATING** **(06 Hours)**

  Objectives of estimating –constituents of estimate, mechanical estimating – costing and cost estimation, functions of estimation organization and prerequisites of estimation, estimating such as design and drafting period, time & motion studies, time allowances etc., estimation of material, labour cost, production estimate sheet, advantages & elements of costing, classification of cost elements.

- **COST ACCOUNTING AND CONTROL** **(06 Hours)**

  Cost accounting, elements of cost, factors affecting selling price, fixed cost, variable cost, computation of actual cost, nature of cost, type of cost and cost control

- **ENGINEERING ECONOMICS & BREAK EVEN ANALYSIS** **(10 Hours)**

  Introduction, time value of money, cash flows, taxation concept, tools for engineering economics, models, operation research, value engineering, make and buy decisions, economic batch size, locational economics, benefits cost ratio, break even analysis, analytical and graphical methods, single products and multiple product cases

- **DEPRECIATION AND REPLACEMENT ANALYSIS** **(10 Hours)**

  Concepts, classification, methods of depreciation, comparison of different depreciation method, selection of depreciation methods, obsolescence, reasons for replacement of equipment, development of systematic replacement programme/policy, replacement models, sudden failure, failure tress.

- **FINANCIAL MANAGEMENT AND ACCOUNTING** **(10 Hours)**

  Definitions and functions of financial management, sources of funds, capitals and its classification, capitalization, sourcing of funds, shares, debentures, trade credits, pubic deposits, banking, foreign exchange and trade, nature of accounting, accounting terminology and types, rules for debit and credit, financial ratios, budget and budgetary control

(Total Lecture Hours: 42)

3. Books recommended:

1. J. Heizer, B. Render, C. Munson, and A. Sachan, Operations Management, 12th Edition, Pearson Education, 2017.
2. M. Mahajan, Industrial Engineering and Production Management, 1st Edition, DhanpatRai & Co. (P) Limited, 2015.
3. B.P. Sinha, Mechanical Estimating and Costing, 1st Edition, Tata McGraw Hill Publishing Co. Ltd., 1995.
4. T.R. Banga and S. C. Sharma, Industrial Organization and Engineering Economics, 24th Edition, Khanna Publishers, 2013.
5. S. K. Sharma and S. Sharma, Industrial Engineering &Organization management, Reprint Edition, S K Kataria and Sons, 2013.

21/07/2019

Computational Fluid Dynamics

ME321

L	T	P	Credit
3	0	0	03

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1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Develop mathematical model for fluid flow and associated transport processes
CO2	Discretize the fundamental equations of flow and other transport processes using finite difference method
CO3	Apply finite volume method for numerical modeling of fluid flow modeling
CO4	Solve two-dimensional incompressible viscous flow problems using stream function-vorticity formulation
CO5	Solve Navier-Stokes equations for incompressible flows using semi-explicit and semi-implicit algorithms

2. Syllabus

- **GOVERNING EQUATIONS FOR FLUID FLOW AND HEAT TRANSFER (06 Hours)**
  Conservation of Mass, Newton's Second Law of Motion, Expanded Forms of Navier stokes equations, Conservation of Energy Principle, Special Forms of the Navier Stokes Equations, Classification of Second order Partial Differential Equations, Initial and Boundary Conditions, Governing Equations in Generalized Coordinates.

- **FINITE DIFFERENCE, DISCRETIZATISON, CONSISTENCY, STABILITY (06 Hours)**
  Elementary Finite Difference Quotients, Basic Aspects of Finite Difference Equations, Errors and Stability Analysis, Some Nontrivial Problems with Discretized Equations

- **FINITE VOLUME METHOD FOR FLUID FLOW MODELING (12 hours)**
  Integral Approach, Discretization of Unsteady, Diffusion, Advection and Source Terms, Advection Schemes: Central Difference Scheme, First Order Upwind Scheme, Second Order Upwind Scheme, QUICK scheme and Other Higher Order Schemes, Finite Volume Solution of Unsteady Advection, Diffusion Problems with Source Term.

- **SOLUTION OF VISCOUS INCOMPRESSIBLE FLOWS BY STREAM FUNCTION – VORTICITY FORMULATION (08 Hours)**
  Two Dimensional Incompressible Viscous Flow, Incorporation of Upwind Scheme, Estimation of Discretization Error, Application to Curvilinear Geometries, Derivation of Surface Pressure and Drag.

- **SOLUTION OF NAVIER -STOKES EQUATIONS FOR INCOMPRESSIBLE FLOWS USING SEMI-EXPLICIT AND SEMI-IMPLICIT ALGORITHMS (10 Hours)**
  Collocated and Staggered Grid, Solution of Unsteady Navier-Stokes Equations using Semi-explicit method, for Collocated and Staggered grid, Momentum Interpolation, SIMPLE Algorithm, Formulation of Coupled Flow with Heat Transfer and Other Scalar Transport.

(Total Lecture Hours: 42)

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3. Books Recommended:

1. D.A. Anderson, Tannehill J.C., Pletcher R.H., Computational Fluid Mechanics and Heat Transfer, CRC Press, 2012.
2. K. Murlidhar, T. Sunderarajan, Computational Fluid Flow and Heat Transfer, Narosa Publisher, 2013
3. J.D. Anderson, Computational Fluid Dynamics, McGraw Hill, 2017.
4. S.V. Patanankar, Numerical Heat Transfer and Flow, Hemispehre Publ. Corporation, 2017.
5. H. K. Versteag, and W. Malalsekara, An Introduction to Computational Fluid Dynamics, Pearson, 2008

21/07/2020

Maintenance and Safety Engineering

ME323

L	T	P	Credit
3	0	0	03

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1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the principles, functions and practices adapted in industry for the successful management of maintenance activities.
CO2	Apply the knowledge of Predictive maintenance and conditioning monitoring concepts for industrial applications.
CO3	Apply the concept of failure pattern, system reliability: Series, Parallel and Mixed configurations.
CO4	Explain the safety engineering aspects in industry.
CO5	Explain the safety codes and standards.

2. Syllabus

- **OBJECTIVE OF MAINTENANCE** **(09 Hours)**
  Types of maintenance – Breakdown, preventive and predictive maintenance - Repair cycle - Repair Complexity, Lubrication and Lubricants. Maintenance of Mechanical transmission systems and process plants.

- **PREDECTIVE MAINTENANCE** **(09 Hours)**
  Vibration and noise as maintenance tool - wear debris analysis - Condition monitoring concepts applied to industries - Total Productive Maintenance (TPM) - Economics of Maintenance- Computer aided maintenance

- **RELIABILITY** **(09 Hours)**
  Definition, concept of reliability based design, failure rate, MTTF, MTBF, failure pattern, system reliability: Series, Parallel and Mixed configurations - Availability and Maintainability concepts-Applications.

- **SAFETY AND PRODUCTIVITY** **(08 Hours)**
  Causes of accidents in industries – accident reporting and investigation - measuring safety performance - Safety organizations and functions - Factories act and rules.

- **SAFETY CODES AND STANDARDS** **(07 Hours)**
  General Safety considerations in Material Handling equipment - Machine Shop machineries-pressure vessels and pressurized pipelines – welding equipment – operation and inspection of extinguishers – prevention and spread of fire–emergency exit facilities.

(Total Lecture Hours: 42)

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3. Books Recommended:

1. P. Gopalakrishnan, Maintenance and Spare Parts Management, 2nd Edition, Prentice Hall of India Pvt. Ltd., New Delhi, 2013
2. L. S. Srinath, Reliability Engineering, Affiliated East West press, 2005
3. Rolland P. Blake, Industrial Safety, 3rd Edition, Prentice Hall of India Pvt. Ltd., New Delhi, 2003.
4. R. C. Mishra and K. Pathak, Maintenance Engineering and Management, 2nd Edition, Prentice Hall of India Pvt.Ltd.,New Delhi, 2012.
5. E. Balagurusamy, Reliability Engineering, McGraw Hill Education, 2017
6. H. P. Garg, Industrial Maintenance, S. Chand & Co Ltd., New Delhi, 2010

21\07\2020

Powder Processing Techniques

ME325

L	T	P	Credit
3	0	0	03

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1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the importance of powder processing route of manufacturing process, and compare powder metallurgy products with cast & wrought products.
CO2	Compare different techniques of production, testing and characterization of ceramic and metal powders.
CO3	Describe different methods of conditioning of powders and analyze various techniques of compactions of powder products.
CO4	Describe mechanism of sintering of green powder compacts and secondary & finishing operations in powder processing.
CO5	Explain detailed procedure of manufacturing of selected products by powder processing.

1. Syllabus:

- **INTRODUCTION** **(06 Hours)**
  History, Basic terms related to powder processing, principle and outline of powder processing techniques, advantages and limitations of powder processing, General characteristics of ceramic and metal powders. Comparison of powder processed parts with cast and wrought products, Design considerations in powder metallurgy.

- **PRODUCTION OF POWDERS** **(06 Hours)**
  Atomization, variants of atomization, Chemical reduction, Carbonyls, Electrolytic deposition, Mechanical pulverization methods - crushing, milling etc.; vapour condensation, precipitation from chemical solution, high temperature extractive metallurgy processes, production of nano powders, Microencapsulated powders.

- **TESTING & CHARACTERIZATION OF POWDERS** **(06 Hours)**
  Physical characterization related to powder particles - shapes, size, mesh number, size distribution, surface area, porosity; flow rate, tap density, apparent density, true density, compressibility and friction; chemical characterization related to chemical compositions, phase composition and surface characterization.

- **POWDER CONDITIONING AND HEAT TREATMENT** **(03 Hours)**
  Alloying, sintering aids, lubricants, plasticizers and binders, mixing and blending, granulation; Equipment for powder conditioning, Heat treatments of powders.

- **COMPACTION OF POWDER PRODUCTS** **(07 Hours)**
  Conventional die pressing, pressure distribution during conventional die pressing, cold iso-static pressing, powder rolling, powder extrusion, injection moulding, hot iso-static pressing, spray deposition (Osprey process), pressureless compaction, compaction using ceramic molds.

- **SINTERING & SECONDARY OPERATIONS** **(10 Hours)**

21/07

Defects and defect chemistry; Solid state sintering, atomic mechanisms, coarsening, densification, sintering kinetics: sintering stages, coarsening and grain growth growth kinetics; Liquid phase sintering: introduction, the different stages, controlling kinetics and thermodynamic factors; Sintering furnaces and their classifications, batch furnace, continuous furnaces, sintering atmosphere, vacuum sintering. Finishing, machining, infiltration, Repressing, Resizing, Impregnation.

- **SELECTED POWDER PRODUCTS** **(04 Hours)**
  Sintered carbides and carbide tools; Cermets; Dispersion strengthened materials; Automotive-engine bearing cap, Electrical contact materials; Self-lubricating bearings & gears, Filters, Friction materials.

(Total Lecture Hours: 42)

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3. Books Recommended:

1. R. M. German, Powder Metallurgy and Particulate Materials Processing, MPIF, 2005.
2. K. Hingashitani, H. Makino, S. Matsusaka, Powder Technology Handbook, CRC Press, 2019.
3. A. Upadhyaya, G. S. Upadhyaya, Powder Metallurgy - Science, Technology & Materials, Universities Press, Taylor & Fracis, 2018.
4. P. C. Angelo, R. Subramanian, Powder metallurgy - Science, Technology and Applications, PHI Learning Pvt. Ltd., 2008.
5. B. K. Datta, Powder Metallurgy: An Advanced Technique of Processing Engineering Materials, 2014.

21/07/2020

Mechanics of Materials

ME327

L	T	P	Credit
3	0	0	03

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1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the mechanical properties of materials
CO2	Illustrate the theoretical basis about the stress, strain and elastic modulus in components.
CO3	Analyze members under uni-axial and axi-symmetric loads.
CO4	Analyze members under torsional and flexural loads.
CO5	Analyze elastic stability of columns

2. Syllabus

- **ANALYSIS OF STRESS AND STRAIN** **(10 Hours)**
  Introduction: Stress and strain: stress at a point, Cauchy stress tensor, analysis of deformation and definition of strain component, principal stresses and strain, stress and strain invariant, Mohr's circle representation. Hooke's law and its application to isotropic materials, elastic constants and their relationships, plane stress and plain strain conditions.

- **MECHANICAL PROPERTIES** **(03 Hours)**
  Uniaxial tension test to determine yield and ultimate strength of materials, stress-strain diagram, proof stress, ductile and brittle materials, hardness and impact strength, conditions affecting mechanical behaviour of engineering materials.

- **MEMBERS IN UNI-AXIAL STATE OF STRESS** **(04 Hours)**
  Uniform cross-section and tapered bars subjected to uniaxial tension and compression, composite bars and statically indeterminate bars, thermal stresses; Introduction to plasticity; Strain energy under axial loading.

- **MEMBERS SUBJECTED TO AXI-SYMMETRIC LOADS** **(03 Hours)**
  Stresses and strains in thin cylindrical shells and spheres under internal pressure, stresses in thin rotating rings.

- **MEMBERS SUBJECTED TO TORSIONAL LOADS** **(04 Hours)**
  Torsion of solid and hollow circular shafts, stepped and composting shafts, Shafts subjected to combined bending, torsion and axial thrust, Strain energy in torsion.

- **MEMBERS SUBJECTED TO FLEXURAL LOADS** **(13 Hours)**
  Statically determinate beams, support reactions, relationship between load, shear force and bending moment, shear force and bending moment diagrams; theory of flexure for initially straight beams, distribution of bending stresses across the beam cross-section, principal stresses in beams; equation of elastic curve for the loaded beam, relationship between bending moment, slope and deflection; calculation of deflection by integration, moment area and unit-load methods, Strain energy in flexure.

- **ELASTIC STABILITY OF COLUMNS** **(05 Hours)**
  Euler's theory of initially straight columns, critical loads for different end condition of columns, eccentric loading, columns with small initial curvature, empirical formulae, Short struts subjected to eccentric loads. Energy methods: principle of virtual work, minimum potential energy, Introduction to theory of photo-elasticity.

(Total Lecture Hours: 42)

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3. Books Recommended:

1. F. P. Beer, E. R. Johnston, Jr., J. T. Dewolf and D. E. Mazureu, Mechanics of Materials, 5th Edition, McGraw Hill, 2009.
2. S. P. Timoshenko and D. H. Young, Elements of Strength of Materials, 5th Edition, East-West Press Pvt. Ltd., 2009.
3. S. Ramamurtham, Strength of Materials, Dhanpat Rai Publications, 2005.
4. E. P. Popov, Engineering Mechanics of Solids, Prentice-Hall, 1999.
5. L. S. Srinath, Advanced Mechanics of Solids, 3rd Edition, Tata McGraw Hill, 2009.

21/07/2020

Additive Manufacturing Processes

ME329

L	T	P	Credit
3	0	0	03

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1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Compare and distinguish various additive manufacturing processes.
CO2	Explain the process chain for selected additive manufacturing process.
CO3	Compare and recommend suitable additive manufacturing process for a given material and application.
CO4	Identify defects in model and reframe in standard format.
CO5	Integrate design concepts with CAD or reverse engineering for geometry preparation for additive manufacturing of part.

2. Syllabus

- **INTRODUCTION** **(06 Hours)**
  Definition, classification, stages of generic additive manufacturing process, benefits, applications, process selection, evaluation, benchmarking, future growth and opportunities

- **LIQUID BASED PROCESSES** **(08 Hours)**
  Photo polymerization, principle and working of stereo lithography apparatus, scanning techniques, curing processes, typical materials and applications.

- **POWDER BASED PROCESSES** **(08 Hours)**
  Powder fusion mechanism, powder handling and recycling, Principle and working of Selective Laser Sintering, Laser Engineering Net Shaping process, Electron Beam Melting, process parameters, typical materials and applications.

- **SOLID BASED PROCESSES** **(08 Hours)**
  Basic principle and working of fused deposition modelling process, liquification, solidification and bonding, bio extrusion, Laminated Object Manufacturing process, Multi jet process, typical materials and applications

- **SOFTWARE ISSUES IN ADDITIVE MANUFACTURING** **(06 Hours)**
  Preparation of CAD models and STL files, STL file problems and repair, slicing, newly proposed formats, standards, softwares to assist additive manufacturing, role of reverse engineering.

- **DESIGN FOR ADDITIVE MANUFACTURING** **(06 Hours)**
  Core concepts and objectives, unique capabilities of Additive Manufacturing, exploring design freedom, design tools.

(Total Lecture Hours: 42)

3. Books Recommended:

1. I. Gibson, D. Rosen, B. Stucker, Additive Manufacturing Technologies, Springer Publisher, 2010.
2. C. K. Chua, K. F. Leong, C. S. Lim, Rapid Prototyping – Principles and Applications, World Scientific, 3rd Edition, 2010.
3. R. Noorani, 3D printing technology, applications and selection, CRC Press, 2017.
4. M. W. M. Cunico, 3D Printers and Additive Manufacturing: the rise of the Industry 4.0, Concept 3D, 2019
5. A. Bandyopadhyay and S. Bose, Additive Manufacturing, CRC Press, 2015

Teaching Scheme: B. Tech. (Mechanical Engineering) III Year

SEMESTER - VI

Sr. No.	Subject	Code	Scheme	Exam Scheme				Total	Credit
				Theory		Tuto.	Pract.		
				Hrs.	Marks	Marks	Marks		
1.	Professional Ethics, Economics and Management	HU308	4 – 0 – 0	3	100	-	-	100	04
2.	Tribology and Mechanical Vibration	ME302	3 – 1 – 2	3	100	25	50	175	05
3.	Production Technology	ME304	3– 0 – 2	3	100	-	50	150	04
4.	Applied Thermal Engineering	ME306	4 – 0 – 2	3	100	-	50	150	05
5.	Institute Elective – 2	ME3YY	3 – 0 – 0	3	100	-	-	100	03
6.	Core Elective - 2	ME3BB	3 – 0 – 0	3	100	-	-	100	03
		Total	20 – 1 – 6	18	600	25	150	775	24

Institute Elective – 2 (ME3YY)

1. Corrosion Engineering: ME362
2. Energy Efficiencies in Industrial Utilities#: ME364
3. Product Design and Development: ME366
4. Lubrication Technology: ME368
5. Plant Layout and Material Handling: ME372
6. Risk, Reliability and Life Testing: ME374
7. Materials Management: ME376

Except ECED and CoED students

Core Elective – 2 (ME3BB)

1. Advance Engineering Materials: ME322
2. Energy and Exergy Analysis of Thermal Systems: ME324
3. Machine Tool Design: ME326
4. Micro Hydro Power Plant: ME328
5. Micro- and Nano-Manufacturing: ME332
6. Finite Element Methods: ME334

21/07/2020

Professional Ethics, Economics and Business Management

HU308

L	T	P	Credit
4	0	0	04

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1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Identify application of ethics in society and development of understanding regarding Professional ethical issues related to Mechanical engineering
CO2	Develop managerial skills to become future engineering managers
CO3	Develop skills related to various functional areas of management (Marketing Management, Financial Management, Operations Management, Personnel Management etc.)
CO4	Build knowledge about modern management concepts (ERP, SCM, e-CRM, etc.)
CO5	Develop experiential learning through Management games, Case study discussion, Group discussion etc.
CO6	Apply knowledge of Economics and Business management aspects in Mechanical engineering

2. Syllabus:

- **PROFESSIONAL ETHICS** **(14 Hours)**

  Introduction, Approaches to Ethics, Meaning of Ethics, Major attributes of Ethics, Business Ethics, Factors influencing Ethics, Importance of Ethics, Ethics in Management, Organizational Ethics, Ethical aspects in Marketing, Mass communication and Ethics - Television, Whistle blowing, Education – Ethics and New Professional, Intellectual Properties and Ethics, Introduction to Professional Ethics, Engineering Ethics, Ethical issues related to Mechanical Engineering

- **ECONOMICS** **(08 Hours)**

  Introduction To Economics, Micro & Macro Economics, Applications & Scopes Of Economics, Demand Analysis, Demand Forecasting, Factors Of Production, Types Of Cost, Market Structures, Break Even Analysis

- **MANAGEMENT** **(12 Hours)**

  Introduction to Management, Features Of Management, Nature Of Management, Development of Management Thoughts – Scientific Management By Taylor & Contribution of Henry Fayol, Coordination & Functions Of Management, Centralization & Decentralization, Decision Making; Fundamentals of Planning; Objectives & MBO; Types of Business Organizations: Private Sector, Public Sector & Joint Sector; Organizational Behavior: Theories of Motivation, Individual & Group Behavior, Perception, Value, Attitude, Leadership

- **FUNCTIONAL MANAGEMENT** **(18 Hours)**

  Marketing Management: Core Concepts Of Marketing, Marketing Mix (4p), Segmentation – Targeting – Positioning, Marketing Research, Marketing Information System, Concept of International Marketing, Difference Between Domestic Marketing & International Marketing;

Operations Management: Introduction to Operations Management, Types of Operation Systems, Types of Layouts, Material Handling, Purchasing & Store System, Inventory Management; Personnel Management: Roles & Functions of Personnel Manager, Recruitment, Selection, Training, Industrial Dispute, Collective Bargaining; Financial Management: Goal of Financial Management, Key Activities In Financial Management, Organization of Financial Management, Financial Institutions, Financial Instruments, Sources of Finance

- **MODERN MANAGEMENT ASPECTS** **(04 Hours)**

Introduction to ERP, e – CRM, SCM, RE – Engineering, WTO, IPR Etc.

(Total Lecture Hours: 56)

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3. Books Recommended:

1. V. Balachandran and Chandrasekaran, Corporate Governance, Ethics and Social Responsibility, PHI, 2nd Edition, 2011
2. L.M. Prasad, Principles & Practice of Management, Sultan Chand & Sons, 8th Edition,2015
3. T. R. Banga & S.C. Shrama, Industrial Organisation & Engineering Economics, Khanna Publishers, 25th Edition, 2015
4. Everett E. Adam, Ronald J. Ebert, Production and Operations Management, Prentice Hall of India, 5th edition, 2012
5. P. Kotler P., K. L. Keller, A. Koshi & M. Jha, Marketing Management – A South Asian Perspective, Pearson, 14th Edition, 2014
6. P.C. Tripathi, Personnel Management & Industrial Relations, Sultan Chand & sons, 21st Edition, 2013
7. P. Chandra, Financial Management, Tata McGraw Hill, 9th Edition, 2015

Further Reading:

1. A. Crane & D. Matten, Business Ethics: Managing Corporate Citizenship and Sustainability in the Age of Globalisation, Oxford University, 2010
2. D. J. Fritzsche, Business Ethics: A Global and Managerial Perspectives, McGraw Hill Irwin, Singapore, 2004
3. S.K. Mandal, Ethics in Business and Corporate Governance, Tata McGraw Hill, 2011

Tribology And Mechanical Vibrations

ME302

L	T	P	Credit
3	1	2	05

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1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the fundamentals of tribology and its engineering importance
CO2	Explain the friction and wear theories in engineering applications.
CO3	Analyze different lubrication theories
CO4	Model single degree of freedom vibrating system using Newton's Law of motion and energy methods.
CO5	Derive equation of motion and determine the natural frequency for single degree of freedom system
CO6	Formulate governing differential equation and solution for force vibration

2. Syllabus

- **INTRODUCTION** **(05 Hours)**
  Definition of tribology, friction, wear and lubrication, importance of the Tribological studies. Surface Topography: Methods of assessment, measurement of surface roughness-different statistical parameters (Ra, Rz, Rmax, etc.), contact between surfaces, deformation between single and multiple asperity contact, contact theories involved

- **FRICTION** **(05 Hours)**
  Coulomb and Amontons laws of friction, its applicability and limitations, comparison between static, rolling and kinetic friction, friction theories, mechanical interlocking, molecular attraction, electrostatic forces and welding, shearing and ploughing, models for asperity deformation.

- **LUBRICATION** **(06 Hours)**
  Types of lubrication, viscosity, characteristics of fluids as lubricant, hydrodynamic lubrication, Reynold's equation, elastohydrodynamic lubrication- partial and mixed, boundary lubrication, various additives, solid lubrication.

- **WEAR** **(06 Hours)**
  Sliding wear: Abrasion, adhesion and galling, testing methods pin-on-disc, block-on ring, etc., theory of sliding wear, un-lubricated wear of metals, lubricated wear of metals, fretting wear of metals, wear of ceramics and polymers. Wearing by plastic deformation and brittle fracture. Wear by hard particles: Two-body abrasive wear, three-body abrasive wear, erosion, effects of hardness shape and size of particles.

- **FUNDAMENTALS OF VIBRATIONS** **(03 Hours)**
  Introduction, definition, SHM, beats phenomenon, complex method of representing harmonic vibrations

- **UNDAMPED FREE VIBRATIONS OF SINGLE DEGREE OF FREEDOM SYSTEM**
  Introduction, deviation of differential equations and resolution, equivalent stiffness of spring combinations, Newton's method and energy method for problem solutions. **(04 Hours)**

- **DAMPED FREE VIBRATIONS OF SINGLE DEGREE OF FREEDOM SYSTEM**
  Different types of damping, free vibrations with viscous dampers **(05 Hours)**

- **FORCED VIBRATION OF SINGLE DEGREE OF FREEDOM SYSTEMS (05 Hours)**
  Forced vibration with constant harmonic excitation, with rotating and reciprocating unbalance, due to the support, vibration isolation and transmissibility, measuring instruments, displacement, velocity, acceleration, frequency measuring instruments.

- **CRITICAL SPEED OF SHAFTS (03Hours)**
  Introduction, critical speed of shaft having single and multiple disc

(Total Lecture Hours: 42)

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3. Practicals:

1. Tuned rectilinear vibration absorber
2. Rectilinear vibration of cantilever beam
3. Free damped vibration
4. Fixed free three rotor system
5. To determine the viscosity using falling ball viscometer
6. Demonstrate friction and wear measurement on pin on disc apparatus
7. Demonstrate the coefficient of friction measurement on reciprocation motion
8. Performance of Journal bearing test rig
9. To measure the surface roughness using profile-meter

4. Books Recommended:

1. R. D. Arnell, P. Davies, J. Halling, and Terence Whomes, Tribology: Principles and Design Applications: Principles and Design Applications, Macmillan International Higher Education, 1991.
2. B. C Majmudar, Introduction to Tribology of Bearings, S Chand & Company, 2010.
3. B. Bhushan, Introduction to Tribology, 2nd Edition, Wiley-Blackwell, 2013.
4. S. S. Rao, Mechanical Vibrations, Pearson Education, 6th Edition, 2018.
5. G. K. Grover, Mechanical Vibrations, Nem Chand & Bros, 2009.

Production Technology

ME304

L	T	P	Credit
3	0	2	04

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the terms related to metrology
CO2	Apply measurement techniques for measuring length, angle and taper, screw thread parameters, gear parameters, and surface roughness.
CO3	Design limit gauges for checking internal and external dimensions of components.
CO4	Illustrate mechanism and state applications of metal forming processes.
CO5	Analyze metal forming processes such as rolling, extrusion, wire-drawing, and forging, and identify probable defects and their remedies.

2. Syllabus

- **INTRODUCTION TO METROLOGY** **(04 Hours)**
  Definition of metrology, important terms such as error, zero error, accuracy, precision, sensitivity, true value, Classification of methods of measurement, Uncertainty of measurement.

- **LIMITS, FITS, AND GAUGES** **(08 Hours)**
  Limit, Fit, Types of fit, Tolerance, Tolerance analysis, Interchangeability, Types of gauges, Design of limit gauges.

- **MEASUREMENT** **(08 Hours)**
  Measurement of length, angle and taper; Screw thread measurement, Gear measurement, Surface roughness measurement, Geometrical Dimensioning and Tolerancing (GD & T).

- **INTRODUCTION TO METAL FORMING** **(04 Hours)**
  Plastic deformation and yield criteria, Material behavior in metal forming processes, Role of temperature in in forming processes, Classification of metal forming processes.

- **MECHANISM OF METAL FORMING PROCESSES** **(10 Hours)**
  Mechanism of bulk deformation processes (rolling, forging, wire drawing, and extrusion) and sheet metal forming processes, Applications of metal forming processes, Mechanism and applications of high energy rate forming processes,

- **ANALYSIS OF BULK DEFORMATION PROCESSES** **(08 Hours)**
  Analysis of forging, rolling, drawing, and extrusion process

(Total Lecture Hours: 42)

3. Practicals:

1. To calibrate given indicating micrometer/micrometer.
2. To find angle of V-block, dovetails, taper, and radius of circular arc.
3. To calibrate given gear tooth vernier, find the tooth thickness and module
4. To find the pitch, effective diameter, best wire size of the given screw threads,
5. To find the angle of external taper, taper of tapered hole, taper of tapered ring.
6. To draw stress-strain behavior for model material.
7. To measure the force required in extrusion.
8. To find flow stress of the given material and to plot a graph of forging ratio vs flow stress

4. Books Recommended:

1. A. K. Bewoor and V. A. Kulkarni, Engineering metrology and measurements, Tata McGraw Hill Education, 2017.
2. N. V. Raghavendra, L. Krishnamurthy, Engineering Metrology and Measurements, Oxford publishers, 2013.
3. R. K. Jain, Engineering Metrology, Khanna Publishers, 1997.
4. S. Kalpakjian, S. R. Schmid, Manufacturing Engineering and Technology, 7th Edition, Pearson, 2018
5. A. Ghosh and A. K. Mallik, Manufacturing Science, East West Press New Delhi, 2010.

Applied Thermal Engineering

ME306

L	T	P	Credit
4	0	2	05

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1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Correlate the suitability of particular fuel for SI/CI engines.
CO2	Compare the working and performance of CI and SI engines.
CO3	Prepare heat balance sheet and calculate SI/CI engine efficiencies.
CO4	Evaluate the refrigeration systems for various applications.
CO5	Determine the properties of moist air and present air conditioning processes on psychometric chart.
CO6	Compute cooling/heating loads for designing air conditioning systems, cold storage plants.

2. Syllabus

- **INTRODUCTION TO INTERNAL COMBUSTION ENGINES** **(03 Hours)**
  Historical Development in IC Engines, General Specifications of I C Engines being used for Two Wheeler, Three Wheeler, Four Wheeler segment.

- **FUEL AIR CYCLE AND ACTUAL CYCLE ANALYSIS** **(05 Hours)**
  Significance of cycle analysis. Effect of variation in specific heat of gases, Dissociation effect, Time burning Loss and other losses affecting the performance of engine cycle. Comparison of air standard cycle-fuel air cycle and actual cycle analysis.

- **COMBUSTION IN SI AND CI ENGINE** **(12 Hours)**
  Stages of combustion in SI Engine, Factors affecting various stages of combustion in SI Engine, Stages of combustion in CI Engine, delay period, factors affecting stages of combustion in C I Engine, Difference of Ignition Delay and ignition lag, Abnormal combustion phenomenon in SI and CI engine and its prevention. Knocking/detonation and its effects, Comparison of normal and abnormal combustion in SI and CI Engines.

- **ENGINE EMISSION AND CONTROL** **(05 Hours)**
  Pollutant - Sources and types – Effect on environment and human health - formation of NOx - Hydrocarbon Emission Mechanism - Carbon Monoxide Formation - Particulate emissions - Methods of controlling Emissions - Catalytic converters and Particulate Traps - Selective Catalytic Reduction(SCR) - Diesel Oxidation Catalyst (DOC). - Emission Norms and Driving cycles - Indian and Euro norms.

- **GAS TURBINE POWER PLANT** **(03 Hours)**
  Introduction to Gas Turbine, Site Selection, Components and Layout, Performance analysis of Brayton Cycle; open cycle and closed cycle gas turbine power plant.

- **AIR REFRIGERATION** **(04 Hours)**
  Reversed Carnot cycle, Bell Coleman cycle, Aircraft refrigeration cycle, Boot strap system, Actual cycle, Ramming, Compression and Turbine efficiencies, Coefficient of performance.

- **VAPOUR COMPRESSION REFRIGERATION** **(07 Hours)**
  Simple vapour compression cycle, Analysis of vapour compression cycle, Modifications and performance improvements to simple vapour compression system, Multistage vapour compression system, properties of refrigerants.

- **VAPPOUR ABSORPTION REFRIGERATION** **(03 Hours)**
  Comparison between vapour absorption and vapour compression system, Aqua-Ammonia and Lithium Bromide absorption system.

- **PSYCHROMETRY OF AIR CONDITIONING PROCESSES** **(14 Hours)**
  Psychrometric properties, Preparation of psychrometric charts, Psychrometric Processes - Mixing process, Sensible heating, Sensible cooling, Humidification, Dehumidification, Cooling and Dehumidification, Heating and humidification, Bypass factor, Apparatus dew point, Sensible heat factor, Air washer, evaporative cooling, Adiabatic humidification, Efficiency of humidification, Summer and Winter air conditioning system, Load calculations, comfort conditions, Central air conditioning plant, Pressure drop in air ducts.

(Total Lecture Hours: 56)

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3. Practicals: (Any 5 Practical from S. No. 1 to 7; and other 5 Practical from S. No. 8 to 14)

1. Study of Valve Timing/Port Timing Diagram for Engine System
2. Performance test of 4 stroke Petrol Engine.
3. Performance test of 4 stroke Diesel Engine.
4. Heat Balance Preparation for 4 stroke Diesel Engine.
5. Heat Balance Preparation for 4 stroke Petrol Engine
6. Determination of friction power of multi cylinder petrol engine using Morse Test Method.
7. Determination of friction power of single/multi cylinder petrol engine using Willan's Line Method.
8. To conduct performance test on vapour compression refrigeration system.
9. To study tools and instruments used in refrigeration and air conditioning
10. To determine psychrometric properties of air.
11. To conduct performance test on air conditioning system
12. To conduct performance test on Ice plant.
13. To conduct performance test on vapour absorption system - Electrolux- Domestic type.
14. To conduct performance test on desert cooler.

4. Books Recommended:

1. V. Ganesan, Internal Combustion Engine, Fourth Edition, Tata Mc-Graw Hill, 2017.
2. M.L. Mathur and R.P. Sharma, Internal Combustion Engine, Dhanpat Rai Publications, 2010.
3. R. Stone, Introduction to Internal Combustion Engines, Fourth edition, Palgrave Macmillan, 2012.
4. R. J. Dossat, Principles of Refrigeration, Pearson Education India, 2002.
5. C. P. Arora, Refrigeration and Air conditioning, Tata McGraw Hill, 2017.

Corrosion Engineering

ME362

L	T	P	Credit
3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Describe importance of corrosion and various terminology associated with corrosion.
CO2	Identify various types of corrosion, significance, causes and remedies.
CO3	Interpret corrosion issues of various grades of materials.
CO4	Analyze effect of different environments and conditions on corrosion behavior.
CO5	Predict and test corrosion rate of materials from available data.
CO6	Explain design guidelines and preventive methods to minimize corrosion of materials.

2. Syllabus

- **INTRODUCTION TO CORROSION** **(04 Hours)**
  Definition, corrosion damage, statistics/summary of losses due to corrosion, importance of corrosion control, corrosion rate expressions, standards/societies related to corrosion, NACE terminology, origin of Pourbaix diagram.

- **TYPES OF CORROSION** **(07 Hours)**
  General corrosion, galvanic corrosion, crevice corrosion, pitting corrosion, intergranular corrosion, selective leaching, erosion corrosion, stress corrosion, overview of hydrogen cracking, high temperature corrosion. Case studies of failures due to various types of corrosion.

- **CORROSION OF VARIOUS MATERIALS** **(08 Hours)**
  Corrosion of carbon steels, stainless steels and alloy steels. Corrosion issues of aluminium, magnesium, copper, nickel, titanium, etc. and its alloys. Corrosion issues of composite materials and its control.

- **CORROSION IN SELECTED ENVIRONMENTS AND ITS CONTROL** **(09 Hours)**
  Atmospheric corrosion, corrosion due to sea water, microbiologically induced corrosion, overview of corrosion in human body, overview of corrosion in automobiles, overview of corrosion in aircraft, corrosion of steel in concrete, corrosion in petrochemical industry, corrosion in paper and pulp industry and its control.

- **CORROSION TESTING** **(08 Hours)**
  Purpose of testing, importance of testing, laboratory, semi-plant and field tests, ASTM standards for testing, material selection and sample preparation, sequential procedure for laboratory and on-site corrosion investigations. Various tests like immersion tests, cabinet tests, Huey test, Streicher test, Warren test, slow strain rate test, electrochemical tests, high temperature and pressure test, paint test, etc. Testing of stress corrosion cracking and pitting. Cases studies for failure analysis related to surface degradation.

- **CORROSION PREVENTION** **(06 Hours)**
  Purification and alloying of metal, material selection, alteration of environment, design modifications, cathodic and anodic protection, coatings (metallic, inorganic, non-metallic and organic)

(Total Lecture Hours: 42)

3. Books Recommended:

1. M. G. Fontana, Corrosion Engineering, 3rd Edition, Tata McGraw-Hill, 2005.
2. R. W. Revie and H. H. Uhlig, Corrosion and Corrosion Control: An Introduction to Corrosion Science and Engineering, 4th Edition, Wiley Publication, 2008.
3. R. Baboian, Corrosion Tests and Standards: Application and Interpretation, 2nd Edition, ASTM International, 2005.
4. E. Bardal, Corrosion and Protection, 1st Edition, Springer-Verlag London Ltd., 2004.
5. A. J. McEvily and J. Kasivitamnuay, Metal Failures: Mechanisms, Analysis, Prevention, 2nd Edition, Wiley Publication, 2013.

Energy Efficiency and Industrial Utilities

ME364

L	T	P	Credit
3	0	0	03

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1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Apply various energy conservation techniques to estimate energy saving potential
CO2	Compare various appliances/utilities based on their stars and labelling, benchmarking values
CO3	Calculate the usage of energy for a given industrial utility and suggest suitable way to minimize energy bill
CO4	Relate the significance of energy usage in buildings and understand the ways to reduce energy bill
CO5	Compute various performance parameters of HVAC systems and suggest suitable ways for improving energy efficiency

2. Syllabus

- **GLOBAL AND NATIONAL ENERGY SCENARIO** **(05 Hours)**
  Energy consumption in various sectors, Energy resources like Coal, Oil and Natural Gas –their demand and supply management, Indian energy scenario, Indian Coal & LPG scenario, Primary and Secondary Sources of Energy, Commercial and Non Commercial Sources, India's installed energy capacity, per capita energy consumption, General aspects of Energy conservation and management, Roles of energy auditors, Roles of energy manager, Energy policy of industry, Energy Conservation Act and its amendments

- **ENERGY EFFICIENCY IN BOILER, STEAM AND FURNACE SYSTEM UTILITIES** **(10 Hours)**
  Energy conservation opportunities in boiler systems, retrofitting of FBC in conventional boilers, Steam line distribution standard practices including sizing and layouts, selection, operation and maintenance of steam traps, energy saving opportunities in steam systems
  Energy Efficiency in Furnaces: Sankey diagram, Fuel economy measures in furnaces
  Insulation and Refractories: Types of insulations, Economic thickness of insulation, Typical refractories for industrial applications

- **COGENERATION** **(03 Hours)**
  Principle of cogeneration, Technical options for cogeneration, Factors influencing cogeneration choice, Important technical parameters for cogeneration, case study on savings with and without cogeneration

- **FANS, BLOWERS AND COMPRESSORS AND PUMP SYSTEMS** **(12 Hours)**
  Energy saving opportunities, performance evaluation and efficient system operation.
  Compressed Air Systems: Efficient operation of compressed air system, Leakage tests.
  Pumps and Pumping Systems: Pump curves, factors affecting pump performance, Energy loss in throttling, Effects of impeller diameter change, Flow control strategy, Variable speed drives, Energy conservation opportunities.

- **ENERGY EFFICIENCY IN HVAC AND REFRIGERATION UNITS (04 Hours)**
Performance assessment of refrigeration units, Factors affecting energy efficiency in refrigeration plants, Energy saving opportunities in cold storage systems, Heat Pumps and Applications, Standards and Labelling of Room Air-conditioners.

- **COOLING TOWERS (02 Hours)**
Performance evaluation and assessment, Efficient system operation, Energy saving opportunities.

- **LIGHTING SYSTEMS (02 Hours)**
Light source and Lamp types, Illuminance level for various tasks, Energy efficient lighting controls, standards and labelling programs in lamps.

- **ENERGY CONSERVATION IN BUILDINGS (04 Hours)**
Energy Conservation Building Codes, ECBC Guidelines on Building Envelops, service hot water, lighting, water pumping, electrical power, escalators and elevators, Star Ratings of buildings.

(Total Lecture Hours: 42)

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3. Books Recommended:

1. General Aspects of Energy Conservation, Management and Audit: Guide Book for Energy Managers and Energy Auditors; Bureau of Energy Efficiency, Ministry of Power
2. Energy Efficiency in Electrical Utilities: Guide Book for Energy Managers and Energy Auditors; Bureau of Energy Efficiency, Ministry of Power
3. Energy Efficiency in Thermal Utilities: Guide Book for Energy Managers and Energy Auditors; Bureau of Energy Efficiency, Ministry of Power
4. S. A. Roosa, Energy Management Handbook, Fairmont Press, 2018
5. A. Thumann, Handbook of Enegry Audits, Fairmont Press, 2012

Product Design and Development

ME366

L	T	P	Credit
3	0	0	03

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1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the fundamental requirement of product design
CO2	Describe the concepts of design and intellectual rights for innovation
CO3	Explain the concepts of design for manufacturing and industrial design aspects
CO4	Design and model the product
CO5	Apply the concept of product life cycle and management to design product

2. Syllabus

- **MOTIVATION/OBJECTIVE OF PRODUCT DEVELOPMENT** **(14 Hours)**

  Customers' need analysis, Market research & feasibility study, New Product Development (NPD) or improving the existing product, Product Design Specifications (PDS), Quality Function Deployment (QFD) technique

- **DESIGN ENGINEERING** **(18 Hours)**

  Conceptual design; concept generation, selection, and testing. Creating design ideas & Problem solutions. Methodologies; brain storming, lateral thinking, Theory of Inventive Problem Solving (TRIZ), Use of available products and literature (patents & copy rights),

  Preliminary design; design considerations, product architecture, functional dimensions and useful life for the application. Concept of reverse engineering, Design for X (DfX), manufacturing, assembly, material selection, reliability & value engineering, Industrial design (human factors); ergonomics safety, aesthetics,

  Detail design & documentation; parts and assembly drawings, design and review reports. Modeling/Prototyping and performance testing.

- **LAUNCHING AND LIFE CYCLE MANAGEMENT** **(10 Hours)**

  Reaching out to customers; Marketing, advertising, promoting, servicing etc, Product life cycle and management.

(Total Lecture Hours: 42)

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3. Books Recommended:

1. K. T. Ulrich, S. D. Eppinger, and M. C. Yang , Product Design & Development, , 7th Edition, McGraw Hill, 2019.
2. G. Pahl, W. Beitz, J. Feldhusen and K. Grote, Engineering Design - A Systematic Approach, 3rd Edition Springer, 2007.
3. L. C. Schmidt and G. Dieter, Engineering Design, 4th Edition, Mc Graw Hill, 2017.
4. Y. Haik, Engineering Design Process, 2nd edition, CL Engineering, 2011.
5. J. G. Bralla, Hand book of Product Design for Manufacturing, 2nd edition, McGraw Hill, 1996.

Lubrication Technology

ME368

L	T	P	Credit
3	0	0	03

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1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain basics of lubricants, primary roles, their types, performance properties and evaluation methods.
CO2	Apply the conceptual selection criteria of lubricants in the industrial applications.
CO3	Identify oil degradation; role of various additives ; selection criteria for lubricants in various situations; various regimes of lubrication and Striback curve
CO4	Explain the theory of lubrication in industrial applications.
CO5	Explain the general safety considerations for lubrication storage and handling of the plants.

2. Syllabus

- **INTRODUCTION** **(08 Hours)**

Introduction: friction, wear and lubrication, Historical background, Purpose of lubrication, Lubrication regimes, Characteristics of lubricants - viscosity, viscosity index, oxidation stability, flash point and fire point, pour point and cloud point, carbon residue, ash content, iodine value, neutralization number, dielectric strength.

- **LUBRICANTS** **(08 Hours)**

Classification of lubricating oils, properties of lubricating oils, tests on lubricants. Grease classification, properties, tests. Specific requirements for automotive lubricants, oxidation, deterioration and degradation of lubricants, additives, synthetic lubricants.

- **PROPERTIES AND ADDITIVES** **(10 Hours)**

Composition and classification of lubricants, lubricating oils – oil refining, types, categories, grading, Grease - composition, function, characteristics, thickeners and additives, soap and its complexes, selection and its practices, solid lubricants, Functional additives – surface, performance enhancing, lubricant protective.

- **THEORY OF LUBRICANTS** **(10 Hours)**

Engine friction - introduction, total engine friction, effect of engine variables on friction, hydrodynamic lubrication, elastohydrodynamic lubrication, boundary lubrication, bearing lubrication, functions of the lubrication system, introduction to design of a lubricating system.

- **LUBRICANTS APPLICATIONS** **(06 Hours)**

Tribological components and industrial machinery, Lubricants testing and test methods, Organization and management of lubrication, lubricant storage and handling, Safety and health hazards, Environmental regulations.

(Total Lecture Hours: 42)

3. Books Recommended:

1. Hand Book of Lubrication and Tribology, Vol. I – Vol. III, CRC Press Inc., 2006
2. D. D. Fuller, Theory and practice of lubrication for engineers,2nd Edition, John Wiley & sons., 1984
3. A. Cameron, Basic Lubrication Theory, Prentice Hall Press, 1971
4. Raymond G. Gunther, Lubrication, Chipton Book Co., 1971
5. A. R. Lansdown, Lubrication &Lubricants selection, 3rd Edition, ASME Press, 2003

Plant Layout and Material Handling

ME372

L	T	P	Credit
3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Demonstrate the capabilities of selecting suitable plant location considering various criteria.
CO2	Demonstrate the knowledge of factory buildings used in industries and its importance.
CO3	Analyze various types of plant layouts used in industries and solve the related problem using various evaluation techniques.
CO4	Evaluate the optimum layouts using optimization techniques.
CO5	Analyze and identify suitable material handling equipment used in industries as per the requirement.

2. Syllabus

- **INTRODUCTION** **(04 Hours)**
  Need of plant layout; basic objectives of plant layout; types of plant layouts; types of production systems.

- **PLANT LOCATION** **(06 Hours)**
  Introduction to plant location, Influence of location on plant layout, plant location selection factors, Models for the plant location selection: median model, gravity model; plant location selection

- **INDUSTRIAL BUILDING** **(04 Hours)**
  Relationship between the building and layout, considerations in industrial building design; types of factory buildings: single storey/horizontal buildings and multi storey buildings.

- **PLANT LAYOUT** **(06 Hours)**
  Definitions of plant layout, types of plant layouts: product Layout, process layout/functional type layout, fixed position layout, group technology layout/cellular layout; advantages and disadvantages.

- **EVALUATION OF LAYOUTS** **(15 Hours)**
  Product layout/assembly line evaluation algorithms: largest candidate rule; Kilbridge and Wester method; ranked positional weights method. Process layout evaluation: qualitative and quantitative factors; layout cost evaluation; comparing two layout layout; computerized relative allocation of facilities technique (CRAFT); equal area and unequal area facility layout problems. Assignment model for addition of new facilities/machine to the existing layout. Group technology layout evaluation: part families and machine cells; rank order clustering technique.

- **MATERIAL HANDLING** **(07 Hours)**
  Principles of material handling, Factors considered for material handling equipment selection, Types of material handling equipment: load formation equipment, positioning equipment,

conveyers, cranes and hoists, industrial trucks, elevators, storage equipment, etc.; material handling equipment selection.

(Total Lecture Hours: 42)

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3. Books Recommended

1. M. P. Groover, Automation, Production Systems, and Computer-Integrated Manufacturing, 5th Edition, Pearson, 2018.
2. R. Panneerselvam, Production and Operations Management, 3rd Edition, Prentice Hall India, 2012.
3. T. H. Allegri, Material Handling, Principles and Practice, CBS Publishers, New Delhi, 2017.
4. P.B. Mahapatra, Computer Aided Production Management, 1st Edition, Prentice Hall India, 2004.
5. S. Roy, Introduction to Material Handling, 2nd Edition, New Age International (P) Ltd, 2017.

Risk, Reliability and Life Testing

ME374

L	T	P	Credit
3	0	0	03

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1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Examine the reliability of any product or system which ultimately maintains the customers' base of any industry.
CO2	Explain the components and systems through its life cycle.
CO3	Evaluate the probabilistic time analysis of products' successes and failures.
CO4	Predict reliability of any component or system which is essential before we put it into any use.
CO5	Estimate the life of a system and their components with concepts of highly accelerated life testing.

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2. Syllabus

- **BASIC CONCEPTS IN RELIABILITY** **(08 Hours)**
  Risk and Reliability, introduction and fundamentals of risk management and reliability engineering, bath tub curve, failure mechanism of mechanical components: causes, modes, function of mechanical elements, failure theories.

- **COMPONENT RELIABILITY** **(06 Hours)**
  Failure data analysis, reliability function, hazard rate, failure rate, and their relationship, MTTF, mean failure rate, MTBF.

- **SYSTEM RELIABILITY** **(06 Hours)**
  Series, parallel, mixed configuration, r-out of-n structure, solving complex systems, Reliability Logic Diagrams (RLD), techniques of reliability estimation: fault tree analysis, tie sets and cutsets, boolean algebra.

- **SYSTEM RELIABILITY IMPROVEMENT** **(08 Hours)**
  Use of better components, simplification, derating, redundancy, working environment control, maintenance, etc. redundancy techniques: introduction, component vs unit redundancy, weakest link technique, mixed redundancy, standby redundancy, redundancy optimization, double failure and redundancy.

- **CASE APPLICATION OF COMPLEX SYSTEM** **(04 Hours)**
  Marine power plant, computer system, nuclear power plant, combats aircraft, etc.

- **RELIABILITY TESTING** **(08 Hours)**
  Introduction, objectives, assumptions, different types of test. life testing in practice: methodology, problems and difficulties. economics of reliability engineering.

- **ACCELERATED LIFE TESTING** **(10 Hours)**
  Introduction, basic concepts, data qualification. accusations faster, stress combination methods, limitations, Accelerated Stress Testing (AST), step stress method for AST, various AST models,

recent development recommended approach. Highly Accelerated Life Testing (HALT), Highly Accelerated Stress Screening (HASS).

(Total Lecture Hours: 42)

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3. Books Recommended:

1. L. S. Srinath, Mechanical Reliability, East-West Press Pvt. Ltd, New Delhi, 2002
2. L. S. Srinath, Reliability Engineering, 4th edition, East-West Press Pvt. Ltd, New Delhi, 2005
3. V. N. A. Naikan, Reliability Engineering and Life Testing, PHI Learning Pvt. Ltd. New Delhi, 2008
4. E. Balagurusamy, Reliability Engineering, TMH, New Delhi, 2017
5. D. T. Patrick, Practical Reliability Engineering, 4th edition, Wiley Publishing company, 2008

Materials Management

ME376

L	T	P	Credit
3	0	0	03

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1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Describe the role and scope of materials management in organization.
CO2	Apply the concepts of classification, codification, specification, standardization and variety reduction for proper store management.
CO3	Apply deterministic and probabilistic inventory control models and selective inventory control to insure a steady supply of materials to meet the needs of the organization
CO4	Evaluate the budget and material requirement plan to insure a steady supply of materials to meet the needs of the organization
CO5	Explain the key characteristics of fundamental and specialized purchasing aspects, store keeping, the public and international purchase.

2. Syllabus

- **MATERIALS MANAGEMENT** **(04Hours)**

  Functions, Objectives, Activities, Cost, advantages, Desirable qualities of purchasing and materials manager

- **CLASSIFICATION, CODIFICATION & SPECIFICATION** **(05 Hours)**

  Need for classification and identifications of materials. Classification of Materials, Codification: Nature, process, merits and demerits, Codification Systems, Stores Vocabulary, Marking of Stores, Objective of specifications, Specification Categories and development

- **STANDARDISATION AND VARIETY REDUCTION** **(05 Hours)**

  Standard, Dimensions, Different levels of standards, Scope, Various foreign standards used in India, Procedure for evolving Indian standards, Benefits, Standardization and variety reduction in products, Techniques of variety reduction, Three S's- Standardization, Simplification and Specialization

- **INVENTORY CONTROL AND MANAGEMENT** **(07 Hours)**

  Classification, Inventory Models (Deterministic and Probabilistic), P and Q Systems in Practice, Selective Inventory Control, Two dimensional Classification, Music 3-D Model, A-B-C analysis for always better control.

- **BUDGETING AND MATERIAL RESOURCE PLANNING** **(07 Hours)**

  Budgetary control, Types, advantages, Material Requirement Planning (MRP) structures, Management, Lot sizing techniques

- **STORE AND STORE KEEPING** **(04 Hours)**

  Objectives, Functions of storekeeper, Benefits of store keeping, Features of successful store keeping, Stores Organization, Location and layout of stores, Types of stores, Stock taking

- **PURCHASING** **(10 Hours)**

  Purchasing Process, purchasing terms and conditions, Principles, Objectives, Methods, Vendor/Supplier rating, e-Procurement, Vendor/Supplier performance evaluation, negotiation, make or buy, outsourcing, and buy commodities, capital goods, Director general of Supplies and Disposals (DGS&D), Supplier registration, Government e-Market place (GeM), tendering, Central Public Procurement Portal (CPPP), Director general of foreign trade (DGFT), Importers, Criteria of Licencing, Negative list, Import procedure

(Total Lecture Hours: 42)

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3. Books Recommended:

1. J. R. T. Arnold, S. N. Chapman and L. M. Clive, Introduction to Materials Management, 7th Edition,Pearson Education, 2010.
2. A. K. Chitale and R. C. Gupta, Materials Management: A Supply Chain Perspective, 3rd Edition, PHI learning Private Limited, 2014.
3. J. Heizer, B. Render, C. Munson and A. Sachan, Operations Management, 12th Edition, Pearson Education, 2017.
4. P. Gopalakrishnan and A. Haleem, Handbook of Materials Management, 2nd Edition, Prentice Hall India Learning Private Limited, 2015.
5. P. Gopalakrishnan and M. Sundaresan, Materials Management: An Integrated Approach by Gopalakrishanan, 1st Edition, Prentice Hall India Learning Private Limited, 1977.

Advanced Engineering Materials

ME322

L	T	P	Credit
3	0	0	03

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1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain major types of special steels, their properties and applications
CO2	Find out metals that can be used for high temperature applications
CO3	Select cast-irons for specific engineering applications
CO4	Correlate metallurgical aspects and application of light metals
CO5	Select nanomaterials for different industrial applications
CO6	Describe material properties and select the suitable material for biological, space and cryogenic service applications

2. Syllabus:

- **INTRODUCTION** **(01 Hour)**
  The urge for advancements in material development and processing.

- **SPECIAL STEELS** **(08 Hours)**
  Metallurgical aspects, Composition, Properties and applications of: different types of Stainless steels, Dual phase steels, TRIP steels, Maraging steels, High speed steels, Hadfield steels, Free cutting steels, Ausformed steels, Tool Steels, manganese steels, chrome steels, electrical steels, bearing steels, spring steels, heat resistant steels, creep steels, HSLA steels, materials in nuclear field, materials used in space

- **SPECIAL AND HIGH TEMPERATURE ALLOYS** **(06 Hours)**
  Ti alloys: physical and mechanical properties, thermomechanical treatment of Ti-alloys, Ti shape memory alloys, Fe based super alloys, Ni based alloys, Co based alloys, Strengthening mechanism, Composition, Properties and their applications. engineering applications at elevated temperatures.

- **ALLOY CAST IRON** **(05 Hours)**
  Austempered ductile iron; alloy cast irons, Ni hard, high silicon cast irons, heat resistant cast irons- high chrome cast iron- structure, property and engineering applications.

- **LIGHT METALS AND THEIR ALLOYS** **(04 Hours)**
  Aluminium, magnesium and titanium alloys: Metallurgical aspects, Properties and applications.

- **NANO MATERIALS** **(04 Hours)**
  Definition, Types, Properties and applications, Carbon nano tubes, Methods of production.

- **SMART MATERIALS AND BIOMATERIALS** **(06 Hours)**

Shape memory alloys, Piezoelectric materials, Electro-rheological fluid, Magneto-rheological fluids,biocompatibility, bio functionality, Important bio metallic alloys like: Ni-Ti alloy and Co-Cr-Mo alloys. Applications.

- **COMPOSITE MATERIALS** **(04 Hours)**
  PMC, CMC, MMC, processing and typical application, Special High Temperature High performance Carbon-Carbon composites.

- **MISCELLANEOUS ADVANCED MATERIALS** **(04 Hours)**
  Magnetic materials, aerospace materials, cryogenic materials, semi-conducting and superconducting materials.

(Total Lecture Hours: 42)

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3. Books Recommended:

1. J. F. Shackelford, B. R. W. Alexander, Materials Science and Engineering Handbook, CRC Press, LLC, 2001.
2. K. G. Budinski, M K Budinski, Engineering Materials: Properties and Selection, General Motors Corporation, Pearson, 2010.
3. I. J. Polmear, Light alloys: Metallurgy of Light Metals, Arnold, 1995.
4. Z. Abdullaeva, Nano and Biomaterials: Compounds, Properties, Characterization and Applications, Wiley-VCH Verlag, 2017.
5. K K Chawla, Composite Material Science and Engineering, Springer, 2012.

21/07/2020

Energy and Exergy Analysis of Thermal Systems

ME324

L	T	P	Credit
3	0	0	3

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1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the importance of the exergy and its difference from energy analysis
CO2	Apply the first law and second law of thermodynamics to various thermal systems
CO3	Determine the physical and chemical exergy of a given system
CO4	Illustrate pictorial representation of exergy balance
CO5	Perform exergy analysis of different thermal systems

2. Syllabus

- **Introduction** **(05 Hours)**
  Fundamentals of mass, energy and entropy balance, and requirement of exergy analysis

- **Basics of exergy analysis** **(10 Hours)**
  Energy and exergy analysis, Exergy classifications, Exergy of closed systems, Exergy of flows, Exergy consumption, Procedure for energy and exergy analysis, reference environment, Exergy analysis implications

- **Exergy analysis of thermodynamic processes** **(10 Hours)**
  Mixing and separation process, heat transfer across a finite temperature difference, expansion and compression processes, Chemical process in combustion.

- **Elements of plant analysis** **(05 Hours)**
  Control mass analysis, control region analysis, Criteria of performance, Pictorial representation of exergy balance, Energy and exergy properties diagram

- **Exergy analysis of thermal power plants** **(12 Hours)**
  Gas turbine power plant with external and internal irreversibility, regeneration, cogeneration, reheater, and intercooler, combined steam and gas turbine power plant, Brayton cycle steam turbine power plants with external and internal irreversibility, super heater, reheater, vacuum condenser, regenerative feed water heating, combined feed water heating and reheating. Combined power plants

(Total Lecture Hours: 42)

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3. Books Recommended:

1. A. Bejan, G. Tsatsaronis, M. J. Moran, M. Moran, Thermal Design and Optimization, John Wiley & Sons, Inc.. 1996
2. I. Dincer Marc A. Rosen, Exergy, Energy, Environment and Sustainable Development, Elsevier Science, 2013
3. A. Bejan, Advanced Engineering Thermodynamics, John Wiley & Sons, Inc., New York. 2016
4. T. J. Kotas, The exergy Method of Thermal Plant Analysis, Butterworth-Heinemann, 2013
5. M. J. Moran, Availability Analysis – A Guide to Efficient Energy Use, ASME, 1989

MACHINE TOOL DESIGN

ME326

L	T	P	Credit
3	0	0	03

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1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the general requirements of machine tools.
CO2	Design mechanical and hydraulic transmission elements.
CO3	Analyze the kinematics of machine elements.
CO4	Explain machine tool control systems.
CO5	Design the column, table and guide ways of machine tools.

2. Syllabus

- **INTRODUCTION** **(03 Hours)**
  General requirements to machine tools, Machine tool design recommendations, Classification of motions to shape surface, Machine tool drives for rectilinear motion, Periodic motion, reversing motion etc.

- **KINEMATICS OF MACHINE TOOLS** **(05 Hours)**
  Kinematics or gearing diagram of Lathe, Drilling Machine, Milling Machine etc. machine tool drive, principles specification of machine tool.

- **DESIGN OF KINEMATICS** **(05 Hours)**
  Methods to determine transmission ratios for drives, Mechanical transmission and its elements, hydraulic transmission and its elements.

- **SPEED AND FEED BOXES** **(05 Hours)**
  General requirement, Design of gear trains, speed box es types, speed changing devices, feed boxes, characteristics of feed mechanism, types of rapid traverse mechanisms, variable devices

- **SPINDLE DESIGN AND SPINDLE BEARING** **(08 Hours)**
  Main requirement, Materials and details of spindle design, Spindle bearings, bearings, types of bearings and their selections, Bearing Materials

- **COLUMNS, TABLES AND WAYS** **(08 Hours)**
  Materials, typical constructions and design, basic design procedure of machine tool structure, design of columns, function and types of guide ways, design criteria and calculation of slide ways.

- **MACHINE TOOLS CONTROL SYSTEMS** **(08 Hours)**
  Requirement of control system selection and construction of control systems Mechanical control system, predilection control, remote control safety devices

(Total Lecture Hours: 42)

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3. Books Recommended:

1. N. K.Mehta, Machine Tool Design, 3re Edition, Tata McGraw Hill, 2017
2. S. K.Basu and D. K.Pal, Design of Machine Tools, 5th Edition, Ox ford and IBH, 2005
3. N. Achertan, Machine Tool Design, University Press of the Pacific, 2000
4. F. Koenigsberger, Design Principles of Metal Cutting Machine Tools, Pergamon Press, 2013
5. G. C.Sen and A.Bhattacharyya, Principles of Machine Tools, 2nd Edition, New Central Book Agency,2009

21/07/2020

Micro-Hydro Power Plant

L	T	P	Credit
3	0	0	03

ME328

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1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the concepts of hydro-electric power plant and classify different hydro-electric and micro hydro-electric power plant
CO2	Analyze flow prediction methods and evaluate flow transfer systems required based on site conditions
CO3	Identify different types of turbines and analyze the performance characteristics of various turbines
CO4	Explain the working of different components of governing systems, and select the appropriate governing and drive for suitable application
CO5	Compare the working of different electrical power sources
CO6	Prepare maintenance schedule of components of micro hydro plant and carry out fault diagnosis

2. Syllabus

- **INTRODUCTION** **(06 Hours)**
  Classification of Hydro-Electric Power Plant, micro hydro power plant overview and components.

- **HYDROLOGY, SITE SURVEY AND CIVIL WORKS** **(10 Hours)**
  Introduction, flow prediction, head measurements, site measurements of flow, civil works, system layout, Weir, spillways, channel, penstocks.

- **TURBINES** **(10 Hours)**
  Introduction, types: impulse, Pelton, Turgo, Cross flow, Reaction, Francis, Propeller, Kaplan and reverse pump: selection of turbine.

- **GOVERNING AND DRIVE SYSTEM** **(06 Hours)**
  Purpose of governing, approaches to the governing, direct couple drives: components.

- **ELECTRICAL POWER** **(06 Hours)**
  Basic electricity, choosing the supply, generators, synchronization

- **OPERATION AND MAINTENANCE** **(04 Hours)**
  Maintenance of components of micro hydro plant, fault diagnosis.

(Total Lecture Hours: 42)

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3. Books Recommended:

1. P. Fraenkel, O. Parish, V. Bolkalders, A. Harvey, Micro-hydro Power: A guide for development workers, ITDG Publishing, 1991.

2. L. Kindberg, Micro-Hydro Power: A Beginners Guide to Design and Installation, National Center for Appropriate Technology, 2014.
3. A. Harvey, Micro-Hydro Design Manual: A Guide to Small-Scale Water Power Schemes, Intermediate Technology Publications, 1993.
4. V. Schnitzer, Micro hydro Power scout guide. Hydro Power GTZ, 2009.
5. J.M. Chapallaz, P. Eichenberger, G. Fischer. Manual on pumps used as turbines, Vieweg, 1992.

21/07/2020

Micro- and Nano- Manufacturing

ME332

L	T	P	Credit
3	0	0	03

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1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Categorize and describe micro- and nano- manufacturing processes based on given application.
CO2	Explain and select suitable micro machining/ micro forming/ MEMS processes based on given parameters and constraints.
CO3	Distinguish between the requirements for micro and nano manufacturing processes
CO4	Recommend a suitable nano- manufacturing process for a given application
CO5	Propose suitable metrological technique for measuring micro and nano features

2. Syllabus

- **INTODUCTION** **(02 Hours)**
  Introduction to miniaturization, scaling laws, micro products and design considerations, classification, applications.

- **MICRO MACHINING PROCESSES** **(14 Hours)**
  Principle of mechanical micromachining, micro turning, micro milling, ultrasonic micro machining, abrasive jet micro machining, micro electro discharge machining, micro electro chemical machining, micro grinding, laser micro machining.

- **MICRO FORMING PROCESSES** **(08 Hours)**
  Micro scale plastic deformation, size effect, micro deep drawing, micro extrusion, micro punching, micro blanking, micro fabrication using bulk metallic glasses, flow induced defects.

- **MEMS TECHNIQUES** **(06 Hours)**
  Classification, principle and working, photo lithography, chemical etching, LIGA, materials.

- **INTRODUCTION TO NANO MANUFACTURING** **(08 Hours)**
  Transition from nano technology to nano manufacturing; diamond turn machining; nano joining, nano soldering, nano welding, mechanical bonding, fastening; chemical vapor deposition, scanning tunneling microscopy, nano lithography.

- **MICRO AND NANO METROLOGY** **(04 Hours)**
  Scanning electron Microscopy, optical microscopy, scanning white light interferometry, scanning probe microscopy, computed tomography, digital volumetric imaging, molecular measuring machine.

(Total Lecture Hours: 42)

21/07/2020

3. Books Recommended:

1. M. Jackson, Micro and Nano Manufacturing, Springer Science media, 2007.
2. W. Ahmed and M. J. Jackson, Emerging Nano Technologies for Manufacturing, Elsevier, 2nd edition, 2015.
3. I. Fassi and D. Shipley, Micro Manufacturing Technologies and their Applications, Springer, 2017.
4. N. Maluf and K. Williams, Introduction to MEMS Engineering, 2nd edition, Artech house, 2004.
5. K. Gupta, Micro and Precision Manufacturing, Springer, 2018

21\07\2020

Finite Element Method

ME334

L	T	P	Credit
3	0	0	03

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1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the fundamental concepts of the theory of the finite element method
CO2	Develop element characteristic equation and generation of global equation.
CO3	Apply suitable boundary conditions to a global equation for bars, trusses and beams
CO4	Evaluate the governing FE equations for solving 1D and 2D problems
CO5	Apply the FE method for thermal, potential flow and transient problems

2. Syllabus

- **INTRODUCTION** **(07 Hours)**
  Basic concepts of FEM, Matrix notations, Exact solution, Approximate solution, general procedure for finite element analysis, various approximate methods, types of elements, Interpolation and shape functions.

- **STIFFNESS (DISPLACEMENT) METHOD** **(07 Hours)**
  Introduction to Stiffness matrix, stiffness matrix for spring element, Global stiffness matrix, application of boundary conditions and forces, essential and natural boundary conditions, elimination method, penalty methods, element stresses and strains, Potential Energy approach to derive spring element Equations.

- **TRUSS STRUCTURES** **(07 Hours)**
  Stiffness Matrix for Bar Element, Global stiffness matrix for bar elements, computation of stress and strain for bar. Other residual method for one dimensional (1-D) bar problems.

- **FLEXURE ELEMENTS** **(07 Hours)**
  Beam theory, Beam stiffness matrix, Global beam stiffness matrix, equivalence load for various distributed loads, potential energy and Galerkin's method for beam elemental equation. .

- **FINITE ELEMENTS FOR TWO-DIMENSIONS** **(06 Hours)**
  Introduction to plane stress and plane strain, constant – strain triangle (CST) stiffness matrix, body and surface force for two-dimensional element, finite element solution of plane stress problem.

- **APPLICATIONS OF FEA IN ENGINEERING** **(08 Hours)**
  Plane elasticity, Heat conduction, Potential flow, Transient problems and Computer implementation.

12/1/07

(Total Lecture Hours: 42)

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3. Books Recommended:

1. R.D. Cook, Concepts and Applications of Finite Element Analysis, 4th Edition, John Wiley & Sons, 2007.
2. D.L. Logan, A first course in the finite element method, 5th Edition, Cenage Learning, 2012.
3. J.N. Reddy, an Introduction to the Finite Element Method, 5th edition, McGraw Hill, x 2017.
4. T.R. Chandrupatla & A.D Belagundu, Finite Elements in Engineering, 4th Edition, Pearson, 2015.
5. O.C. Zienkiewicz, R.L Taylor and J.Z Zhu, The finite element method its basis and fundamentals, 7th edition, Elsevier,2013

21/07/2020

Teaching Scheme: B. Tech. (Mechanical Engineering) IV Year

SEMESTER - VII

Sr. No.	Subject	Code	Scheme	Exam Scheme				Total	Credit
				Theory		Tuto.	Pract.		
				Hrs.	Marks	Marks	Marks		
1.	**Industrial Management Techniques**	**ME401**	**3 – 1 - 0**	**3**	**100**	**25**	**-**	**125**	**04**
2.	**CAD-CAM**	**ME403**	**4 – 0 – 2**	**4**	**100**	**-**	**50**	**150**	**05**
3.	**Core Elective – 3**	**ME4AA**	**3 – 0 – 0**	**3**	**100**	**-**	**-**	**100**	**03**
4.	**Core Elective - 4**	**NE4BB**	**3 – 0 – 0**	**3**	**100**	**-**	**-**	**100**	**03**
5.	**Summer Training**	**ME405**	**0 – 0 – 4**	**0**	**-**	**-**	**100**	**100**	**02**
6.	**Project Preliminaries**	**ME407**	**0 – 0 – 6**	**0**	**-**	**-**	**150**	**150**	**03**
		Total	**13 – 1 – 12**	**13**	**400**	**25**	**300**	**725**	**20**

Core Elective – 3 (ME4AA)

1. Refrigeration and Air Conditioning Systems: ME421
2. Automobile Engineering: ME423
3. Surface Engineering and Heat Treatment: ME425
4. Production and Operations Management: ME427
5. Fundamentals of Combustion: ME429

Core Elective – 4 (ME4BB)

1. Renewable Energy Systems: ME431
2. Mechanics of Composite Materials: ME433
3. Gas Dynamics: ME435
4. Fatigue, Fracture and Failure Analysis: ME437
5. Smart Materials and Structures: ME439

21/02/2020

Industrial Management Techniques

ME401

L	T	P	Credit
3	1	0	04

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1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1	Formulate Linear Programming(LP) models for engineering and management systems, and apply solution techniques and algorithms to solve these problems
CO2	Formulate assignment & transportation models for engineering and management systems, and apply solutions techniques and algorithms to solve these problems.
CO3	Formulate Network models for engineering and management systems, and apply solution techniques and algorithms to solve these problems
CO4	Formulate Queuing models for engineering and management systems, and apply solution techniques and algorithms to solve these problems
CO5	Apply strategies and payoff to solve game theory problems
CO6	Apply statistical process control tools for designing of products and process controls.

2. Syllabus

- **LINEAR PROGRAMMING PROBLEMS** **(10 Hours)**
  Formulation, Graphical method, Simplex method, Difficulties in Simplex method, Duality
- **ASSIGNMENT & TRANSPORTATION MODELS** **(08 Hours)**
  Allocations, Problem of imbalance, Hungarian assignment method, Alternate optima, Travelling salesman problem, basic transportation problem, unbalanced transportation problem, Optimal solution, degeneracy, Transhipment & Inventory control problems
- **NETWORK ANALYSIS** **(08 Hours)**
  Project Management, Network analysis, Critical Path Activities, Program Evaluation and Review Techniques (PERT), Crashing analysis, Activity on node analysis and Resource scheduling.
- **STATISTICAL PROCESS CONTROL** **(08 Hours)**
  Discrete and continuous probability distributions, Control Charts for variables and attributes, Type I and II errors, Process capability, Acceptance Sampling Plans (single, double and multiple sampling plans)
- **QUEUING THEORY** **(04 Hours)**
  Models, Elements, Operating Characteristics and Deterministic queuing models
- **GAME THEORY** **(04 Hours)**
  Two Person Zero Sum Games, Dominance Rule, Application of Linear Programming to game problems.

21/07/2020

(Total Lecture Hours: 42)

3. Books Recommended:

1. H. A. Taha, Operations research: An Introduction. 10th Edition, Pearson Education, 2019.
2. S. D. Sharma, Operations Research: Theory, Method & Applications, 1st Edition, Kedarnath Ramnath Publishers, 2012.
3. P. K. Gupta and D. S. Hira, Operations Research, Revised Edition, S. Chand & Company Ltd., 2017
4. A. Mitra, Fundamentals of Quality Control and Improvement, 3rd Edition, John Wiley & Sons, 2008.
5. N. D. Vohra, Quantitative Techniques in Management, 5th Edition, Mc-Graw Hill, 2017.

21\07\2020

CAD-CAM

ME403

L	T	P	Credit
4	0	2	05

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1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the fundamental principles of CAD and learn drafting commands to generate part drawings.
CO2	Explain knowledge about computer aided drafting and modelling for part models and drawings.
CO3	Apply CAD concepts to design engineering components.
CO4	Explain the fundamental principles of CAM and learn NC & CNC programming techniques and APT language to generate the tool paths and tool motion.
CO5	Explain computer aided process planning and flexible manufacturing systems.
CO6	Apply CAM concepts to manufacture components.

2. Syllabus

- **PRINCIPLES OF COMPUTER AIDED DESIGN** **(03 Hours)**
  Computer configuration for CAD applications, Computer peripherals for CAD

- **FUNDAMENTALS OF COMPUTER GRAPHICS** **(12 Hours)**
  Two dimensional transformation, three dimensional transformation and projections, Two dimensional transformation of points, lines, parallel & intersecting lines, rotation, reflection, scaling and combined transformations. Rotation about an arbitrary point, reflection about arbitrary line. Homogeneous coordinate system. Three dimensional scaling, shearing, rotation, reflection and transformations.

- **PLANE CURVES AND SPACE CURVES** **(06 Hours)**
  Curve representation, Parametric and Non Parametric curves, Parametric presentation of circle, ellipse, parabola, and hyperbola. Cubic spline, Bezier curve and B spline curve.

- **DRAFTING AND MODELLING** **(07 Hours)**
  Computer Aided Drafting with drafting commands and 3d modelling commands for feature generation. Introduction to various software for drafting and 3D surface/solid modelling. Computer aided engineering and about CAE software.

- **INTRODUCTION TO COMPUTER AIDED MANUFACTURING** **(02 Hours)**
  Numerical control of machine tools, Functions, Classification, Open loop and closed loop CNC systems, MCU

- **CONSTRUCTIONAL FEATURES & PART PROGRAMMING FOR NC & CNC MACHINES** **(12 Hours)**
  Tooling for NC Machines, ISO G & M Codes, NC part programming, tool

setting, cutter compensation, tool length offset method, canned cycles, parametric programming.

- **APT language** **(08 Hours)**
  APT language structure, APT Geometry, motion commands, post processor commands, repetitive programming, compilation and control commands

- **COMPUTER AIDED PROCESS PLANNING (CAPP)** **(03 Hours)**
  Process and product planning, Concurrent Engineering, CAPP types, advantages and disadvantages, implementation consideration, commercial process planning system.

- **FLEXIBLE MANUFACTURING SYSTEMS (FMS)** **(03 Hours)**
  Introduction, General Considerations for FMS, types of FMS, hierarchy of computer control in FMS.

(Total lecture hours: 56)

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3. Practicals:

1. Applying drafting commands using drafting software/sketcher mode in packages.
2. Creating part drawings based on given sketches as per dimensions.
3. Applying programming technique for generating drawings in drafting.
4. Applying programming knowledge to design a mechanical part.
5. Applying CAD commands to build 3D models.
6. CNC part programming using linear and circular interpolation for FANUC controller.
7. CNC part programming using tool radius compensation for FANUC controller.
8. CNC part programming using peck drilling and canned cycle for FANUC controller.
9. CNC part programming using mirror and subroutine for FANUC controller.
10. CNC part programming using stock removal cycles for FANUC controller.

4. Books Recommended:

1. P. N. Rao, "CAD/CAM: Principles and Applications", Tata McGraw Hill, 2010.
2. K. K. Tiwati and S. K. Sinha, "CNC Programming (Fanuc Control)", Galgotia Publications, 2011.
3. M. P. Groover and E. W. Zimmers, "Computer Aided Design and Manufacturing", Prentice Hall India (Pearson Education), 2003.
4. C. Elanchezhian, T. S. Sunder and G. S. Sundar, "Computer Aided Manufacturing", Laxmi Publications, New Delhi, 2006.
5. D. F. Rogers and J. A. Adams, "Mathematical Elements for Computer Graphics", McGraw Hill Education, 2017.

21/07/2020

Refrigeration and Air Conditioning

ME421

L	T	P	Credit
3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Describe the properties of refrigerants and evaluate performance of the actual vapour compression refrigeration systems.
CO2	Evaluate the performance of compound vapour compression refrigeration systems for various applications.
CO3	Describe vapour absorption system for large cooling load application and evaluate its performance.
CO4	Explain working principles of non-conventional refrigeration systems and evaluate the performance of steam jet refrigeration system.
CO5	Compute cooling/heating loads for designing air conditioning systems for residential and commercial building.
CO6	Design the air duct systems for large commercial buildings.

2. Syllabus

- **VAPOUR COMPRESSION REFRIGERATION SYSTEM** **(06 Hours)**
Refrigerants – properties, applications, selection, mixed refrigerants, retrofit study, standard rating cycle for domestic refrigerator, methods of defrosting. refrigeration system components: compressors, condensers, expansion devices, evaporators

- **COMPOUND VAPOUR COMPRESSION REFRIGERATION SYSTEMS** **(08 Hours)**
Multi stage compression with water intercooler, liquid subcooler, flash chamber, flash intercoolers and multiple expansion valves, multi evaporator systems, cascade refrigeration system

- **VAPOUR ABSORPTION SYSTEMS** **(04 Hours)**
Temperature concentration and enthalpy concentration diagrams, enthalpy balance for various components of aqua ammonia systems, Vapour absorption system- Electrolux refrigerator

- **NON - CONVENTIONAL REFRIGERATION SYSTEMS** **(06 Hours)**
Steam jet refrigeration system, Performance analysis of steam jet refrigeration system, thermo electric refrigeration system, vortex tube Refrigeration, pulse tube refrigeration, adiabatic demagnetization. vapour adsorption refrigeration system

- **AIR CONDITIONING** **(10 Hours)**
Review of air conditioning processes, summer and winter load calculations, internal and external heat gains, cooling coils, bypass factor, effective sensible heat factor, design consideration for cooling coils, high latent heat load, design of evaporative cooling system, de-humidifiers and air washers, Comfort air conditioning, thermodynamics of human body, comfort charts, effective temperature, central air conditioning system, factory air conditioning.

- **AIR HANDLING UNIT** **(08 Hours)**

Air handling unit, room air distributions, fluid flow and pressure losses, duct design, air filters, humidifiers, fan, blowers

(Total Lecture Hours: 42)

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3. Books Recommended:

1. W. F. Stoeaker, Refrigeration and Air Conditioning, McGraw Hill, 2004.
2. R.J Dossat, Principles of Refrigeration, John Wiley & Sons, 2000.
3. C.P. Arora, Refrigeration and Air Conditioning, Tata McGraw Hill, 2008.
4. S.C. Arora and S. Domkundwar, A Course in Refrigeration and Air Conditioning, Dhanpat Rai & Sons, 2018.
5. P. Manohar, Refrigeration and Air Conditioning, New Age International, 2011.

21/07/2020

Automobile Engineering

ME423

L	T	P	Credit
3	0	0	03

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1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain vehicle dynamics and performance.
CO2	Describe types of suspension systems and modern vehicles with latest developments.
CO3	Analyze power transmission systems and drive mechanisms of an automobile.
CO4	Analyze steering, braking and other ancillary systems of an automobile.
CO5	Illustrate battery, electrical and ignition systems of an automobile.

2. Syllabus

- **AUTOMOTIVE POWER SOURCES** **(03 Hours)**
  IC Engines: Types and Classification based on strokes (Four Stroke and Two Stroke engines), Rotary engines, based on fuel used (petrol, diesel, lpg, cng), electric motors for electric vehicles, hybrid vehicles.

- **VEHICLE DYNAMICS AND PERFORMANCE** **(05 Hours)**
  Resistance to motion of vehicle, air, rolling and gradient resistances, acceleration, gradebility, traction, force estimation, reaction estimation, C.G. estimation.

- **TRANSMISSION SYSTEM AND DRIVE MECHANISMS OF AUTOMOTIVE VEHICLE** **(04 Hours)**
  Manual, Semi-automatic, Automatic, Hydraulic, Pneumatic, CVT's, differential, Flywheel, Torque, thrust, propeller shaft, joints (universal) Differential, axles, materials , bearing loads, rear wheel drive, front wheel drive, all-wheel drive.

- **CLUTCH** **(04 Hours)**
  Types and necessity, description and working, torque converters, Pedal Pressure, Centrifugal automatic,vacuum hydraulic operated clutch, Fluid transmission – advantages and disadvantages.

- **GEAR BOX** **(05 Hours)**
  Types and necessity, Sliding mesh, constant mesh, synchromech, epicyclic, Overdrives, Electric transmission –advantages and disadvantages.

- **BRAKES** **(05 Hours)**
  Types (drum and disc), response time and distances, braking efficiency, weight transfer during braking, shoe and disc brakes, brake power ratio, mechanical , hydraulic and power brakes. Layout and details of components, pedal and braking force estimation, Anti Braking System (ABS).

- **STEERING SYSTEMS** **(05 Hours)**
  Statically determinate beams, support reactions, relationship between load, shear force and bending moment, shear force and bending moment diagrams; theory of flexure for initially straight beams, distribution of bending stresses across the beam cross-section, principal stresses in beams; equation

of elastic curve for the loaded beam, relationship between bending moment, slope and deflection; calculation of deflection by integration, moment area and unit-load methods, S.E. in flexure.

- **SUSPENSION SYSTEMS** **(04 Hours)**
  Suspension system types, springs, material used, shackles and mounting, independent suspension system , torsion bar, tie rods, shock absorber – types, construction and working, vibration and riding comforts, suspension geometry (caster, camber, toe-in and toe-out, kingpin), anti squat, anti dive.

- **ELECTRICAL & ELECTRONICS EQUIPMENT** **(05 Hours)**
  Battery, Permanent Magnet & Electromagnet starting motors, magnetos, alternator and regulators, contact point ignition system, Electronic ignition systems, driver information & control devices power modulus, ECM, Dynamos, spark plugs, heaters, electrical systems of automotive vehicle, charging systems, sensors, actuators.

- **CHASSIS, WHEELS, TYRES - FUNCTIONS OF TYRES, TREAD DESIGN** **(02 Hours)**

(Total Lecture Hours: 42)

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3. Books Recommended:

1. W.H. Crouse, Automobile Mechanics, Tata McGraw Hill, New Delhi, 2007.
2. H. Heinz, Vehicle and Engine Technology, Arnold, London, 1999.
3. T.R. Banga and N. Singh, Automobile Engineering, Khanna Publishers, Delhi, 2005.
4. J. R. Ellis, Vehicle Dynamics, Wiley-Blackwell, 1994.
5. R. P. Sharma, Course in Automobile Engineering, Dhanpat Rai and Sons, New Delhi, 1998.

Surface Engineering and Heat Treatment

ME425

L	T	P	Credit
3	0	0	03

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1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Describe the importance of surface engineering and heat treatment.
CO2	Summarize concepts of various surface coating techniques.
CO3	Determine phase transformation mechanism during heat treatment.
CO4	Analyze various phases achieved through heat treatment and its significance
CO5	Distinguish heat treatment processes adopted for various ferrous and non-ferrous metals.
CO6	Express significance of various furnaces used for heat treatment.

2. Syllabus

- **INTRODUCTION TO SURFACE ENGINEERING** **(05 Hours)**
  Introduction to surface modification, need for surface modification, surface dependent engineering properties, importance of substrate and their pretreatment. Significance of surface engineered materials in modern engineering application. Industrial case studies describing surface failures.

- **SURFACE ENGINEERING PROCESSES** **(09 Hours)**
  Classification of surface engineering processes. Various chemical/thermochemical treatment processes, electro-deposition and electro-less deposition techniques, various vapour deposition techniques, various surfacing techniques. Evaluation of coatings, importance of process parameters, criteria for selection of surface engineering techniques, case studies based on coatings and surface modification of important engineering component.

- **PHASE TRANSFORMATION DURING HEAT TREATMENT** **(06 Hours)**
  Principle of heat treatment, variables of heat treatment, effect of heat treatment on various properties of materials. Recapitulation of phase diagram and TTT diagram. Phase transformation mechanism in steel during heat treatment, decomposition of austenite, transformation products of austenite: pearlite, bainite, martensite, etc., significance of retained austenite. Effect of heat treatment cycle on microstructure.

- **HEAT TREATMENT OF FERROUS ALLOYS** **(09 Hours)**
  Study of microstructural changes at various temperatures during slow cooling of steel. Influence of alloying elements on phase stability. Heat treatments for carbon steels, alloy steels, structural and tool steels, cast irons, etc. Hardenability of steels, effect of quenching media, PWHT. Surface treatment processes.

- **HEAT TREATMENT OF NON-FERROUS ALLOYS** **(07 Hours)**
  Principle of heat treatment for non-ferrous alloys. Heat treatment of aluminium alloys, magnesium alloys, copper and its alloys, nickel alloys and titanium alloys.

- **FURNACES AND OTHER ISSUES DURING HEAT TREATMENT** **(06 Hours)**
  Classification of heat treatment furnaces, controlled atmospheres for furnace. Industrial heat treatment practices. Distortion in heat treated components, possible defects, causes and remedies.

Air pollution during heat treatment, environmental and safety regulations. Energy economy of heat treatment.

(Total Lecture Hours: 42)

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3. Books Recommended:

1. T. Burakowski and T. Wierzchon, Surface Engineering of Metals: Principles, Equipment, Technologies, 1st Edition, CRC press, 1998.
2. M. Ohring, Material Science of Thin Films, 2nd Edition, Academic press, 2002.
3. J. Takadoum, Materials and Surface Engineering in Tribology, 1st Edition, John Wiley & Sons, 2008.
4. T. V. Rajan, C. P. Sharma and A. Sharma, Heat Treatment: Principles and Techniques, 2nd Edition, PHI Learning Pvt. Ltd., 2011.
5. R. C. Sharma, Principles of Heat Treatment of Steels, 1st Edition (Reprint), New Age International, 2018.

Production and Operations Management

ME427

L	T	P	Credit
3	0	0	03

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1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Develop an understanding of how the operations and processes have strategic importance and can provide a competitive advantage.
CO2	Evaluate and rank capacity and constraint management by solving the problems.
CO3	Evaluate and rank aggregate plan and schedule production by solving the problems.
CO4	Develop Material Requirement Planning (MRP) structure and apply various lot sizing techniques to the dependent inventory models.
CO5	Describe the concepts of lean, agile and quick response manufacturing and compare them.

2. Syllabus

- **OPERATIONS STRATEGY AND PROCESS STRATEGY** **(06 Hours)**

  Operations of goods and services, Developing Mission and strategy, Issues of operations strategy, Strategy development and implementation, Strategic planning, Core competency, Outsourcing, Design and selection of goods and services, Product development Product design issue, Process strategy, process analysis and design.

- **CAPACITY AND CONSTRAINT MANAGEMENT** **(07 Hours)**

  Capacity, Bottleneck analysis and theory, Break -Even Analysis (Single & Multiproduct), Risk Reduction, Capacity Decisions using Expected monetary value, investment analysis

- **AGGREGATE PLANNING** **(08 Hours)**

  Planning Process, Nature of Planning, Strategies, methods, Aggregate planning in services.

- **MATERIAL REQUIREMENT PLANNING AND ERP** **(08 Hours)**

  Dependent Demand, Dependent inventory model, Material Requirement Planning (MRP) structures, Management, Lot sizing techniques, Extension of MRP, MRP in-services

- **SHORT TERM SCHEDULING** **(08 Hours)**

  Issues, Scheduling process, Focused facilities, Loading jobs, Sequencing jobs, Finite capacity scheduling, Service scheduling

- **LEAN, AGILE AND QUICK RESPONSE MANUFACTURING** **(05 Hours)**

  Lean and Just-In-Time, Total Quality Management (TQM), Toyota production System, Lean organization, Lean in Services, Agility, Dimensions of agility, Quick response manufacturing, Manufacturing excellence, Total productive maintenance (TPM)

(Total Lecture Hours: 42)

3. Books Recommended:

1. J. Heizer, B. Render, C. Munson and A. Sachan, Operations Management, 12th Edition, Pearson Education, 2017.
2. Everett E. Adam, R. J. Ebert, Production and Operations Management: Concepts, Models and Behaviour, 4th Revised Edition, Prentice Hall, 1989.
3. E. S. Buffa and R. K. Sarin, Modern Production/ Operations Management, 8th Edition, John Wiley & Sons, 1987.
4. S.Eilon, Elements of Production Planning and Control, 3rd Edition, Universal Publishing Corporation, 1991.
5. L. J. Krajewski and L. P. Ritzman, Operations Management: Strategy and Analysis, 5th Edition, Pearson Education, 1999.

Fundamentals of Combustion

ME429

L	T	P	Credit
3	0	0	03

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1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Describe different combustion mechanisms and how these can be efficiently used in engineering applications.
CO2	Illustrate elementary chemical and physical processes of combustion phenomena
CO3	Describe combustion characteristics and how these can be measured.
CO4	Illustrate different type of pollutants generated by combustion, their effects on health and on the environment.
CO5	Explain basic concepts about combustion processes for efficient designing of burners for different types of fuels and combustion chambers.

2. Syllabus

- **INTRODUCTION** **(04 Hours)**
  Introduction to combustion, Applications of combustion, Types of fuel and oxidizers, Characterization of fuel, Various combustion mode, Scope of combustion.

- **THERMODYNAMICS OF COMBUSTION** **(08 Hours)**
  Thermodynamics properties, Laws of thermodynamics, Stoichiometry, Thermochemistry, adiabatic temperature, chemical equilibrium.

- **COMBUSTION KINETICS** **(08 Hours)**
  Basic Reaction Kinetics, Elementary reactions, Chain reactions, Multistep reactions, simplification of reaction mechanism, Global kinetics.

- **PHYSICS OF COMBUSTION** **(04 Hours)**
  Fundamental laws of transport phenomena, Conservations Equations.

- **PREMIXED FLAME** **(08 Hours)**
  Laminar premixed flame, laminar flame structure, Laminar flame speed, Flame speed measurements, Flame stabilizations.

- **DIFFUSION FLAME** **(08 Hours)**
  Gaseous Jet diffusion flame, Liquid fuel combustion, Atomization, introduction to Spray and Solid fuel combustion.

- **COMBUSTION AND ENVIRONMENT** **(02 Hours)**
  Atmosphere, Chemical Emission from combustion, Quantification of emission, Emission control methods.

(Total Lecture Hours: 42)

21/07/2020

3. Books Recommended:

1. K.K. Kuo, Principles of Combustion, John Wiley and Sons, 2005.
2. S.R. Turns, An introduction to combustion, New York: McGraw-Hill, 2017.
3. C.K. Law, Combustion physics, Cambridge University Press, 2010.
4. D.P. Mishra, Fundamentals of Combustion, Prentice Hall of India, 2010.
5. H. S. Mukunda, Understanding combustion, Universities Press, 2009.

21/05/2020

Renewable Energy Systems

ME431

L	T	P	Credit
3	0	0	03

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1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Design solar systems for a given energy utility by applying principles of solar energy conversion
CO2	Estimate the wind potential and perform power forecast analysis
CO3	Design bio-energy based systems for a given utility by applying principles of bio-mass to bio-energy conversion.
CO4	Characterize different types of waste and compare various conversion technologies.
CO5	Compare Hydrogen with other energy resources in present context

2. Syllabus

- **SOLAR RADIATION** **(12 Hours)**
  Extra-terrestrial and terrestrial, Solar radiation measuring instruments, Estimation of Solar Radiation, Various earth-sun angles. **Solar Energy Conversion Systems:** Solar Thermal Systems: Basics, Flat plate collectors-liquid and air type. Theory of flat plate collectors, selective coating, advanced collectors, Concentrators: optical design of concentrators, solar water heater, solar dryers, solar stills, Solar ponds, solar cooling and refrigeration, Solar thermal power generation. Solar Photovoltaic Systems: Principle of photovoltaic conversion of solar energy, Solar cells, Home lighting systems, Solar lanterns, Solar PV pumps, Govt. policies. Introduction to Solar Photovoltaic Thermal Systems: Air based, Water based, Refrigerant based Systems. Solar energy storage options: Electrical and Thermal Energy storage options for Solar Energy

- **BIOMASS & BIOENERGY** **(12 Hours)**
  Biogas System: Anaerobic digestion, biogas production, Types of digesters, installation, operation and maintenance of biogas plants, Biogas plant manure utilisation and manure values, factors affecting biogas production, Biogas utilisation and storage, biogas for motive power generation, design calculations for biogas plants, Govt. policies. **Liquid Biofuels:** Biodiesel – The mechanism of transesterification, fuel characteristics of biodiesel, technical aspects of biodiesel/Ethanol and other liquid fuels utilization in engine. **Biomass gasification:** Different types, power generation

- **WIND ENERGY CONVERSION SYSTEMS:** **(08 Hours)**
  History of wind energy, Current status and future prospects, Wind energy in India. Power available in the wind, Components of Wind Energy Conversion Systems, Horizontal and Vertical axis wind turbine, Wind turbine power and torque characteristics, Tip speed ratio, Wind speed prediction and forecasting, Betz limit, Govt. Policies

21/07/2020

WASTE TO ENERGY CONVERSION **(06 Hours)**
Introducing Municipal Solid Waste Management; Waste Generation and characterization, Waste

Processing Techniques; Source Reduction, Biological Conversion Products: Compost and Biogas, Incineration pyrolysis and Energy Recovery, waste plastic, RDF utilization, Govt. Policies

- **HYDROGEN ENERGY AND FUEL CELLS** **(04 Hours)**
  Benefits of Hydrogen Energy, Hydrogen Production Technologies, Hydrogen Energy Storage, Use of Hydrogen Energy, Advantages and Disadvantages of Hydrogen Energy, Problems Associated with Hydrogen Energy, Basic principle of working of fuel cell.

(Total Lecture Hours: 42)

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3. Books Recommended:

1. J. A. Duffie and W.A. Beckman, Solar Engineering and Thermal Processes, John Wiley and Sons., 2013.
2. G. N. Tiwari, Solar Energy, Narosa Publishing House Pvt. Ltd., 2012.
3. H. S. Mukunda, Understanding Clean Energy and fuels from biomass. Wiley India Pvt. Ltd, 2011
4. K. M. Mital, Biogas Systems, Principle and Applications. New Age International Ltd, 1996
5. G. D. Rai, Non-Conventional Energy Sources, Khanna Publication, 1988

21/05/2020

Mechanics of Composite Materials

ME433

L	T	P	Credit
3	0	0	03

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1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the composite materials and their constituents
CO2	Explain the mechanical properties and behaviour of composite materials
CO3	Apply constitutive equations of composite materials at micro and macro levels
CO4	Determine stresses and strains relation in composites materials
CO5	Apply failure criteria and critically evaluate the results

2. Syllabus

- **INTRODUCTION** **(04 Hours)**
  Introduction of composite materials, Need for composites, Types of composites, Metal matrix, Ceramic matrix and Carbon-Carbon composites, Polymer matrix composites.

- **COMPOSITE CONSTITUENT MATERIALS** **(05 Hours)**
  Characteristics of thermosetting and thermoplastic resins. Characteristics of Glass, Carbon and Kevlar Fibers, method of making and properties, types of fiber materials.

- **MICROMECHANICS OF UNIDIRECTIONAL FIBER COMPOSITES** **(10 Hours)**
  Prediction of elastic properties using strength of materials approach. Introduction to elasticity based approach for prediction of elastic constants (concentric cylinder model). Empirical relations (Halpin-Tsai) for elastic property prediction. Comparison of different approaches with examples. Prediction of strength and discussion on failure modes, Prediction of thermal and diffusion properties.

- **SHORT FIBERCOMPOSITES** **(03 Hours)**
  Load transfer length, Prediction of elastic properties. Elastic property calculation for random fiber composites.

- **ANALYSIS OF ORTHOTROPIC LAMINA** **(10 Hours)**
  Generalized Hooke's law, Material symmetry. Orthotropic materials and transversely isotropic materials. Transformation of stress and strain. Stress-strain relations for transversely isotropic lamina under plane stress in material axis and off axis Failure theories (Maximum stress, strain, Tsai-Hill and Tsai-Wu).

- **ANALYSIS OF LAMINATED COMPOSITES** **(10 Hours)**
  Description of laminate sequence and type of laminates (UD, Symmetric and Asymmetric, Balanced, Quasi-Isotropic) etc. Classical laminate theory (CLT). Failure analysis of laminates using CLT: First ply failure, progressive failure analysis. Hygro-thermal stresses in laminates. Discussion on interlaminar stresses.

(Total Lecture Hours: 42)

3. Books Recommended:

1. K. K Autar, Mechanics of Composite Materials, 2nd Edition, CRC Press, 2006.
2. J. N. Reddy, Mechanics of laminated composite plates and shells theory and analysis, 2nd Edition, CRC press, 2003.
3. R. M. Jones, Mechanics of composite materials, 2nd Edition, Taylor and Fransis, 2018.
4. K. Serope, S. Steven, Manufacturing engineering and technology, 8th edition, Pearson, 2019.
5. P. K. Mallick, Fiber-reinforced composites: Materials, Manufacturing, and Design, 3rd Edition, CRC Press, 2007.

Gas Dynamics

ME435

L	T	P	Credit
3	0	0	03

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1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Predict the effect of compressibility and flow behavior in the field of gas dynamics
CO2	Solve 1-D design problems based on Isentropic, Fanno and Rayleigh flow
CO3	Evaluate the different possible conditions for flow without chocking in 1-D duct with variable area, friction and heat transfer.
CO4	Estimate the position and effect of shock within the 1-D duct.
CO5	Explore the shock phenomenon and learn to use shock polar diagram for 2-D flows.

2. Syllabus

- **INTRODUCTION** **(04 Hours)**
  Thermodynamics of compressible flow, Perfect Gas, General effect of compressibility, Wave Motion, Propagation of Infinitesimal waves, Mach number, Pressure disturbances in a Compressible flow, Stagnation condition.

- **1-DIMENSIONAL, STEADY, ISENTROPIC FLOW IN VARIABLE AREA PASSAGES** **(09 Hours)**
  Introduction, governing equations, Effect of area change in the fluid properties, Equations for Isentropic flow, Maximum mass flow rate, Flow through nozzle & diffuser, Numerical.

- **FLOW IN CONSTANT AREA DUCT WITH FRICTION** **(06 Hours)**
  Introduction, governing equations, Fanno flow equations, Variation of Mach number with duct length, Numerical.

- **FLOW IN CONSTANT AREA DUCT WITH HEAT TRANSFER** **(06 Hours)**
  Introduction, governing equations, Slope of Rayleigh line on p-v diagram, Fundamental equation of Rayleigh line, Maximum heat transfer, Numerical

- **NORMAL SHOCK** **(10 Hours)**
  Introduction, classification of shock, Physical equations of Normal shock, Rankine – Hugoniot Relations, Prandtle equation, Numerical

- **OBLIQUE SHOCK** **(07 Hours)**
  Introduction, governing equations, Rankine–Hugoniot Relations, Prandtle Equations, θ-β-M relation, Shock polar diagram & Hodograph method for the solution of 2- D flows.

(Total Lecture Hours: 42)

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3. Books Recommended:

1. S.M. Yahya, Fundamental of Compressible Flow with Aircraft & Rocket Propulsion, New Age International Ltd., 2016
2. E. Rathakrishnan, Gas Dynamics, PHI Learning Pvt. Ltd., 2017
3. A. H. Shapiro, Compressible Fluid Dlow, Ronald Press Company, 1953
4. M. J Zucrow and J.D. Hoffman, Gas Dynamics, John Wiley & Sons, 1976
5. R. D. Zucker and Oscar Biblarz, Fundamental of Gas Dynamics, Wiley, 2002

Fatigue, Fracture and Failure Analysis

ME437

L	T	P	Credit
3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the principles of fatigue analysis and fracture mechanics
CO2	Explain the S-N curve with respect to mean stress, material surface effect and performance fatigue life analysis
CO3	Describe the behaviour of ductile and brittle failure
CO4	Calculate fracture parameter and analyze crack propagation
CO5	Evaluate stress intensity factor by various methods

2. Syllabus

- **INTRODUCTION AND MECHANISM OF FATIGUE** **(08 Hours)**
  Fatigue limit, relation between static strength and fatigue strength. Different approaches to fatigue, Stress-life approach (S-N curves), Variable Amplitude Loading, Applications, Environmental effects.

- **THEORY OF ELASTICITY AND PLASTICITY** **(08 Hours)**
  Notion of stress and strain, Principal Stresses and Principal Coordinates, Maximum shearing Stress, Stress tensors, Compatibility equations, Generalized Hoke's Law, General formulation of elastic problem, Tresca's and von-Mises' Yield Criteria

- **FRACTURE MECHANICS** **(06 Hours)**
  Introduction to fracture mechanics, fracture modes, Griffith's Fracture Criterion and Irwin's Fracture Criterion, Linear elastic fracture mechanics (LEFM)

- **METHODS FOR EVALUATING STRESS INTENSITY FACTORS** **(10 Hours)**
  Analytical Solutions- Exact Solutions, Energy approach, Green's function. Semi-Analytical Solutions- Collocations, Conformal mapping. Numerical Methods- Finite element method (FEM), Finite difference method (FDM), Extended finite element method (XFEM). Experimental Methods- Compliance method, Photo elasticity, Interferometry and Holography.

- **INTRODUCTION TO FAILURE** **(06 Hours)**
  Philosophy and criteria of material selection, Importance of failure analysis and its relationship to material selection, different types of failures, Fundamental causes of failure, General practice in failure analysis, ductile brittle and fatigue failure.

- **CRACK PROPAGATION AND ANALYSIS** **(04 Hours)**
  The Crack tip Plastic Zone, Methods for Measuring Fracture Toughness, Crack Initiation and Crack Propagation under different loading conditions.

(Total Lecture Hours: 42)

3. Books Recommended:

1. S.P Timoshenko and J.N Goodier, Theory of Elasticity, 3rd Edition, McGraw Hill, 2017.
2. R.B Charlie and A Chaudhary, Failure Analysis of Engineering Materials, McGraw Hill, New York, 2001.
3. K Hellan, Introduction to Fracture Mechanics, McGraw-Hill, 1984.
4. S Mohammadi, Extended finite element method, 1st Edition, Blackwell, 2007.
5. P Kumar, Elements of fracture mechanics, Tata McGraw Hill, New Delhi, 2017.

21/07/2020

Smart Materials and Structures

ME439

L	T	P	Credit
3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the basic principles of smart materials.
CO2	Explain various actuators and sensors in smart structures.
CO3	Analyse smart composites.
CO4	Explain signal processing and control systems.
CO5	Describe the utilization of smart materials in engineering applications.

2. Syllabus

- **INTRODUCTION:** **(12 Hours)**
  Introduction to Smart Materials and Structures, Principles of Piezoelectricty, Single Crystals and Polycrystalline, Piezoelectric Polymers, Magnetostrictive materials, Electro-active Materials, Electronic Materials, Electro-active Polymers, Ionic Polymer Matrix Composite (IPMC), Shape Memory Effect, Shape Memory Alloys, Shape Memory Polymers, Electro-rheological Fluids, Magneto Rhelological Fluids.

- **SENSING AND ACTUATION:** **(10 Hours)**
  Piezoelctric Sensors and actuators, Accelerometers, Active Fibre Sensing, Magnetostrictive Sensing, Shape Memory Actuators, Application of Smart Sensors and actuators for Structural Health Monitoring (SHM), Closed loop and Open loop Smart Structures, Active Vibration Control, Active Shape Control, Passive Vibration Control, Hybrid Vibration Control.

- **SMART COMPOSITES:** **(08 Hours)**
  Review of Composite Materials, Micro and Macro-mechanics, Modelling Laminated Composites based on Classical Laminated Plate Theory, Effect of Shear Deformation, Dynamics of Smart Composite Beam, Governing Equation of Motion and Finite Element Modelling of Smart Composite Beams.

- **SIGNAL PROCESSING AND CONTROL SYSTEMS:** **(08 Hours)**
  Data Acquisition and Processing – Signal Processing and Control for Smart Structures – Sensors as Geometrical Processors – Signal Processing – Control System.

- **ADVANCES IN SMART STRUCTURES AND MATERIALS:** **(04 Hours)**
  Self-Sensing Piezoelectric Transducers, Energy Harvesting Materials, Autophagous Materials, Self- Healing Polymers, Intelligent System Design, Emergent System Design.

(Total Lecture Hours: 42)

3. Books Recommended:

1. A.V. Srinivasan, Smart Structures –Analysis and Design, 1st Edition, Cambridge University Press, New York, 2001
2. M. V. Gandhi and B. S. Thompson, Smart Materials and Structures, Chapmen & Hall, London, 1992.
3. C. Brian, Smart Structures and Materials, Artech House, 2000
4. P. Gauenzi, Smart Structures, Wiley, 2009
5. W. G. Cady, Piezoelectricity, Dover Publication, New York, 2014.

21/05/2020

Teaching Scheme: B. Tech. (Mechanical Engineering) IV Year

SEMESTER - VIII

Sr. No.	Subject	Code	Scheme	Exam Scheme				Total	Credit
				Theory		Tuto.	Pract.		
				Hrs.	Marks	Marks	Marks		
1.	Core Elective – 5	ME4XX	3 – 0 – 0	3	100	-	-	100	03
2.	Core Elective - 6	ME4YY	3 – 0 – 0	3	100	-	-	100	03
3.	Core Elective - 7	ME4ZZ	3 – 0 – 0	3	100	-	-	100	03
4.	Innovation, Incubation and Entrepreneurship	HU410	3 – 0 – 0	3	100	-	-	100	03
5.	Project	ME402	0 – 0 – 12	0	-	-	300	300	06
		Total	12 – 0 – 12	12	400	-	300	700	18

Core Elective – 5 (ME4XX)

1. Design of Heat Exchanger: ME422
2. Design of Pressure Vessels: ME424
3. Radiation Heat Transfer: ME426
4. Theory of Elasticity and Plasticity: ME428
5. Sheet Metal Forming: ME432
6. Total Quality Management: ME434

Core Elective – 6 (ME4YY)

1. Jet Propulsion Systems: ME436
2. Robotics: ME438
3. Experimental Fluid Mechanics: ME442
4. Data Analytics: ME444
5. Advanced Welding Processes: ME446

Core Elective – 7 (ME4ZZ)

1. Automation and Smart Manufacturing: ME448
2. Theory and Analysis of Cryogenic Systems: ME452
3. Computer Aided Machine Design: ME454
4. Foundry Technology: ME456
5. Logistics and Supply Chain: ME458
6. Two Phase Flow: ME462

21/07/2020

Design of Heat Exchangers

ME422

L	T	P	Credit
3	0	0	03

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1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the different types of heat exchangers used in applications.
CO2	Analyze heat exchanger based on LMTD and e-NTU method
CO3	Develop mathematical model for double pipe and Shell and tube type heat exchanger
CO4	Solve the sizing problem of Shell and tube type heat exchanger
CO5	Develop and solve mathematical model for tube finned and plate finned heat exchanger
CO6	Analyze the radiation furnace using well stirred model and longitudinal model.

2. Syllabus

- **INTRODUCTION** **(08 Hours)**
  Classification of heat exchanger, selection of heat exchanger, overall heat transfer coefficient, LMTD method for heat exchanger analysis for parallel, counter, multi-pass and cross flow heat exchanger, e-NTU method for heat exchanger analysis, fouling, cleanliness factor, percent over surface, techniques to control fouling, additives, rating and sizing problems, heat exchanger design methodology

- **DESIGN OF DOUBLE PIPE HEAT EXCHANGERS** **(10 Hours)**
  Thermal and hydraulic design of inner tube and annulus, total pressure drop, Tube – Side heat transfer and pressure loss calculations

- **DESIGN OF SHELL & TUBE HEAT EXCHANGERS:** **(10 Hours)**
  Basic components, basic design procedure of heat exchanger, approximate sizing of shell & tube heat exchangers, shell – side and tube – side calculations. Design procedure for plain and finned tubes, TEMA code, J-factors, conventional design methods, Bell-Delaware method.

- **DESIGN OF COMPACT HEAT EXCHANGERS AND REGENERATORS** **(08 Hours)**
  Heat transfer enhancement, plate fin heat exchanger, tube fin heat exchanger, heat transfer and pressure drop, Types of regenerator matrix. Design of coils. Design of automobile radiator.

- **DESIGN OF RADIATION FURNACES** **(03 Hours)**
  Well stirred model and longitudinal model.

- **FOULING MECHANISMS** **(03 Hours)**

(Total Lecture Hours: 42)

21/07/2020

3. Books Recommended

1. R. K. Shah and D. P. Sekulic, Fundamentals of Heat Exchangers Design, John Wiley & Sons, 2003.
2. S. Kakaç, H. Liu, A. Pramuanjaroenkij, Heat Exchangers: Selection, Rating, and Thermal Design, Third Edition, CRC Press, 2012.
3. W. M. Kays and A. L. London, Compact Heat Exchangers, McGraw Hill, New York, 1964.
4. Saunders E.A.D., Heat Exchangers - Selection, Design and Construction, Longman Scientific & Technical, 1998.
5. J.E. Hesselgreaves, R.Law, D. Reay, Compact Heat Exchangers, Selection, Design and Operation, 2nd Edition, Butterworth-Heinemann, 2016

21/05/2020

Design of Pressure Vessels

ME424

L	T	P	Credit
3	0	0	03

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1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Describe the factors influencing the design of pressure vessels
CO2	Analyze stresses in pressure vessels
CO3	Describe requirements of the relevant industry standards in the design of pressure vessels.
CO4	Design and select heads, covers nozzles, openings and supports of pressure vessels
CO5	Analyse buckling of pressure vessels

2. Syllabus

- **INTRODUCTION** **(07 Hours)**
  Factors influencing the design of vessels, Classification of pressure vessels, material selection, loads & types of failures.

- **STRESSES IN PRESSURE VESSELS** **(13 Hours)**
  Stresses in circular ring, cylinder & sphere, membrane stresses in vessels under internal pressure, thick Cylinders, Shrink-Fit stresses, Autofrettage of thick cylinders, thermal stresses.

- **DESIGN OF HEADS AND COVERS** **(05 Hours)**
  Introduction, Design for hemispherical head, ellipsoidal head, torispherical head, conical and toriconical head, flat heads and covers.

- **DESIGN OF NOZZLES AND OPENINGS** **(05 Hours)**
  Introduction, stress concentration about a circular hole, cylindrical and spherical shell with circular hole under internal pressure, nozzles in pressure vessels.

- **SUPPORTS FOR VERTICAL & HORIZONTAL VESSELS** **(05 Hours)**
  Design lugs support, Skirt support and saddle supports.

- **BUCKLING OF VESSELS** **(07 Hours)**
  Buckling phenomenon – Elastic Buckling of circular ring and cylinders under external pressure – collapse of thick walled cylinders or tubes under external pressure – Effect of supports on Elastic Buckling of Cylinders – Buckling under combined External pressure and axial loading.

(Total Lecture Hours: 42)

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3. Books Recommended:

1. M.V. Joshi and V.V Mahajan, Process Equipment Design, McMillan, India, 1996.
2. J.F. Harvey, Theory and Design of Pressure Vessels, 1st edition, CBS, 2001.

3. K. P. Singh and A. L. Soler, Mechanical Design of Heat Exchangers, Arcturus Publishers, New Jersey, 1984.
4. Moss Demis R.,Pressure Vessel Design Manual, Gulf Publishing Co., Houston, 1987.
5. IS 2825: 1969, Code for Unfired Pressure Vessels.

21\07\2020

Radiation Heat Transfer

L	T	P	Credit
3	0	0	03

ME426

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1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Describe the basic laws of radiation heat transfer
CO2	Calculate radiation heat transfer between black and gray body surfaces
CO3	Develop solutions for surface-to-surface radiation heat transfer
CO4	Analyse problems involving gas radiation heat transfer
CO5	Develop solutions for radiation transfer in participating media
CO6	Develop solutions to estimate radiation parameters using inverse method

2. Syllabus

- **RADIATION** **(02 Hours)**
  Importance of thermal radiation, Nature of Radiation.

- **BLACKBODY AND ITS CHARACTERISTICS** **(07 Hours)**
  Key attributes of a black body, Solid angle, Spectral or Monochromatic radiation intensity, Spectral hemispherical emissive power, Radiation pressure and radiation energy density, Relationship between intensity and temperature, Candidate blackbody distribution function, Planck's blackbody radiation distribution function, Wein's displacement law, universal blackbody function, Problems.

- **RADIATIVE PROPERTIES OF NON-BLACK SURFACES** **(08 Hours)**
  Why do we need a gray body model?, Spectral directional emissivity, Hemispherical spectral emissivity, Directional total emissivity, Hemispherical total emissivity, Kirchoff law, Absorptivity, Spectral directional absorptivity, Directional total absorptivity, Hemispherical total absorptivity, Reflectivity, Transmissivity, Spectral transmissivity, Optical pyrometry, Problems.

- **RADIATIVE HEAT TRANSFER BETWEEN SURFACES** **(10 Hours)**
  Enclosure theory, View factor, View factor algebra, View factors from direct integration, Enclosure analysis – Gray surface, Enclosure analysis – Non gray surface, Problems.

- **RADIATION IN PARTICIPATING MEDIA** **(10 Hours)**
  Principal difficulties in studying gas radiation, Important properties fir study of gas radiation, Equation of transfer or Radiative transfer equation, Solution to the Radiative transfer equation, Concept of mean beam length, Enclosure analysis in the presence of absorbing/emitting gas, Emissivity and absorptivity of gas mixture, Radiation Combined with Conduction and Convection, Problems.

- **INVERSE PROBLEMS IN RADIATION** **(05 Hours)**
  Introduction to inverse problems, Parameter estimation by least squares minimizations, Problems.

(Total Lecture Hours: 42)

21\07

3. Books Recommended:

1. R. Siegel and J.R. Howell, Thermal Radiation Heat Transfer, Taylor & Francis, 2015.
2. M.F. Modest, Radiative Heat Transfer, McGraw Hill, 2013.
3. C. Balaji, Essentials of Radiation Heat Transfer. John Wiley & Sons, 2014.
4. M.N. Ozisik, Inverse Heat Transfer: Fundamentals and Applications. CRC Press, 2000.
5. F.P. Incropera, A.S. Lavine, T.L. Bergman, and D.P. DeWitt, Fundamentals of Heat And Mass Transfer. John Wiley & Sons Inc., 2011

21\07

Theory of Elasticity and Plasticity

L	T	P	Credit
3	0	0	03

ME428

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1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Examine the theoretical concepts and principles underlying elasticity and plasticity.
CO2	Apply concept of material yielding and plastic behaviour to solve engineering problems.
CO3	Explain stress-strain relations in elastic and plastic deformation
CO4	Explain load instability and tearing in sheet metal forming.
CO5	Describe slip - line field theory in plastic deformation.

2. Syllabus

- **Stress & Strain Analysis** **(08 Hours)**
  Introduction, Definition of stress & strain, Stress & Strain Tensor, Principal Stresses & Strains, Stress & Strain invariants, Stress & Strain Deviator Tensor, for state of stress and state of strain, generalized Hooke's law, Hooke's law for isotropic and homogeneous materials, plane stress and plane strain.

- **Yield Criteria** **(06 Hours)**
  Criteria for yielding – Tresca criterion, Von mises Criterion, Effective stress -strain.

- **Plastic Stress - Strain Relationships** **(12 Hours)**
  Stress - strain relation in plasticity, State of plastic stress - strain rate, Strain rate sensitivity, plastic Anisotropy, stress - stain relations for strain hardening metals, Saint Venant's theory of plastic flow, Levy-Mises (flow rule), Prandtl - Reuss Theory of elastic and plastic deformation

- **Load instability and Tearing** **(10 Hours)**
  Uniaxial tension of a perfect strip, Tension of an imperfect strip, Tensile instability in stretching continuous sheet - condition for local necking in uniaxial and biaxial tension.

- **Slip - Line Field Theory** **(06 Hours)**
  Slip line theory, Hencky's theory of small plastic deformation plasticity conditions, Velocity Equations, Geometry of Slip-line, Geometrical Construction of Slip-line fields, Upper and Lower Bounds, Slip Line Characteristics, Hodograph.

(Total Lecture Hours: 42)

21/07/2020

3. **Books Recommended:**

1. R. Hill, The Mathematical Theory of Plasticity, Oxford University Press, London, 2004.
2. S. J. Hu, Z. Marciniak, J. L. Duncan, Mechanics of Sheet Metal Forming, Butterworth-Heinemann, 2002.
3. S. Singh, Theory of Elasticity, Khanna Publishers, New Delhi, 2000.
4. U. C. Jindal, Experimental Stress Analysis, Pearson Education India, 2012.
5. H. Jane Helena, Theory of Elasticity and Plasticity, PHI, 2017

21/07/2020

Sheet Metal Forming

L	T	P	Credit
3	0	0	03

ME432

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1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the concept of material yielding and plastic behaviour of sheet.
CO2	Explain the significance of intrinsic material properties used in the sheet metal forming..
CO3	Examine an insight of the sheet deformation processes, load instability and tearing in sheet metal forming.
CO4	Classify various modes of deformation and defects involved in sheet metal forming Processes.
CO5	Analyse principles, capabilities and applications of sheet metal forming processes.
CO6	Evaluate the formability criteria for sheet metal component manufacturing.

2. Syllabus

- **FUNDAMENTALS OF METAL FORMING** **(03 Hours)**

  Introduction, Advantages of metal forming, cold and hot forming, various metal forming processes, Uniaxial Tensile Test - load–extension diagram, engineering stress–strain curve, true stress–strain curve, Anisotropy, Rate sensitivity, Effect of properties on forming.

- **BIAXIAL STRESS TESTING METHODS FOR SHEET METALS** **(03 Hours)**

  Introduction, Geometry of cruciform specimen, method of strain measurement, Biaxial stress strain curve, measurement of yield locus, factors affecting the maximum equivalent plastic strain applicable to gauge area, case studies.

- **SHEET DEFORMATION PROCESSES (PLANE STRESS)** **(09 Hours)**

  Deformation in uniaxial tension, stress and strain ratios, theory of yielding in plain stress condition - Maximum shear stress, Hydrostatic stress, Tresca yield condition, Von Mises yield condition, Levy–Mises flow rule, Relation between the stress and strain ratios,. Work of plastic deformation, Work hardening hypothesis, Effective stress and strain functions, Concept of Formability, formability limits and formability diagram. Factors affecting the forming limit curve.

- **LOAD INSTABILITY AND TEARING** **(10 Hours)**

  Uniaxial tension of a perfect strip, Tension of an imperfect strip, Tensile instability in stretching continuous sheet - condition for local necking in uniaxial and biaxial tension.

- **ANALYSIS OF STAMPING AND DEEP DRAWING PROCESS** **(06 Hours)**

  Two-dimensional model of stamping, stretch and draw ratios in a stamping, three-dimensional stamping model, limiting drawing ratio and anisotropy, effect of strain-hardening and friction on drawing stress, redrawing and reverse redrawing of a cylindrical cup, wall ironing of deep-drawn cups, estimation of drawing force.

- **ANALYSIS OF BENDING PROCESS** **(04 Hours)**

  Strain distribution in bending, bending without tension, bending of sheet in v-die, determination of work load, stock length and punch angle, springback and reverse bending, bending line construction.

- **ANALYSIS OF PUNCHING AND BLANKING PROCESS** **(03 Hours)**

  Mode of metal deformation and failure, deformation model and fracture analysis, determination of working force.

- **ANALYSIS OF SHEET HYDROFORMING** **(04 Hours)**

  Free expansion of a cylinder by internal pressure, Forming a cylinder to a square section, Tube forming in a frictionless die, Tube forming with sticking friction (or very high friction), Constant thickness forming, sequential hydroforming

(Total Lecture Hours: 42)

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3. Books Recommended:

1. R. Hill, The Mathematical Theory of Plasticity, Oxford University Press, London, 2004.
2. S.J. Hu, Marciniak Z., J.L. Duncan, Mechanics of Sheet Metal Forming, Butterworth-Heinemann, 2002.
3. G. Schuler, Metal forming handbook, Springer Verlag Berlin, Heidelberg, 1998.
4. S.P. Timoshenko, Theory of Elasticity, McGraw Hill, 2017.
5. A. Ghosh and A. K. Malik, Manufacturing Science, East-West Press Pvt Ltd, 2010.

Total Quality Management

ME434

L	T	P	Credit
3	0	0	03

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1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Develop an understanding of quality concepts and total quality management and to examine the prominent philosophies such as those of Deming and Juran.
CO2	Identify the key aspects of the quality improvement cycle and to select and use appropriate tools and techniques for controlling, improving and measuring quality.
CO3	Explain the cost of quality and concept of quality circle.
CO4	Explain the basic frameworks for quality and performance such as ISO certifications, Total Quality Management (TQM), and six sigma.
CO5	Review and summarize the case studies of organizations in the manufacturing, service and education industries.

2. Syllabus

- **QUALITY CONCEPTS AND TOTAL QUALITY MANAGEMENT (TQM) (10 Hours)**

  Quality concepts & Quality management philosophies, TQM linkages with productivity - factors affecting quality & productivity, Quality – Productivity Determinant model, Traditional versus modern quality management, principles of Total Quality (TQ). Concepts, features and element of TQM, TQM versus traditional management practices, Models of TQM, TQM implementation – Strategic framework and Roadblocks. Philosophies of Quality Gurus

- **QUALITY TOOLS (04 Hours)**

  Seven basic (Fishbone Diagrams, Histograms, Pareto Analysis, Flowcharts, Scatter Plots and Run Charts) quality tools. Seven new quality tools (Affinity Diagrams, Relations Diagrams, Tree Diagrams, Matrix Diagrams, Arrow Diagrams, Process Decision Program Charts, Matrix Data Analysis)

- **QUALITY COST AND QUALITY CIRCLE (04 Hours)**

  Costs of quality (COQ), Juran's model of optimum quality costs, analysis of COQ for improvement, Quality Circle Philosophy, its structure, implementation & operation, Brainstorming – field of application, Types of Brainstorming, 5 – M checklists.

- **TOTAL ORGANIZATIONAL INVOLVEMENT AND TOTAL PRODUCTIVE MAINTENANCE (04 Hours)**

  Total employees involvement (TEI), Effective communications, training & mentoring, recognition & reward, feedback & performance appraisal competencies required for different managerial roles, techniques of TEI, reward, techniques of zero defects programme, Features of TPM, Causes of machine failures, types of maintenance, overall equipment effectiveness (OEE), Case studies

- **QUALITY FUNCTION DEPLOYMENT** **(03 Hours)**

  Voice of Customer (VOC), House of Quality, QFD methodology, Case studies

- **5 - S OF HOUSEKEEPING** **(03 Hours)**

  Seiri, Seiton, Seiso, Seiketsu and Shjitsuke, Audit of 5 - S (Auditor's checklist and Display of 5 - S status), Case studies

- **KAIZEN PDCA CYCLE AND POKA YOKE** **(05 Hours)**

  Kaizen versus innovation, The seven wastes, Techniques of Kaizen, kaizen implementation, Techniques, Pillars and working principles of Poka yoke, Case studies

- **SIX SIGMA AND PROCESS CAPABILITY ANALYSIS** **(05 Hours)**

  Methodology of Six Sigma -- DMAIC, Statistics associated with Six Sigma, Determination of First – time yield (FTY) of process, Z value, Defects per unit (DPU), Defects per million opportunities (DPMO) and calculating of sigma value of the process, Process capability index, upper and lower capability indices, The CpK index, capability ratio, the Taguchi capability index etc.

- **QUALITY CERTIFICATIONS AND QUALITY AWARDS** **(02 Hours)**

  ISO 9000 series and QS 9000 series certification, ISO 9000 series of standards, ISO 9001 requirements Implementation, Documentation, Internal Audits, Registration.

- **FAILURE MODE & EFFECT ANALYSIS** **(02 Hours)**

  Design and Process FMEA, Case studies

(Total Lecture Hours: 42)

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3. Books Recommended:

1. P. N. Mukherjee, Total Quality Management, 1st Edition, Prentice Hall India Learning Private Limited, 2006
2. P. M. Charantimath, Total Quality Management, 1st Edition, Pearson Education, 2003.
3. L. Suganthi and A. A. Samuel, Total Quality Management, New title edition, Prentice Hall India Learning Private Limited, 2004.
4. S. Ramasamy, Total Quality Management, 1st Edition, Tata Mcgraw Hill Publishing Co Ltd, 2015.
5. J. R. Evans and W. M. Lindsay, 6th Edition, The Management and Control of Quality, South-Western College Publication, 2004.

21/08/2020

Jet Propulsion Systems

L	T	P	Credit
3	0	0	03

ME436

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1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explore various components of gas turbine cycles with basic cycle variations for application in jet propulsion systems
CO2	Analyze the thermodynamics and performance parameter of jet propulsion systems.
CO3	Illustrate ideal and actual air breathing gas turbine cycles with performance curves
CO4	Evaluate fluid flow properties for different performance parameters
CO5	Explore rocket propulsion theory and discuss types of chemical rockets

2. Syllabus

- **INTRODUCTION & OVERVIEW** **(6 Hours)**
  Introduction of Gas Turbine cycle and various components of GTP, Introduction of Jet propulsion systems, Computation of stagnation properties, Basic components of air breathing engines, Inlet ducts for aircraft gas turbines, Brief idea about compressor, combustion chamber, turbine, and aircraft nozzles.

- **AIR BREATHING ENGINES** **(12 Hours)**
  Performance parameters for air breathing engine (Thrust, Efficiency, Aircraft Range, Take-off Thrust, Specific Fuel Consumption), Basic gas generator & its variations, Turbojet, Turboprop, Turbofan, Pulse jet, Ram jet, Scramjet, Thrust Augmentation

- **PARAMETRIC CYCLE ANALYSIS OF IDEAL AND ACTUAL AIR BREATHING GAS TURBINE ENGINES** **(16 Hours)**
  Parametric Cycle Analysis of Ideal Turbo Jet Engine, Real Turbojet Cycle, Analysis of Turbofan Engine, Analysis of Turbofan Engine, Analysis of Turboprop Engine, Ramjet & Scramjet Engine, Numerical

- **INTRODUCTION TO ROCKET PROPULSION** **(8 Hours)**
  Introduction, Rocket propulsion theory, Chemical Rockets (Solid Rockets, Liquid Rockets, Solid & Liquid Propellants, Propellant feed system

(Total Lecture Hours: 42)

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3. Books Recommended:

1. M. S. Ramgir and M. J. Sable, Gas Turbine & Jet propulsion, Technical Publications, 2006.
2. J. D. Mattingly, Elements of Propulsion: Gas Turbines & Rockets, the American Institute of Aeronautics and Astronautics, 2006.
3. V. Ganeshan, Gas Turbines, Tata McGraw Hill Education Pvt. Ltd, 2010.
4. S. M. Yahya, Fundamentals of Compressible flow, New Age International Publishers, 2005.
5. G. P. Sutton and O. Biblarz, Rocket Propulsion Elements, John Wiley & Sons, Inc., 2016.

Robotics

ME438

L	T	P	Credit
3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the concept of robot arm kinematics.
CO2	Apply the concept of robot arm dynamics.
CO3	Analyze manipulator trajectories and robot end effectors.
CO4	Describe the control of robot manipulators
CO5	Analyze sensors and vision systems in robot.

2. Syllabus

- **INTRODUCTION** **(03 Hours)**
  Background, Historical development, Robot arm kinematics & dynamics, Manipulator trajectory planning & motion control, Robot sensing, Robot programming language, Machine intelligence.

- **ROBOT ARM KINEMATICS** **(07 Hours)**
  Introduction, The direct kinematics problem, The inverse kinematics problems and their solutions.

- **ROBOT ARM DYNAMICS** **(07 Hours)**
  Introduction, Lagrange-Euler formulation, Newton-Euler formulation, Generalized D'Alembert equations of motion.

- **MANIPULATOR TRAJECTORIES** **(05 Hours)**
  Introduction, General considerations in trajectory planning, Joint interpolated trajectories, Planning of manipulator trajectories.

- **CONTROL OF ROBOT MANIPULATORS** **(06 Hours)**
  Introduction, Control of robot arm, Computed torque technique, Near minimum time control, Variable structure control, Nonlinear decoupled feedback control, Resolved motion control, Adaptive control.

- **ROBOT END EFFECTORS** **(04 Hours)**
  Types of end effectors, Types of grippers, Tools as end effectors, Robot-End effecter Interface, Gripper selection & design.

- **SENSORS IN ROBOTICS** **(04 Hours)**
  Introduction, Transducers & sensors, Sensors in robotics, Range sensing, Proximity sensors, Touch sensors, Tactile sensors, Force & torque sensor, Misc. sensors & sensor based system.

- **ROBOT VISION SYSTEMS** **(04 Hours)**
  Introduction, Low level, medium level and high level vision, Image acquisition, Illumination technique, Imaging geometry, Preprocessing, Relationship between pixels.

- **ROBOT PROGRAMMING LANGUAGES** **(02 Hours)**
Introduction, Characteristics of robot level languages, Characteristics of task level languages.

(Total Lecture Hours: 42)

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3. Books Recommended:

1. A. Ghosal, Robotics: Fundamental Concepts and Analysis, 1st Edition, Oxford University Press, 2006.
2. K.S. Fu, R.C. Gonzalez, C.S.G. Lee, Robotics: Control, Sensing, Vision, and Intelligence, 1st Edition, McGraw-Hill, 2008.
3. J. J. Craig, Introduction to Robotics: Mechanics and Control, 4th Edition, Pearson, 2018.
4. S. K. Saha, Introduction to Robotics, 2nd Edition, McGraw-Hill, 2015.
5. N. Odrey, M. Weiss, M. Groover, R. N. Nagel, A. Dutta, Industrial Robotics: Technology, Programming and Applications, 2nd Edition, McGraw-Hill, 2012.

21/07/2020

Experimental Fluid Mechanics

ME442

L	T	P	Credit
3	0	0	03

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1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the need of experiments in fluid mechanics
CO2	Explain the concepts and methods of various measurements techniques in fluid mechanics
CO3	Explore different analysis techniques commonly used in experimental work
CO4	Explore modern experimental techniques in fluid mechanics
CO5	Interpret experimental data in fluid mechanics

2. Syllabus

- **INTRODUCTION** **(04 Hours)**
  Need of Experiments, Model making, non-dimensional parameters.

- **WIND TUNNELS** **(08 Hours)**
  Low Speed wind tunnel, Losses in wind tunnel Circuit, High Speed/ supersonic wind tunnels, Shock tubes, Hypersonic facilities.

- **MEASUREMENT OF MATERIAL PROPERTIES** **(10 Hours)**
  Density, Surface tension, Contact Angle, Viscosity, Thermal conductivity, Thermal diffusivity, Diffusion.

- **PRESSURE MEASUREMENTS** **(04 Hours)**
  Measurements of the pressure with the wall tapings, Measurements of the pressure with the static tubes, Pressure sensitive paints.

- **VELOCITY, VORTICITY AND MACH NUMBER** **(04 Hours)**
  Pressure based velocity measurements, Thermal Anemometry, Particle based techniques.

- **DENSITY BASED TECHNIQUES** **(04 Hours)**
  Shadow graphy, Schlieren method, background-oriented Schlieren, Interferometry.

- **TEMPERATURE MEASUREMENTS** **(04 Hours)**
  Thermochromic Liquid Crystals, infrared imaging, Temperature measurement by absorption, light scattering and laser induced fluorescence, Temperature sensitive paints

- **FLOW VISUALIZATION** **(04 Hours)**
  Aims and principles of flow visualizations, dye lines and contours in liquid flow, smoke visualization in air flows, hardware of flow visualization experiments, modern flow visualization techniques, image processing.

(Total Lecture Hours: 42)

21/07/2020

3. Books Recommended:

1. C. Tropea and A.L. Yarin, Springer handbook of experimental fluid mechanics, Springer Science & Business Media, 2007.
2. E.O. Doebelin and D. N. Manik. Measurement systems: application and design, Mc. Graw Hill, 2019.
3. R. Goldstein, Fluid mechanics measurements, Taylor & Francis 1996.
4. S. P. Venktesh, Mechanical measurements, John Wiley & Sons, Ltd, 2015.
5. J. P. Holman, Experimental methods for engineers, Mc. Graw Hill, 2017.

21/07/2020

Data Analytics

L	T	P	Credit
3	0	0	03

ME444

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1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the importance of data analytics in decision making.
CO2	Apply the descriptive analytics and probability concepts in decision making.
CO3	Apply the sampling and estimation techniques in decision making.
CO4	Formulate and test the hypothesis in decision making.
CO5	Apply the regression models in decision making.

2. Syllabus

- **Introduction to Business Analytics** **(06 Hours)**
  Business Analytics: The Science of Data Driven Decision Making, Descriptive Analytics, Predictive Analytics, Prescriptive Analytics, Descriptive, Predictive and Prescriptive Analytics Techniques, Buf Data Analytics, Web and Social Media Analytics, Machine Learning Algorithms, Framework for Data-Driven Decision Making, Analytics Capability Building

- **Descriptive Analytics** **(04 Hours)**
  Introduction to Descriptive Analytics, Data Types and Scales, Types of Data Measurement Scales, Population and Sample, Measures of Central Tendency, Percentile, Decile, and Quartile Measures of Variation, Measures of Shape – Skewness and Kurtosis, Data Visualization

- **Probability** **(08 Hours)**
  Probability Theory – Terminology, Fundamental Concepts in Probability – Axioms of Probability, Application of Simple Probability, Bayes' Theorem, Random Variables, Probability Density Functions and Cumulative, Distribution Function of a Continuous Random Variable, Binomial Distribution, Poisson Distribution, Geometric Distribution, Parameters of Continuous Distribution, Uniform Distribution, Exponential Distribution, Normal Distribution, Chi-Square Distribution, Student's t-Distribution, F- Distribution.

- **Sampling and Estimation** **(08 Hours)**
  Population Parameters and Sample Statistic, Sampling, Probabilistic Sampling, Non-Probability Sampling, Sampling Distribution, Central Limit Theorem, Sample Size Estimation for Mean of the Population, Estimation of Population Parameters, Methods of Moments, Estimation of Parameters Using Methods of Moments, Estimation of Parameters Using Maximum Likelihood Estimation, Confidence Interval for Population Mean, Population Proportion, Population Mean When Deviation is Unknown, Population Variance

- **Hypothesis Testing, Analysis of Variance, Correlation Analysis** **(08 Hours)**
  Setting Up a Hypothesis Test, One-Tailed and Two Tailed Test, Hypothesis Testing for Population mean with known Variance: Z-test, Population Proportion: Z-test for Proportion, Variance: t-test, Paired Sample- t-Test, Comparing Two Populations: Two Sample Z- and t-test, Non-Parametric Tests: Chi-Square Tests, Analysis of Variance, Correlation

- **Simple Linear Regression and Multiple Linear Regression** **(08 Hours)**

Simple Linear Regression, History of Regression-Francis Galton's Regression Model, Simple Linear Regression Model Building, Estimation of Parameters Using Ordinary Least Square, Interpretation of Simple Linear Regression Coefficients, Validation of the Simple Linear Regression Model , Outlier Analysis, Confidence Interval for Regression Coefficients, Confidence Interval for the Expected Value of Y for a Given X, Prediction Interval for the Value of Y for a Given X, Multiple Linear Regression

(Total Lecture Hours: 42)

3. Books Recommended:

1. U. D. Kumar, Business Analytics: The Science of Data Driven Decision Making, Prentice Wiley, 2017
2. S. C. Albright and W. L. Winston, Business Analytics: Data Analysis & Decision Making, Cengage Learning, 2015
3. R. Bartlett, A Practitioner's Guide to Business Analytics: Using Data Analysis Tools to Improve your Organization's Decision Making and Strategy, McGraw Hill Professional, 2013
4. R. N. Prasad and S. Acharya, Fundamentals of Business Analytics, Wiley India Pvt. Ltd., 2016.
5. R. E. James, Business Analytics, Pearson Education, 2017

Advanced Welding Processes

ME446

L	T	P	Credit
3	0	0	03

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1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Classify advanced welding processes and explain the importance of the same.
CO2	Explain principles of advanced welding processes.
CO3	Describe equipments and procedures of advanced welding processes.
CO4	List process variables of advanced welding processes, and correlate the effects of the same on quality of welds.
CO5	Explain applications, advantages and limitations of advanced welding processes.

2. Syllabus:

- **INTRODUCTION** **(02 Hours)**
  History, Importance, classification, advantages and limitations in general, comparison between fusion & non-fusion welding processes

- **DIFFUSION WELDING** **(07 Hours)**
  Theory and principle of process, key variables, intermediate materials, equipment and tooling, joint design, economics, advantages and limitations, materials and applications.

- **ULTRASONIC WELDING** **(07 Hours)**
  Principles of operation, process characteristics and applications, vacuum brazing theory, mechanisms and key variables, equipment and tooling, stop-off and parting agents, advantages, limitations, economics materials and applications.

- **FRICTION WELDING** **(03 Hours)**
  Basic principles, process variants, different stages of friction welding, mechanism of bonding, influence of process parameters, weld quality and process control, joining of dissimilar materials, advantages, limitations and applications.

- **FRICTION STIR WELDING & PROCESSING** **(07 Hours)**
  Metal flow phenomena, equipments, tool materials & design, types of joints process variables, advantages, limitations, applications; Friction Stir Processing - Process, Tools, Applications; Allied processes -friction stir spot welding process, friction stir channeling; future trends of developments and growth.

- **RADIANT ENERGY BEAM WELDING PROCESSES** **(08 Hours)**

Electron beam welding - background of the process, guns, weld environment, welding in different degrees of vacuum, equipments and safety, joint design, applications; Laser beam welding - physics of lasers, types of lasers, process parameters, applications and limitations.

- **PLASMA ARC WELDING** **(06 Hours)**
  Theory and principle, transferred arc and non-transferred arc techniques, equipment and tooling, operating characteristics, shielding, process parameters, joint design, advantages, disadvantages, economics, materials and applications, needle arc micro plasma welding - characteristics of process, weld penetration and bead shape, applications; plasma arc spraying process, cladding process, process parameters for cladding.

- **EXPLOSIVE WELDING** **(02 Hours)**
  Theory and key variables, parameters, weld quality, equipment and tooling, advantages and limitations, joint design, materials and applications.

(Total Lecture Hours: 42)

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3. Books Recommended:

1. R. S. Parmar, Welding Processes and Technology, Khanna Publishers, Delhi, 2003.
2. R. S. Mishra and M. W. Mahoney, Friction Stir Welding and Processing, ASM International, 2007.
3. D. Lohwasser and Z. Chen, Friction Stir Welding - From Basics to Applications, CRC press, Woodhead Publishing Limited, Delhi, 2009.
4. D. H. Phillips, Welding Engineering - An Introduction, Wiley, 2016.
5. O. P. Khanna, A Text book of Welding Technology, Dhanpat Rai Publications, 2015.

Automation and Smart Manufacturing

L	T	P	Credit
3	0	0	03

ME448

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1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the concepts of automation, smart manufacturing and industry 4.0.
CO2	Apply the knowledge of automation for improvement of existing mechanical engineering systems.
CO3	Analyze the working of key elements of the automation systems such as sensors, transducers, actuation system, etc.
CO4	Evaluate the efficacy of existing automation systems.
CO5	Analyze the key drivers of a smart manufacturing system such as additive manufacturing, internet of things and augmented reality.
CO6	Create a pathway for smart factory development.

2. Syllabus

- **AUTOMATION** **(12 Hours)**
  Introduction to Automation of different manufacturing processes. Levels of automation, types of automation system, Data conversion devices, transducers, Microprocessor based controllers and its application, Programmable Logic Controllers, system interfacing, ladder logic, functional blocks, structured text, and applications. Modular Production Systems – Distribution, Conveying, Pick & Place etc.

- **MEASUREMENT AND MOTION CONTROL SYSTEMS** **(08 Hours)**
  Brief overview of measurement systems, classification, characteristics and calibration of different sensors. Measurement of displacement, position, motion, force, torque, strain gauge, pressure flow, temperature sensor sensors, smart sensor. Principles and structures of modern micro sensors. Basics of motion control, Mechanically and Electronically Coordinated Motion, Component of Motion Control system, Example of single axis and multi-axis motion control system

- **SMART MANUFACTURING** **(12 Hours)**
  Introduction to smart manufacturing, Key Drivers of Smart Manufacturing, Role of Additive Manufacturing technologies in smart manufacturing, Manufacturing of Smart Materials, 4D Printing, Artificial Intelligence in manufacturing.

- **INDUSTRY 4.0** **(10 Hours)**
  The concept of Industry 4.0 and Smart factories, Design Principles and Goals of Industry 4.0, Impact of Industry 4.0, Components of Industry 4.0, Introduction to the concept of Dark Factories, Big data analysis, Internet of Things.

(Total Lecture Hours: 42)

3. **Books Recommended:**

1. M. P. Groover, Automation, Production Systems, and Computer-Integrated Manufacturing, 4th Edition, Pearson, 2015.
2. A. Esposito, Fluid Power with Applications, 6th Edition, Pearson Prentice Hall, 2012.
3. W. Bolton, Mechatronics, 4th Edition, Pearson Education (India), 2011.
4. D. Shetty, A. R. Kolk, Mechatronic System Design, 2nd Edition, PWS Publicity Boston, 2010.
5. Z. Luo, Smart Manufacturing Innovation and Transformation: Interconnection and Intelligence, Business Science Reference (an imprint of IGI Global), 2014.

Theory and Design of Cryogenic systems

ME452

L	T	P	Credit
3	0	0	03

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1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Select suitable cryogen and material for development of cryogenic system for different applications
CO2	Design and analyze gas liquefaction system and cryogenic refrigeration systems including cryocoolers.
CO3	Select proper cryogenic insulating material and designing of cryogenic insulation.
CO4	Analyse and design gas purification and separation system using cryogenics.
CO5	Select and design storage, handling, and transfer systems for cryogens.
CO6	Design vacuum system for cryogenic application.

2. Syllabus

- **INTRODUCTION AND APPLICATIONS** **(03 Hours)**
- **CRYOGENICS FLUIDS** **(03 Hours)**
  Properties of air, Oxygen, Nitrogen, Hydrogen, Helium and its isotopes
- **CRYOGENICS REFRIGERATION SYSTEMS** **(04 Hours)**
  Recuperative & regenerative cycles, Joule Thomson cycle ; Gifford, Mcmohan cycle, Stirling cycle, Pulse Tube refrigeration, Magneto caloric refrigeration, Vuilleumier refrigerator.
- **GAS LIQUEFACTION SYSTEMS** **(04 Hours)**
  Ideal systems, Linde, Linde dual pressure system, Claude, Heylandt, Kapitza systems, Cascade cycle.
- **CRYOGENIC INSULATION** **(03 Hours)**
  Vacuum insulation, Multilayer insulation (MLI), Methods of measuring effective thermal conductivity of MLI, Liquid & vapour shield, Evacuated porous insulation, Gas filled powders and fibrous materials, Solid foams
- **CRYOGENIC INSTRUMENTATION** **(03 Hours)**
  Peculiarities of cryogenic strain measurement, Pressure, Flow, Density, Temperature and liquid level measurement for cryogenic application
- **PURIFICATION AND SEPARATION OF GASES, LIQUEFIED NATURAL GAS** **(04 Hours)**
  Principles of gas separation: Separation by condensation & flashing, Separation by distillation. Air separation system: Linde single column system, Linde double Column systems etc., Liquefaction of Natural Gas
- **STORAGE & HANDLING SYSTEMS** **(03 Hours)**

Dewar vessel design, Piping, Support systems, Vessel safety devices and storage systems, Industrial storage systems

- **TRANSFER SYSTEMS** **(03 Hours)**
  Transfer from storage, Uninsulated transfer lines, Insulated lines, Transfer system components.

- **PROPERTIES AND SELECTION OF MATERIALS** **(04 Hours)**
  Study of material properties & their selection for cryogenic application.

- **VACUUM SYSTEMS, CRYO PUMPING** **(03 Hours)**

- **EQUIPMENTS FOR LOW TEMPERATURE SYSTEMS** **(05 Hours)**
  Heat exchangers, Compressor, Expanders.

(Total Lecture Hours: 42)

3. Books Recommended:

1. C. Hastlden Cryogenic Fundamentals, Academic Press, 2001.
2. R. Barron, Cryogenic Systems, Plenum Press, 2001.
3. G. Walker, Cryocoolers, Springer, 2014.
4. Y. Mikulin, Theory and Design of Cryogenic systems, MIR Publication, 2002.
5. R. F. Barron, Cryogenics Systems, Oxford Press., 2002

21\07\2020

Computer Aided Machine Design

ME454

L	T	P	Credit
3	0	3	03

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1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the computer aided aspects of mechanical design.
CO2	Explain the concept of static analysis methods.
CO3	Describe the transient and dynamic analysis methods.
CO4	Analyze cyclic symmetric structures.
CO5	Analyze and design of machine components.

2. Syllabus

- **COMPUTER AIDED ASPECTS OF MECHANICAL DESIGN** **(06 Hours)**
  Introduction, mechanical design, formulation of specific design problem, computer aided aspects of design, failure under dynamic loading.

- **OPTIMIZATION OF DESIGN** **(07 Hours)**
  Unconstrained minimization of function, Lagrange multipliers, numerical optimization, Newton's and gradient methods, quadratic convergence, direct search methods, methods of successive linear approximation.

- **STATIC ANALYSIS** **(06 Hours)**
  Determinant and matrices, Gaussian elimination, Gauss-Jordan method, Cholesky's factorisation method, Potter's method, Jacobi's method, Gauss-Siedel method.

- **TRANSIENT ANALYSIS** **(06 Hours)**
  Single degree of freedom system, multi-degree of freedom system, explicit schemes, implicit schemes, mode superposition method, modal analysis, stability analysis.

- **DYNAMIC ANALYSIS** **(06 Hours)**
  Basic concepts of Eigenvalue problems, properties of Eigenvalues and vectors, Eigenvalue bounds and inequalities, Iteration method, transformation methods, approximation methods.

- **CYCLIC SYMMETRIC STRUCTURES** **(05 Hours)**
  Static analysis under symmetric loading, asymmetric loading, free vibration analysis, force vibration analysis.

- **STRESS ANALYSIS OF MACHINE COMPONENTS** **(06 Hours)**
  Cases of static analysis: analysis of frames, analysis of cylindrical shells, analysis of spur gear teeth. Computer aided dynamic analysis, case studies: dynamic analysis of frames, dynamic analysis of cylindrical shells, dynamic analysis of spur gear teeth, bladed discs, transient vibrations of turbine blades.

(Total Lecture Hours: 42)

3. Books Recommended:

1. R. V. Dukkipati, M. A. Rao and R. Bhat, Computer Aided Analysis and Design of Machine Elements, New Age International Pvt. Ltd., 2015.
2. V. Ramamurti, Finite Element Method in Machine Design, Narosa Publishing House Pvt. Ltd., 2009.
3. R. G. Budynas and K. Nisbett, Shigley's Mechanical Engineering Design, 11th Edition, McGraw Hill, 2020.
4. M. F. Spotts, Design of Machine Elements, Pearson Education India Ltd., 2004.
5. C. S. Krishnamoorthy, S. Rajeev and A. Rajaraman, Computer Aided design Software and Analytical Tools, 2nd Edition, Narosa Publishing House Pvt. Ltd., 2018.

21/07/2020

Foundry Technology

ME456

L	T	P	Credit
3	0	0	03

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1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain about flow and heat transfer of molten metal and correlate the effects of the same on resultant structure-properties of cast metals.
CO2	Describe the design of patterns and mold parts and explain procedures of testing of core and mold materials.
CO3	Calculate the size of gating system elements and pouring time for sand castings.
CO4	Calculate the size and determine the shape and location of risers and describe effects of feeding aids for achieving directional solidification.
CO5	Describe and compare procedures of casting various ferrous and non-ferrous metals and alloys.

2. Syllabus:

- **SCIENCE OF SOLIDIFYING METAL** **(08 Hours)**
  Metal flow analysis - pressure, velocity and losses, turbulence & fluidity of molten metals, gas evolution and venting, heat flow during solidification – thermal gradient & cooling rate, conduction, Chvorinov's rule for solidification time, shrinkage, cooling stresses, distortion, effect on microstructure of metals.

- **TECHNOLOGY OF TOOLINGS** **(10 Hours)**
  Design of Tools for metal casting – intermediate tools (pattern), final tools(molds/die), part orientation and mold parting; testing of mold materials, positioning of undercuts, types of core and core print design , core strength, No-bake cores, core heat transfer and gas transfer, pattern allowances, multi-cavity mold layout. Pattern & mold material for investment casting and shell molding processes.

- **DESIGN OF RISERS** **(09 Hours)**
  Types of risers – top & side risers, Open & blind risers; requirements, location, capacity & efficiency, Design of risers – riser size, riser shape, modulus method, Caine's curve method, shape factor method, Neck size; Directional solidification, Feeding aids – external & internal chills, insulating/exothermic sleeves and covers, paddings, fin, effective feeding distance of chills, concept of Modulus extension factor(MEF) for feeder sleeves.

- **DESIGN OF GATING SYSTEM** **(09 Hours)**
  Elements of gating system, Calculation of ideal filling time, filling rate of ferrous and non-ferrous metals, size & position of choke, gating ratio, pressurized and non-pressurized gating system, design of down sprue, sprue well, runner, gate, selection of gates, gate-casting junction, filtration of molten metal, evaluation of gating design.

- **CASTING OF FERROUS AND NON-FERROUS ALLOYS** **(06 Hours)**

Molding, melting, pouring, solidification, major issues in casting of Grey Iron, S. G. Iron, Steels and alloy steels, Aluminum alloys, Cu alloys.

(Total Lecture Hours: 42)

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3. Books Recommended:

1. B. Ravi, Metal Casting: Computer Aided Design and Analysis, PHI Learning Pvt. Ltd., 2005.
2. R.W. Heine, C. R. Loper and P.C. Rosenthal, Principles of Metal Casting, Tata McGraw-Hill, 2017.
3. P. L. Jain, Principles of Foundry Technology, TMH Publications, 2014.
4. P. Beeley, Foundry Technology, Elsevier (reprint by: Butterworth-Heinemann), 2001.
5. A. K. Chakrabarti, Casting Technology and Cast Alloys, PHI Ltd., 2005.

21/07/2020

Logistics and Supply Chain Management

ME458

L	T	P	Credit
3	0	0	03

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1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the concepts of logistics, supply chain, supply chain performance, supply chain drivers and metrics.
CO2	Identify the key factors for distribution network and to develop the framework for network design decisions.
CO3	Evaluate the forecast, aggregate plan and sales & operation plan for supply chain.
CO4	Apply deterministic and probabilistic inventory control models for evaluating the supply chain inventory level.
CO5	Apply analytics for solving the supply chain problems.

2. Syllabus

- **LOGISTICS MANAGEMENT** **(04 Hours)**

  Logistics Management-An Introduction, Key actors, Classification of Logistics Applications, Total logistics cost, Logistics to supply chain Management

- **BUILDING A STRATEGIC FRAMEWORK TO ANALYSE SUPPLY CHAINS** **(05 Hours)**

  Historical evolution of supply chain, Understanding the supply chain, supply chain performance: achieving strategic fit, supply chain drivers and metrics and case studies

- **DESIGNING THE SUPPLY CHAIN NETWORK** **(05 Hours)**

  Designing distribution networks and applications to e-business, network design in the supply chain, network design in an uncertain environment, and case studies

- **PLANNING DEMAND AND SUPPLY IN A SUPPLY CHAIN** **(10 Hours)**

  Demand forecasting strategy in a supply chain, aggregate planning in a supply chain, sales and operation planning: Planning supply and demand in a supply chain, and case studies.

- **PLANNING AND MANAGING INVENTORIES IN A SUPPLY CHAIN** **(08 Hours)**

  Managing economies of scale in a supply chain: cycle inventory, managing uncertainty in a supply chain: safety inventory, determining the optimal level of product availability, and case studies.

- **SUPPLY CHAIN MANAGEMENT ANALYTICS** **(10 Hours)**

  Techniques for evaluating supply chain, evaluating disaster risk in supply chain, Managing bullwhip effect, Supplier selection analysis, Transportation mode analysis and Warehouse storage.

(Total Lecture Hours: 42)

3. Books Recommended:

1. S. Chopra and P. Meindel, Supply Chain Management: Strategy, Planning, and Operation, 6th Edition, Pearson Education, 2016.
2. M. Christopher. Logistics and Supply Chain Management: Strategies for Reducing cost and Improving Services, 1st Edition, Pearson Education, 1998.
3. D. Simchi-Levi, P. Kaminsky, E. Simchi-Levi, Designing and Managing the Supply Chain: Concepts, Strategies, and Case Studies, 3rd Edition Revised, McGraw-Hill/Irwin, 2008.
4. J. F. Shapiro, Modeling the Supply Chain, 2nd Wadsworth Publishing Co Inc., 2006.
5. J. Heizer, B. Render, C. Munson and A. Sachan, Operations Management, 12th Edition, Pearson Education, 2017.

21/07/2020

Two Phase Flow

L	T	P	Credit
3	0	0	03

ME462

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1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Solve commonly encountered two phase flow with or without phase change in a variety of engineering processes.
CO2	Develop one-dimensional models of two-phase flow with and without phase change.
CO3	Explain modern gas-liquid measurement techniques and instruments.
CO4	Perform simple numerical analysis for Euler-Euler and Euler-Lagrange two-phase flow.
CO5	Predict pressure drop for gas-solid and gas-liquid flow as well as flow boiling.

2. Syllabus

- **INTRODUCTION:** **(08 hours)**
  Introduction, simultaneous flow of liquids and gases, horizontal two phase flow, lockhart and Martinelli procedure, flow factor method, vertical two phase flow, two phase flow through inclined pipes.

- **FLOW REGIMES:** **(05 hours)**
  Flow regimes in vertical horizontal and inclined pipes, gas-liquid flow in pipes, flow regimes in vertical, horizontal and inclined pipes, pressure drop and void fraction modelling for specific flow regimes.

- **BOUNDARY LAYER ANALYSIS:** **(08 hours)**
  Pneumatic transport and hydro-transport of solids in pipes, modelling of interaction forces, air-lift pump modeling, two phase flow boundary layer analysis, circulation in boiler-natural and forced, effective pressure head in boiler tubes, variation of major parameters of drum during transient conditions, hydrodynamics stability of vapor-liquid system.

- **SIMULTANEOUS FLOW OF FLUIDS AND SOLIDS:** **(08 hours)**
  Introduction, dynamics of particles submerged in fluids, flow through packed bed, fluidization, calculation of pressure drop in fixed bed, determination of minimum fluidization velocity, expanded bed, dilute phase, moving solid fluidization, elutriation in fluidized bed, semi-fluidization, pulsating columns, oscillating fluidized bed.

- **TWO PHASE FLOW WITH CHANGE OF PHASE:** **(05 hours)**
  Film wise condensation of pure vapors, drop wise condensation in plated surfaces, condensation in presence of non-condensable gas-pool boiling, boiling in forced flow inside tubing.

- **GAS LIQUID FLUIDIZATION:** **(08 hours)**
  Gas-liquid particle process, gas liquid particle operation, flow of gas-bubble formation, bubble growth gas holdup, gas mixing liquid holdup, liquid mixing, flow of liquid mixing, gas liquid mass transfer.

(Total Lecture Hours: 42)

3. Books Recommended:

1. J.G. Collier and J.R. Thome, Convective Boiling and Condensation, Oxford University Press, 1996.
2. C. Kleinstreuer, Two-Phase Flow: Theory and Applications, Taylor & Francis, 2003.
3. P. B. Whalley, Boiling, Condensation and Gas-Liquid Flow. Oxford University Press, 1990.
4. L.S. Tong and Y.S. Tang, Boiling Heat Transfer and Two-Phase Flow, Taylor and Francis, 1997.
5. M. Ishii and T. Hibiki, Thermo-Fluid Dynamics of Two-Phase Flow, Springer, 2011.

21/07/2020

Innovation, Incubation and Entrepreneurship

HU 406

L	T	P	Credit
3	0	0	03

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1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the concepts of Entrepreneurship
CO2	Develop skills related to various functional areas of management (Marketing Management, Financial Management, Operations Management, Personnel Management etc.)
CO3	Develop skills related to Project Planning and Business Plan development
CO4	Demonstrate the concept of Innovation, Intellectual Property Rights (IPR) and Technology Business incubation
CO5	Build knowledge about Sources of Information and Support for Entrepreneurship
CO6	Develop Entrepreneurial Culture

2. Syllabus:

- **CONCEPTS OF ENTREPRENEURSHIP** **(10 Hours)**
  Scope of Entrepreneurship, Definitions of Entrepreneurship and Entrepreneur, Characteristics of an Entrepreneur, Entrepreneurial Development models and Theories, Entrepreneurs Vs Managers Classification of Entrepreneurs; Major types of Entrepreneurship – Techno Entrepreneurship, Women Entrepreneurship, Social Entrepreneurship, Intrapreneurship (Corporate entrepreneurship), Rural Entrepreneurship, Family Business etc.; Problems for Small Scale Enterprises and Industrial Sickness; Entrepreneurial Trait Tests; Entrepreneurial Environment – Political, Legal, Technological, Natural, Economic, Socio – Cultural etc.; Motivation; Business Opportunity Identification

- **FUNCTIONAL MANAGEMENT AREA IN ENTREPRENEURSHIP** **(12 Hours)**
  Marketing Management: Basic concepts of Marketing, Development of Marketing Strategy and Marketing plan, Online Marketing, New Product Development Strategy
  Operations Management: Basic concepts of Operations management, Location problem, Development of Operations strategy and plan
  Personnel Management: Main operative functions of a Personnel Manager, Development of H R strategy and plan
  Financial Management: Basics of Financial Management, Ratio Analysis, Capital Budgeting, Working Capital Management, Cash Flow Statement, Break Even Analysis

- **PROJECT PLANNING** **(06 Hours)**
  Product Development – Stages in Product Development; Feasibility analysis – Technical, Market, Economic, Financial etc.; Project report; Project appraisal; Setting up an Industrial unit – procedure and formalities in setting up an Industrial unit; Business Plan Development

- **PROTECTION OF INNOVATION THROUGH IPR** **(04 Hours)**
  Introduction to Intellectual Property Rights – IPR, Patents, Trademarks, Copy Rights

- **INNOVATION AND INCUBATION** **(06 Hours)**

Innovation and Entrepreneurship, Creativity, Green Technology Innovations, Grassroots Innovations, Issues and Challenges in Commercialization of Technology Innovations, Introduction to Technology Business Incubations, Process of Technology Business Incubation

- **SOURCES OF INFORMATION AND SUPPORT FOR ENTREPRENEURSHIP** **(04 Hours)**

  State level Institutions, Central Level institutions and other agencies

(Total Lecture Hours: 42)

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3. Books Recommended:

1. Vasant Desai, Dynamics of Entrepreneurial Development and Management, Himalaya Publishing House, India, 6th Revised Edition, 2011
2. P. M. Charantimath, Entrepreneurial Development and Small Business Enterprises, Pearson Education, 3rd Edition, 2018
3. H. David, Entrepreneurship: New Venture Creation, Pearson Education, 2016
4. P. Chandra, Projects: Planning, Analysis, Selection, Financing, Implementation and Review, Tata McGraw Hill, 9th Edition, 2019
5. T. R. Banga & S. C. Shrama, Industrial Organisation & Engineering Economics, Khanna Publishers, 25th Edition, 2015

Further Reading:

1. L. M. Prasad, Principles & Practice Of Management, Sultan Chand & Sons, 8th Edition,2015
2. Everett E. Adam, Ronald J. Ebert, Production and Operations Management , Prentice Hall of India, 5th edition, 2012
3. P. Kotler, K. L. Keller, A. Koshi & M. Jha, Marketing Management – A South Asian Perspective, Pearson, 14th Edition, 2014
4. P. C. Tripathi, Personnel Management & Industrial Relations, Sultan Chand & sons, 21st Edition, 2013
5. P. Chandra, Financial Management, Tata McGraw Hill, 9th Edition, 2015

21/07/2020

Revised Syllabus of
Five Years Integrated M.Sc.
Chemistry
(M. Sc. II to V)
(Sem. – III to X)

APPLIED CHEMISTRY DEPARTMENT

SARDAR VALLABHBHAI NATIONAL INSTITUTE OF TECHNOLOGY,
SURAT

SECOND YEAR OF FIVE YEARS INTEGRATED M. SC. (CHEMISTRY)

M. SC. - II, SEMESTER – III

Sr. No.	Subject	Code	Scheme	Credit	Examination Scheme				Total Marks
					Theory	Tutorial	Practical		
							Int.	Ext.	
1.	English & Professional Communication-II	HU-201	3-0-0	03	100	00	00	00	100
2.	Chemistry of Elements	CY-201	3-1-2	05	100	25	30	20	175
3.	Hydrocarbons & Their Functional Groups	CY -203	3-1-2	05	100	25	30	20	175
4.	States and Properties of Matter	CY -205	3-1-2	05	100	25	30	20	175
5.	Economics and Business Management/ Probability and Statistics-I	HU-203/ MA-209	3-1-0	04	100	25	00	00	125
6.	Computational Chemistry Lab.-I	CY -207	0-0-4	02	00	00	60	40	100
Total contact hours per week=29				**Total Credits=24**		**Total Marks=850**			

SECOND YEAR OF FIVE YEARS INTEGRATED M. SC. (CHEMISTRY)

M. SC. - II, SEMESTER – IV

Sr. No.	Subject	Code	Scheme	Credit	Examination Scheme				Total Marks
					Theory	Tutorial	Practical		
							Int.	Ext.	
1.	Introduction to Life Science	CY-202	3-0-0	03	100	00	00	00	100
2.	Coordination and Bioinorganic Chemistry	CY-204	3-1-2	05	100	25	30	20	175
3.	Stereochemistry and Reaction Mechanism	CY-206	3-1-2	05	100	25	30	20	175
4.	Equilibrium and Changes	CY-208	3-1-2	05	100	25	30	20	175
5.	Modern Physics	PH-212	3-0-0	03	100	00	00	00	100
6.	Computational Chemistry Lab.-II	CY-212	0-0-4	02	00	00	60	40	100
Total contact hours per week=28				**Total Credits=23**		**Total Marks=825**			

ENGLISH & PROFESSIONAL COMMUNICATION-II

L	T	P	C
3	0	0	3

Scheme

HU201

1. Course Outcomes (COs):

At the end of the course the students will able to:

CO1	Express themselves using appropriate vocabulary and grammar.
CO2	Draft scientific reports and formal proposals.
CO3	Comprehend scientific and general content more skilfully and meaningfully.
CO4	Predict human transactions and behavioural modes.
CO5	Communicate effectively through various means and at varied levels.

2. Syllabus:

- **FUNCTIONAL ENGLISH GRAMMAR** **(08 Hours)**
  Language functions, Modals, Tenses, Active and Passive Voice, Conditional Sentences, Concord errors.

- **TECHNICAL WRITING** **(06 Hours)**
  Formal and informal report- Information and recommendation reports, Progress and Periodic Report, Feasibility and trip report. Proposal Writing- Types, logistics of proposals, the deliverables of proposals persuasion and proposal, the structure of the proposal.

- **LISTENING AND READING COMPREHENSION** **(10 Hours)**
  Listening and Note Taking, Paraphrasing, Reading using SQ3R, Predicting, Understanding Gist Reading and Listening General and Scientific Texts and Developing Vocabulary.

- **LANGUAGE THROUGH LITERATURE** **(08 Hours)**
  Short Stories:
  1. The Remarkable Rocket by Oscar Wild.
  2. An Astrologer's Day by R. K. Narayan.
  3. The Case of the Lower Case Letter by Jack Delany.

- **GROUP COMMUNICATION & ACADEMIC WRITING** **(10 Hours)**
  Transactional Analysis; SOP; LOR; Research Paper, Dissertation, Thesis; Types of Group Communication- Seminar, Conferences, Convention, Symposium, Panel Discussion etc.

(Total Lecture Hours: 42)

3. Books Recommended:

1. M. Markel, *Practical Strategies for Technical Communication,* 2nd Edition, Bedford/ St. Martin's, 2016.
2. R. V. Lesikar, M. E. Flatley, *Basic Business Communication Skills for Empowering the Internet Generation,* Tata McGraw Hill publishing company limited. New Delhi 2005.
3. L J. Gurak, J. M. Lannon, *Strategies for Technical Communication in The Workplace* Pearson, 2013.

4. C. L. Bovee, J. V. Thill, M. Chaturvedi, *Business Communication Today*, 9th Edition. Pearson, 2009.
5. W. S. Pfeiffer, T.V.S. Padmaja, *Technical Communication: A Practical Approach*, 6th Edition, Pearson 2013.

CHEMISTRY OF ELEMENTS

CY201

L	T	P	C
3	1	2	5

Scheme

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Gain knowledge of basic chemistry of main group elements.
CO2	Identify different group elements based on the structure and properties.
CO3	Differentiate between lanthanides and actinides.
CO4	Describe basic concepts of acids and bases.
CO5	Acquire knowledge on properties and use of non-aqueous solvents.

2. Syllabus:

- ***s*- and *p*-BLOCK ELEMENTS** **(12 Hours)**
  s- and *p*- group elements and their compounds: allotropy, structure and bonding, Chemistry and compounds of boron, nitrogen and phosphorous, allotropic forms of carbon, carbides of calcium and silicon, silanes, structure of silicate minerals and silicones. Basic properties of halogens and inter halogen compounds.

- ***d*-BLOCK ELEMENTS** **(08 Hours)**
  Transition elements, position in periodic table, electronic configuration, General characteristics such as oxidation state, size, melting and boiling points, reactivity, ionization energies, magnetic behavior, colour, tendency to form complexes, comparison of properties of first transition series with second and third transition series.

- **LANTHANIDES AND ACTINIDES** **(08 Hours)**
  Electronic configuration and general properties of lanthanides and actinides, extraction and separation of lanthanides and actinides, lanthanide contraction, comparison of *d*- and *f*- block elements, oxidation state, colour and magnetism, trans-uranium elements and their stabilities, coordination chemistry and applications of lanthanide and actinide compounds.

- **ACIDS AND BASES** **(06 Hours)**
  Arrhenius, Bronsted and Lowry concepts of acids and bases. Classification of acids and bases as hard and soft. Pearson's HSAB concept, application of HSAB principle. General trends in acid strength.

- **NON-AQUEOUS SOLVENTS** **(08 Hours)**
  Introduction, solvent classification, effect of the physical properties of the solvent in chemical reactions, acid base reaction, oxidation-reduction reactions, solvolytic reactions, the dielectric constant, the activity coefficient, solubility, ion solvent interactions. Elementary study of ammonia, HF and SO_2 as non- aqueous solvents.

(Total Lecture Hours: 42)

3. Practicals:

- **Inorganic qualitative analysis of inorganic salt mixture containing two cations and two anions**

  Cations: K^+, NH_4^+, Ba^{2+}, Sr^{2+}, Ca^{2+}, Mg^{2+}, Pb^{2+}, Bi^{3+}, Cu^{2+}, Fe^{2+}or Fe^{3+}, Al^{3+}, Co^{2+}, Ni^{2+}, Zn^{2+} and Mn^{2+}.

  Anions: CO_3^{2-}, SO_4^{2-}, S^{2-}, NO_2^-, NO_3^-, Cl^-, Br^-, I^-, CH_3COO^- and PO_4^{3-}.

4. Books Recommended:

1. J. D. Lee, *Concise Inorganic Chemistry*, 5th Edition, Wiley-Blackwell, New Jersey, 1999.
2. T. Moeller, *Inorganic Chemistry: A Modern Introduction*, 2nd Edition, John Wiley & Sons Inc., New York, 1982.
3. F. A. Cotton, G. Wilkinson, C. A. Murillo, M. Bochmann, *Advanced Inorganic Chemistry*, 6th Edition, John Wiley & Sons, New York, 1999.
4. H. Sisler, *Chemistry in Non-Aqueous Solvents*, 3rd Edition, Chapman & Hall, London, 1964.
5. N. N. Greenwood, A. Earnshaw, *Chemistry of the Elements*, 2nd Edition, Butterworth-Heinemann, Massachusetts, 1997.

5. Additional Reading Material:

1. T. Moeller, *The Chemistry of the Lanthanides*, 1st Edition, Chapman & Hall Ltd., London, 1973.
2. C. J. Jones, *d - and f - block Chemistry*, 1st Edition, Royal Society of Chemistry (RSC), Cambridge, 2006.
3. G. L. Miessler, D. A. Tarr, *Inorganic Chemistry*, 3rd Edition, Pearson, 2008.

HYDROCARBONS & THEIR FUNCTIONAL GROUPS

CY203

L	T	P	C
3	1	2	5

Scheme

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Develop knowledge in fundamental aspects of organic chemistry.
CO2	Acquire knowledge on chemical properties of hetero functional groups.
CO3	Acquaint basic knowledge in the chemical properties of carbohydrates and heterocyclic compounds.
CO4	Extend basic knowledge in stability and chemical properties of cycloalkanes.
CO5	Construct practical skills for the purification of solid and liquid organic compounds.

2. Syllabus:

- **HETERO FUNCTIONAL GROUP – I** **(12 Hours)**
  Aliphatic and aromatic halides, hydroxy derivatives, aliphatic alcohols and phenols. Ethers – aliphatic, and aromatic carbonyl compounds. Acid and base-catalyzed ring opening of epoxides, orientation of epoxide ring opening, reactions of Grignard and organolithium reagents with epoxides. Preparation and synthetic applications of ethyl acetoacetate and diethyl malonate, tautomerism.

- **HETERO FUNCTIONAL GROUP – II** **(08 Hours)**
  Aliphatic and aromatic carboxylic acids and their functional derivatives. Nitrogen containing compounds - preparations and reaction mechanisms.

- **CYCLOALKANES** **(06 Hours)**
  Nomenclature, methods of formation, chemical reactions, Baeyer's strain theory and its limitations, theory of strainless ring. Reactions and stereochemistry of substituted cyclohexane.

- **HETEROCYCLIC COMPOUNDS** **(08 Hours)**
  Nomenclature, aromaticity, synthesis, properties, reactivity, uses and canonical structures of: pyrrole, furan, thiophene, pyridine, quinoline and isoquinoline.

- **CARBOHYDRATES** **(08 Hours)**
  Introduction, basic structural features and types of carbohydrates, reactions and conversions, role in biological systems. Introduction to disaccharides, glycosidic bond, structure determination of sucrose, lactose, maltose and gentiobiose.

(Total Lecture Hours: 42)

3. Practicals:

1. Purification of liquid organic compounds
   a. Distillation
   b. Fractional distillation
   c. Steam distillation/Vacuum distillation
   d. Determination of boiling point using distillation
   d. Distillation at reduced pressure

2. Purification of solid organic compounds
    a. Crystallization
    b. Sublimation
    c. Fractional recrystallization

4. Books Recommended:

1. M. A. Fox, J. K. Whitesell, *Organic Chemistry*, 3rd Edition, Jones & Bartlett Learning, Massachusetts, 2004.
2. P. Y. Bruice, *Organic Chemistry*, 3rd Edition, International Edition, Prentice-Hall, New Jersey, 2009.
3. R. T. Morrison, R. N. Boyd, *Organic Chemistry*, 7th Edition, Prentice Hall, New Jersey, 2011.
4. A. Streitwieser, Jr., C. H. Heathcock, *Introduction to Organic Chemistry*, 4th Edition, MacMillan, New York, 1998.
5. R. R. Gupta, M. Kumar, V. Gupta, *Heterocyclic Chemistry*, Volume 2, 1st Edition, Springer India Pvt. Ltd., New Delhi, 2009.

5. Additional Reading Material:

1. T. W. G. Solomons, C. B. Fryhle, *Organic Chemistry*, 9th Edition, Wiley India Pvt. Ltd., Navi Mumbai, 2009.
2. B. S. Furniss, A. J. Hannaford, P. W. G. Smith, A. R. Tatchell, *Vogel's Textbook of Practical Organic Chemistry*, Pearson India, Noida, 5th Edition, 2005.
3. P. Sykes, *A Guidebook to Mechanism in Organic Chemistry*, Pearson (publisher), 6th Edition, 2003.

STATES AND PROPERTIES OF MATTER

CY205

L	T	P	C
3	1	2	5

Scheme

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Recognize the basic theoretical knowledge of solids and liquids applicable in multidisciplinary fields.
CO2	Recall basics of solutions and apply thermodynamic treatment in solutions.
CO3	Accumulate a fundamental knowledge of colloidal state.
CO4	Classify state of matter based on physical properties.
CO5	Perform the experiments related to physical chemistry approach which includes solution preparation, and titration dealing with conductometry, colorimetry, and pH-metry.

2. Syllabus:

- **SOLID STATE** **(10 Hours)**
  Unit cell, Bravais lattice and its types, Miller indices, X-ray diffraction, Bragg's law and its derivation, Calculation of basis per unit crystal, volume, density per unit cell, Diffraction techniques (Qualitative treatment only): single crystal and powder, Structure elucidation of ZnS (Wurtzite and blende), Specific heat of solids (Dulong Petit law, Einstein's theory, Debye correction qualitatively), Band theory, Superconductivity, Point defects (Schottky and Frenkel).

- **LIQUID STATE** **(10 Hours)**
  General features of liquid state (short and long range order/disorder, hole theory), Vapor pressure, Young and Laplace equation, Surface tension, Surface energy, Excess pressure, Capillarity phenomenon, Work of adhesion and cohesion, Contact angle, Spreading of liquids, Temperature dependence of surface tension, measurement of surface tension, Viscosity of liquids, Temperature dependence of viscosity of liquids, Poiseuille's equation and Measurement of surface viscosity, Numericals.

- **COLLOIDAL CHEMISTRY - I** **(10 Hours)**
  Colloids: Definition, general properties of colloids (optical and electrical), Types of colloidal system, Classifications of colloids, Colloidal state, multimolecular, macromolecular and associated colloids, Stability and kinetics of colloids, Zeta potential. Rayleigh equation and its outcomes, Sol, Lyophobic and lyophilic sol, Size range and its preparation.

- **SOLUTION** **(12 Hours)**
  Types of solutions, Ideal and non-ideal solutions, The thermodynamic properties of ideal solutions, Molecular interpretation of the entropy of mixing, Vapor pressure and thermodynamics of non-ideal systems, general considerations (mixing and excess functions), Solvents of non-ideal solutions, the activity and activity coefficients, solutes of non-ideal solutions, The Gibbs-Duhem equation and determination of solute activity, Partial and apparent molar properties (chemical potential, enthalpy and volume), Methods for their determinations.

(Total Lecture Hours: 42)

3. Practicals:

1. Preparation of the solution, calibration, Standard Deviation.
2. Determination of the partition coefficient of Benzoic acid in Kerosene.
3. To find out the strength of HCl solution (N/10) by conductometric titration against standard NaOH solution.
4. To verify Beer's law for $K_2Cr_2O_7$ solution spectrophotometrically and determine the unknown concentration.
5. To determine the dissociation constant of weak monobasic acid by pH-metric titration.
6. Determination of surface tension of a given solution by drop weight (stalagnometer) method.
7. Complexometric determination of total hardness of water by EDTA titration.
8. To determine rate constant of decomposition of H_2O_2 by acidified KI solution.

4. Books Recommended:

1. B. R. Puri, L. R. Sharma, M.S. Pathania, *Principles of Physical Chemistry*, 47th Edition, Vishal Publications, New Delhi, 2017.
2. G. Raj, *Advanced Physical Chemistry*, 4th Edition, Goel Publishing House, Meerut, 1990.
3. A. R. West, *Solid State Chemistry and its Applications*, 2nd Edition, student edition, John Wiley & Sons, New York, 2014.
4. P. Atkins, J. de Paula, J. Keeler *Atkins' Physical Chemistry*, 11th Edition, 2018.
5. K. J. Laidler, *Chemical Kinetics*, 3rd Edition, Person, 2003.

ECONOMICS AND BUSINESS MANAGEMENT

L	T	P	C
3	1	0	4

Scheme

HU203

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Develop managerial skills.
CO2	Acquire skills related to various functional areas of management (marketing management, financial management, operations management, personnel management etc.)
CO3	Build knowledge about modern management concepts (ERP, SCM, e-CRM, etc.)
CO4	Record experiential learning in management through real life examples and case study etc.
CO5	Apply knowledge of economics and business management aspects in their field.

2. Syllabus:

- **ECONOMICS** **(08 Hours)**
  Introduction to Economics, Micro & Macro Economics, Applications & Scopes of Economics, Demand Analysis, Demand Forecasting, Factors of Production, Types of Cost, Market Structures, Break Even Analysis

- **MANAGEMENT** **(12 Hours)**
  Introduction to Management, Features of Management, Nature of Management, Development of Management Thoughts – Scientific Management By Taylor & Contribution of Henry Fayol, Coordination & Functions of Management, Centralization & Decentralization, Decision Making; Fundamentals of Planning; Objectives & MBO; Types of Business Organizations: Private Sector, Public Sector & Joint Sector; Organizational Behavior: Theories of Motivation, Individual & Group Behavior, Perception, Value, Attitude, Leadership

- **FUNCTIONAL MANAGEMENT** **(18 Hours)**
  Marketing Management: Core Concepts of Marketing, Marketing Mix (4p), Segmentation – Targeting – Positioning, Marketing Research, Marketing Information System, Concept of International Marketing, Difference Between Domestic Marketing & International Marketing; Operations Management: Introduction to Operations Management, Types of Operation Systems, Types of Layouts, Material Handling, Purchasing & Store System, Inventory Management; Personnel Management: Roles & Functions of Personnel Manager, Recruitment, Selection, Training, Industrial Dispute, Collective Bargaining; Financial Management: Goal of Financial Management, Key Activities In Financial Management, Organization of Financial Management, Financial Institutions, Financial Instruments, Sources of Finance

- **MODERN MANAGEMENT ASPECTS** **(04 Hours)**
  Introduction to ERP, e – CRM, SCM, RE – Engineering, WTO, IPR Etc.

(Total Lecture Hours: 42)

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3. Books Recommended:

1. L. M. Prasad, *Principles & Practice of Management*, 8th Edition, Sultan Chand & Sons, 2015.
2. T. R. Banga, S. C. Shrama, *Industrial Organisation & Engineering Economics*, 25th Edition, Khanna Publishers, 2015.
3. E. E. Adam, R. J. Ebert, *Production and Operations Management*, 5th Edition, Prentice Hall of India, 2012.
4. P. Kotler, K. L. Keller, A. Koshi, M. Jha, *Marketing Management – A South Asian Perspective*, 14th Edition, Pearson, 2014.
5. P. C. Tripathi, *Personnel Management & Industrial Relations*, 21st Edition, Sultan Chand & Sons, 2013.

4. Additional Reading Material:

1. P. Chandra, *Financial Management*, 9th Edition, Tata McGraw Hill, 2015.

PROBABILITY AND STATISTICS-I

MA209

L	T	P	C
3	1	0	4

Scheme

1. Course Outcomes (Cos):

At the end of the course students will be able to:

CO1	Recognize the basic ideas of measures of central tendency, dispersion and their applications.
CO2	Acquire the knowledge of various Probability distributions and their applications.
CO3	Compute correlation, regression and confidence intervals to formulate hypotheses.
CO4	Apply statistical techniques for sampling of big data.
CO5	Demonstrate the statistical techniques for estimation of data.

2. Syllabus:

- **PROBABILITY AND DESCRIPTIVE MEASURES** **(07 Hours)**
  Historical development, Basic Concepts, rule, Measures of Central Tendency, Measures of Dispersion, Tchebycheff's theorem and Empirical Rule Measures of relative standing, some principles of statistical model. Random variables, Probability, conditional probability and Baye's theorem. Expected value, moment generation function and variance of a random variable, covariance.

- **PROBABILITY DISTRIBUTIONS** **(08 Hours)**
  Probability Distributions: binomial and multinomial distribution, geometric distribution, hypergeometric distribution, normal distribution, gamma distribution, exponential distribution, negative binomial distribution, Two dimensional distribution, joint and marginal distribution.

- **CENTRAL LIMIT THEOREM** **(04 Hours)**
  Central limit theorem for Bernoulli trails, normal approximation to binomial, the general central limit theorem.

- **CORRELATION, REGRESSION AND TESTING OF HYPOTHESIS** **(08 Hours)**
  Correlation, multiple correlation, Linear Regression, Properties of the Least Square Estimators, Inferences concerning the Regression coefficients, Analysis of variance for Linear Regression, Testing the usefulness of the Linear Regression Model. Multiple regression, Testing the significance of the regression coefficients, Testing of linear hypothesis, Bias in the regression estimators due to choice of wrong model.

- **SAMPLING METHODS** **(07 Hours)**
  Random Sampling and Methods of Sampling, Sampling Distribution and Standard Error, Sampling Distribution of the Sample Mean, Central Limit Theorem, Sampling Distribution of the Sample Proportion, Sampling Distribution of the difference between two sample means and Sampling Distribution of the difference between two sample proportions.

- **ESTIMATION METHODS** **(08 Hours)**
  Point Estimation, Interval Estimation, Confidence Interval, Large Sample Confidence Interval for a Population Mean μ, Large Sample Confidence Interval for a Population Proportion, estimating the

difference between two Population means, estimating the Difference between two Binomial proportions, Maximum Likelihood Estimation.

(Total Lecture Hours: 42)

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3. Books Recommended:

1. W. Mendenhall, R. J. Beaver, B. M. Beaver, *Introduction to Probability & Statistics*, 12th Edition, India Edition, Thomson, 2012.
2. G. Smith, *Essential Statistics, Regression & Econometrics*, 2nd Edition, 2015.
3. C. Grinstead, J. Snell, *Introduction to Probability*, American Mathematical Society, 2006.
4. Montgomery, *Applied Statistics and Probability for Engineers*, 6th Edition, Wiley India Pvt Ltd, 2014.
5. R. E. Walpole, S. L. Myers, K. Ye, *Probability& Statistics for Engineers & Scientists*, 9th Edition, Pearson, 2012.

COMPUTATIONAL CHEMISTRY LAB. – I

L	T	P	C
0	0	4	2

Scheme

CY207

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Develop computational chemistry literacy.
CO2	Explore the importance of computational chemistry software.
CO3	Hands-on experience with some standard computational software.
CO4	Compute 3D structure of molecules.
CO5	Calculate electronic and thermodynamic properties.

2. Syllabus:

- **INTRODUCTION** **(12 Hours)**
  Practice with some commonly used drawing and visualization softwares: Chemdraw, Chemsketch, Avogardo, molden etc; Scope of computational chemistry; Demonstration of basic theory for molecular mechanics and quantum mechanical calculations; Introduction to some quantum mechanical softwares: Gaussian; Hyperchem; Spartan; Gamess; Molecular dynamic softwares: Gromacs, Lammps, Amber, MDynaMix; Molecular docking softwares: Autodock.

- **WORKING WITH COMPUTATIONAL SOFTWARE (OPTIMIZATION)** **(22 Hours)**
  Hands-on experience with Gaussian and GaussView; Single point energy calculations, geometry optimization with MM, Semi-empirical, Ab-Initio and DFT methods, Effects of basis sets, location of transition states, Frequency calculations, conformational analysis, predicting molecular stability, studying chemical reactions and reactivity, modeling in solutions.

- **CALCULATING ELECTRONIC AND THERMODYNAMIC PROPERTIES** **(22 Hours)**
  Predicting thermochemistry: Thermal energy: E (Thermal), Constant volume molar heat capacity (C_V), Entropy (S), Free Energy (sum of electronic and thermal Free Energies), Enthalpy (sum of electronic and thermal Enthalpies), Atomization energies, Electron Affinity, Ionization Potential, Proton Affinity, Electrostatic potential Map and electron density, Mulliken's Atomic charges. NBO's, molecular orbitals and band gap calculations, dipole moment, polarizability, volume.

(Total Contact Hours: 56)

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3. Practicals:

1. To demonstrate the use of chemical structure drawing program ChemDraw and molecular modeling counterpart Chem3D to draw and manipulate different organic chemistry structures.
2. Practice for drawing chemical structure with ChemDraw and Chem3D.
3. To demonstrate the theories and applications of the computational tools in understanding chemical phenomena.
4. Practice with Gaussian 09W ad Gaussview: predicting least strain structure of cyclohexane and substituted cyclohexane.
5. Optimization of the various conformations of propene, vinyl alcohols, vinyl amine by semi-empirical, HF and DFT methods.

6. To calculate the structure of a transition state between the two stable structures of 1,3-butadiene.
7. To calculate various thermodynamic properties of naphthalene.
8. To calculate Mulliken's Atomic charges. NBO's, molecular orbitals and band gap calculations, Electrostatic potential Map and electron density with suitable examples
9. To calculate the atomization energies and Electron Affinity.
10. To calculate the Ionization Potential and Proton Affinity.

4. Books Recommended:

1. J. B. Foresman, A. Frisch, *Exploring Chemistry with Electronic Structure Methods*, Gaussian, Inc., Pittsburgh, 1996.
2. D. Young, *Computational Chemistry: A Practical Guide for Applying Techniques to Real World Problems*; John Wiley & Sons, inc: USA, 2001.
3. F. Jensen, *Introduction to Computational Chemistry*, 2nd Edition, John Wiley & Sons, inc: England, 2007.
4. A. Tomberg, *Gaussian 09w Tutorial An Introduction to Computational Chemistry Using g09w and Avogadro Software.*
5. C. J. Cramer, *Essentials of Computational Chemistry: Theories and Models,* 2nd Edition, Wiley & Sons, New York, 2002.

SECOND YEAR OF FIVE YEARS INTEGRATED M. Sc. (CHEMISTRY)

M. Sc. - II, SEMESTER – IV

Sr. No.	Subject	Code	Scheme	Credit	Examination Scheme				Total Marks
					Theory	Tutorial	Practical		
							Int.	Ext.	
1.	Introduction to Life Science	CY-202	3-0-0	03	100	00	00	00	100
2.	Coordination and Bioinorganic Chemistry	CY-204	3-1-2	05	100	25	30	20	175
3.	Stereochemistry and Reaction Mechanism	CY-206	3-1-2	05	100	25	30	20	175
4.	Equilibrium and Changes	CY-208	3-1-2	05	100	25	30	20	175
5.	Modern Physics	PH-212	3-0-0	03	100	00	00	00	100
6.	Computational Chemistry Lab.-II	CY-212	0-0-4	02	00	00	60	40	100
Total contact hours per week=28				**Total Credits=23**		**Total Marks=825**			

INTRODUCTION TO LIFE SCIENCE

L	T	P	C
3	0	0	3

Scheme

CY202

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Identify basics of life science.
CO2	Distinguish on interfaces between chemistry and biology.
CO3	Acquire knowledge about prokaryotic Diversity.
CO4	Explain cell structure and metabolisms.
CO5	Apply fundamental knowledge on bacteria and microorganisms.

2. Syllabus:

- **INTRODUCTION TO CELL BIOLOGY** **(09 Hours)**
  Origin of life, Discovery of cell and Cell Theory; Comparison between plant and animal cells; Cell wall; Plasma membrane; Cytoskeleton; Protoplasm; Mitochondria; Chloroplast; ER; Golgi complex; Lysosome, Ribosome; Nucleus; Chemical components of a cell; Cell division and cell cycle: Mitosis and meiosis (different phases in cell division), their regulation, steps in cell cycle, and control of cell cycle.

- **HEREDITY AND VARIATION** **(09 Hours)**
  Mendelian inheritance; deviations from Mendelism – incomplete dominance, co-dominance, (example of heredity and variation multiple alleles and inheritance of blood groups), chromosome theory of inheritance; chromosomes and genes. DNA as genetic material; Structure of DNA and RNA; DNA packaging; DNA replication; Central dogma; transcription, genetic translation.

- **PROKARYOTIC DIVERSITY** **(09 Hours)**
  Prokaryotic Diversity: Importance of Taxonomy, Nomenclature and Bergey's Manual; **Archaea:** Archaea as earliest Life forms; Halophiles; Methanogens; Hyperthermophilic archaea; Thermoplasma; **Bacteria:** Purple and green bacteria; Cyanobacteria; Acetic acid bacteria; Spirilla; Spirochaetes; Pseudomonads; Lactic and propionic acid bacteria; Mycobacteria; Rickettsias, Chlamydias and Mycoplasms; **Viruses:** Bacterial, Plant, Animal and Tumor viruses; Discovery, classification and structure of viruses; **Eukarya:** Algae, Fungi, Slime molds and Protozoa.

- **STRUCTURE AND FUNCTION OF BACTERIAL CELL** **(05 Hours)**
  The cell wall of bacteria containing peptidoglycan and related molecules; the outer membrane and cytoplasmic membrane. Water and ion transport across membrane. Membrane structure & transport – Models of membrane structure, Membrane lipids, proteins and carbohydrates; Solute transport by Simple diffusion, Facilitated diffusion and Active transport.

- **METABOLIC DIVERSITY AND SYNTROPY AMONG MICROORGANISMS** **(10 Hours)**
  Bacterial Growth and Diversity, Bacterial cell cycle, Measurements and Isolation of Microorganism – Different Cultures – Media and Techniques of Staining (Gram-negative and Gram-positive bacteria); Introduction to photosynthesis in microorganisms (Role of Chlorophylls, carotenoids and phycobilins); Calvin cycle; Chemolithotrophy; Oxidation-reduction by bacteria: (Hydrogen - iron -

nitrite – oxidizing bacteria; Nitrate and sulfate reduction); Methanogenesis and acetogenesis: Fermentations – diversity and syntropy.

(Total Lecture Hours: 42)

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3. Books Recommended:

1. D. O. Morgan, *The cell cycle: Principle of controls*, 1st Edition, New Science Press, 2007.
2. D. M. Prescott, *Reproduction in Eukaryotic cells*, 1st Edition, Academic press, 1976
3. R. Y. Stainer, J. L. Ingraham, M. L. Wheelis, P. R. Painter, *General Microbiology*, 5th Edition, The MacMillan Press Ltd, 1987.
4. D. L. Nelson, M.M. Cox, *Lehninger's Principles of Biochemistry,* 5th Edition, CBS Publications, 2008.
5. M. J. Pelczar, R. D. Reid, *Microbiology,* 5th Edition, Tata McGraw Hill, 1986.

COORDINATION AND BIOINORGANIC CHEMISTRY

L	T	P	C
3	1	2	5

Scheme

CY204

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Describe the fundamentals of coordination compounds.
CO2	Generalize basic theories on bonding in coordination compounds.
CO3	Identify metal hydrides and their importance.
CO4	Explain role of metal ions in biological processes.
CO5	Explore the use of metal ions and complexes in medicine.

2. Syllabus:

- **COORDINATION CHEMISTRY** **(20 Hours)**
  Ligands, coordination numbers, coordination sphere, Nomenclature, Werner's theory, EAN, Chelates, isomerism in coordination compounds, Valence Bond theory, octahedral, tetrahedral and square planner complexes, Crystal field theory (CFT), Crystal field splitting of d-orbitals in octahedral, square planar and tetrahedral complexes, CFSE, factors affecting the magnitude of Δ, spectrochemical series, Jahn-Teller effect and other crystal-field effects, limitations of CFT, LFT, nephelauxetic series, molecular orbital theory of coordination chemistry, sigma and pi bonding in complexes, Magnetism of complexes.

- **BIOINORGANIC CHEMISTRY** **(12 Hours)**
  Biological roles of alkali and alkaline earth metal ions, ions transport (active) across biological membrane and its significance, mechanism of Na^+/K^+-ions pump; Metalloproteins and enzymes: role of metal ions in the active sites, structure and functions of enzymes containing Zn, Mg, Ca and Cu; Carbonic anhydrase and carboxypeptidase, Zinc finger proteins; Bioinorganic chemistry of copper-electron transfer proteins, dioxygen transport and metabolism, Plastocyanin, haemocyanin, Ascorbate oxidase; nitrogen fixation, Essential and toxic metals ions in different biological processes, Porphyrins, Metalloporphyrins, haemoglobin, and myoglobin, ferritin and transferrin. Structures and functions of cytochromes, cytochrome c; iron-sulfur proteins (ferredoxines) and cytochrome c oxidase, photosynthesis: chlorophyll; Metal complexes in medicine

- **INORGANIC HYDRIDES** **(10 Hours)**
  Classification, preparation, bonding and their applications. Transition metal compounds with bonds to hydrogen, carbonyl hydrides and hydride anions. Classification, nomenclature, Wades Rules, preparation, structure and bonding in boron hydrides (boranes), carboranes, metalloboranes and metallocarboranes.

(Total Lecture Hours: 42)

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3. Practicals:

1. **Iodo / Iodimetric Titrations**
   a. Estimation of Cu(II) and $K_2Cr_2O_7$ using sodium thiosulphate solution (Iodimetrically).
   b. Estimation of (i) arsenite and (ii) antimony in tartar-emetic iodimetrically

2. **Complexometric Titrations (EDTA titrations)**: Titration of mixtures using masking and demasking agents.
   a. Complexometric estimation of (i) Mg^{2+} and (ii) Zn^{2+} using EDTA
   b. Estimation of total hardness of water samples
3. **Argentometry**
   a. Estimation of Cl^- (i) By Mohr's method, (ii) By Volhard's method, (iii) By Fajan's method.
   b. Estimation of copper as CuSCN.
   c. Estimation of iron as Fe_2O_3 by precipitating iron as $Fe(OH)_3$ through,
      (i) Heterogeneous and (ii) Homogeneous media.
   d. Estimation of Al^{3+} by precipitating with oxime and weighing as $Al(oxine)_3$ (aluminiumoxinate).

4. Books Recommended:

1. J. D. Lee, *Concise Inorganic Chemistry*, 5th Edition, Wiley-Blackwell, New Jersey, 1999.
2. J. E. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi, *Inorganic Chemistry-Principles of Structure and Reactivity*, 4th Edition, Pearson Education, London, 2006.
3. S. J. Lippard, J. M. Berg, *Principles of Bioinorganic Chemistry*, University Science Books, Mill Valley, 1994.
4. W. Kaim, B. Schewederski, A. Klein, *Bioinorganic Chemistry -- Inorganic Elements in the Chemistry of Life: An Introduction and Guide*, 2nd Edition, John Wiley & Sons, New York, 2013.
5. E. Crabb, *Metals and life*, 1st Edition, RSC, 2009.

5. Additional Reading Material:

1. R. Crichton, *Biological Inorganic Chemistry: A new introduction to molecular structure and function*, 2rd Edition, Elsevier, 2012.
2. P. Atkins, Shriver, *Inorganic Chemistry*, 5th Edition, Oxford, 2009.

STEREOCHEMISTRY AND REACTION MECHANISM

L	T	P	C
3	1	2	5

Scheme

CY206

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Demonstrate the stereochemistry of simple organic molecules.
CO2	Explain the stereospecific and stereo selective synthesis.
CO3	Acquire the basic concepts and knowledge of various substitution reactions.
CO4	Gain the knowledge in the reaction mechanisms and how the factors are influenced in substitution reactions.
CO5	Apply practical knowledge in the identification of organic compounds.

2. Syllabus:

- **STEREOCHEMISTRY** **(08 hours)**
  Prochirality, chirality, CIP nomenclature of more than one chiral center, methods of resolution, stereospecific and stereoselective synthesis, asymmetric synthesis, optical activity in absence of chiral carbon (biphenyl, allenes and spiranes), chirality due to helical shape.

- **AROMATIC ELECTROPHILIC SUBSTITUTION** **(09 Hours)**
  Aromaticity, Mobius and Huckel rule for polyenes and annulene, effect of substituents on reactivity, theory of activity and deactivity effects. Arenium ion mechanism, orientation and reactivity, ortho and pararatio, Ipso effect, orientation in other ring systems, calculation of partial rate factor, quantitative treatment of reactivity in substrates and electrophiles. Chemistry of naphthalene, anthracene and phenanthrene.Carcinogenicity.Nonbenzenoid aromatic compounds.

- **NUCLEOPHILIC SUBSTITUTION REACTIONS** **(11 Hours)**
  SN^2, SN^1, mixed SN^1 and SN^2 and SET mechanism. Nucleophilic substitution at an allylic, aliphatic trigonal and vinylic carbon.Reactivity effects of structure, attacking nucleophile, leaving group and reaction mechanism, solvent effect, phase transfer catalyst, ambident nucleophile and regioselectivity. Energy profile diagram, diazonium coupling Vilsmeier reaction, Gattermann – Koch reaction, and other carbocyclic rings. $ArSN^1$ and benzyne mechanisms, reactivity effect of substrate structure, leaving group and attacking nucleophile.Introduction of azide, phosphorus and sulphur nucleophiles.

- **REACTION MECHANISM** **(07 Hours)**
  Investigation of reaction mechanism, SN^1 mechanism, nucleophilic substitution of allylic halides. Neighbouring group mechanism, neighbouring group participation by π- and σ- bonds, $-OH$, $-NH_2$, $-COO$, -halogen and aromatic ring, stereochemistry of reactions.

- **ELIMINATION REACTIONS** **(07 Hours)**
  E_1, E_2 and E_1CB mechanism and their spectrum orientation of the double bond, reactivity effects of substrate structures, attacking base, leaving groups and the medium, mechanism and orientation in pyrolytic elimination. Von-Richter and Sommlet-Houser rearrangement.

(Total Lecture Hours: 42)

3. Practicals:

1. Identification of single organic compounds (I to VII).

4. Books Recommended:

1. E. L. Eliel, S. H. Wilen, *Stereochemistry of Organic Compounds*, 1st Edition, John Wiley & Sons, New York, 2008.
2. D. Nasipuri, *Stereochemistry of Organic Compounds: Principles and Applications*, 2nd Edition, New Age International (P) Limited, New Delhi, 2005.
3. M. B. Smith, J. March, *March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure*, 6th Edition, Wiley-Interscience, New Jersey, 2012.
4. A. Streitwieser, Jr., C. H. Heathcock, *Introduction to Organic Chemistry*, 4th Edition, MacMillan Publishing Company, New York, 1998.
5. J. Clayden, N. Greeves, S. Warren, *Organic Chemistry*, 2nd Edition, Oxford University Press, Oxford, 2012.

5. Additional Reading Material:

1. K. P. C. Volhardt, N. E. Schore, *Organic Chemistry: Structure and Function*, 7th Edition, W. H Freeman & Co., 2014.
2. H. Maskill (Ed.), *The Investigation of Organic Reactions and their Mechanisms*, 1st Edition, Blackwell Publishing Ltd. Oxford, 2006.
3. R. L. Shriner, C. K. F. Hermann, T. C. Morrill, D. Y. Curtin, R. C. Fuson, *Systematic Identification of Organic Compounds*, 8th Edition, John Wiley & Sons, New York, 2004.
4. P. S. Kalsi, *Stereochemistry Conformation and Mechanism*, 8th Edition, New Age International, 2015.
5. Jerry March, *Advanced Organic Chemistry: Reactions, Mechanisms, and Structure*, 7th Edition, Wiley-Blackwell; 4th Revised Edition, 2015.

EQUILIBRIUM AND CHANGES

CY208

L	T	P	C
3	1	2	5

Scheme

1. Course Outcomes (Cos):

At the end of the course students will be able to:

CO1	Demonstrate successive relationships between varied equilibria constants and apply the mechanism of phase rule with phase diagram for various systems.
CO2	Explain the thermochemistry in deep and calculate heat of a reaction.
CO3	Enumerate basics of EMF series and its application.
CO4	Accumulate a deep knowledge in surface phenomena applicable in multidisciplinary areas.
CO5	Perform the experiments related to physical chemistry approach which includes Kinetics, Conductometry, Colorimetry, pH-metry, Potentiometry and Titration .

2. Syllabus:

- **THERMOCHEMISTRY** **(08 Hours)**
  Standard state, standard enthalpy of formation, Hess's law and its applications, heat of reaction at constant pressure and at constant volume, enthalpy of neutralization, bond dissociation energy and its calculation from thermochemical data, Kirchhoff's equation, Joule Thomson effect, inversion temperature. Nernst distribution law: Derivation, application and limitations, distribution coefficient, Henry's law, solvent extraction. Numericals.

- **IONIC EQUILIBRIA** **(08 Hours)**
  Ostwald's dilution law and its derivation, Strength of acids and bases on their dissociation constants, ionic product of water, pH scale, measurement of pH, Common Ion effect, buffer capacity, buffer in biological systems, Henderson's equations, hydrolysis of salts, hydrolysis constant, relationship between K_h, K_a, K_b, K_w, degree of hydrolysis, acid base indicators, concept of solubility product. Numericals.

- **PHASE EQUILIBRIA** **(08 Hours)**
  Definition of Phase, Phase boundaries, Components, degree of freedom, phase rule, Thermodynamic condition for phase equilibrium, Phase rule and its derivation, Phase equilibrium for one component system (for example H_2O, S, CO_2), First and second order phase transition, Clapeyron equation, Clausius-Clapeyron equation, Liquid vapor equilibrium for two component system, Critical solution temperature, Completely immiscible systems, Simple eutectic systems: Zn-Cd, Pb-Ag.

- **ELECTROCHEMISTRY – II** **(09 Hours)**
  Single electrode potential, Hydrogen electrode, Galvanic cell, EMF series, Nernst equation, Reversible electrodes, metal-metal ion electrodes, Calomel electrode, Standard Hydrogen Electrode (SHE), Oxidation-Reduction electrodes, Potentiometric titration, Application of electrochemistry in Corrosion control by cathodic protection, batteries, and fuel cells, Interface of chemical sciences with other disciplines. Numerical.

- **SURFACE CHEMISTRY** **(09 Hours)**
  Adsorption (Physisorption and chemisorption), adsorption isotherms, BET equation for estimation of surface area. Solid-liquid interfaces, Contact angle and wetting, Solid-gas interface, Surface

active agents and their classification, Gibbs adsorption from solution, Critical micellar concentration (CMC), micelles, thermodynamics of micellization, reverse micelles.

(Total Lecture Hours: 42)

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3. Practicals:

1. Determine the rate constant and the order of the reaction of $KBrO_3$ and KI in acid medium.
2. Determination of the partition coefficient of iodine (I_2) between carbon tetrachloride (CCl_4) and water.
3. Determination of ionization constant of a weak acid by Conductometric method.
4. Determination of equivalent conductance (Λ_∞) of weak monobasic (acetic acid) and verify Ostwald's Dilution Law.
5. To find out the strength of HCl solution (N/10) by pH-metric titration against standard NaOH solution.
6. To study the kinetics of saponification of ester by conductometric method.
7. Determination of absorbance of $K_2Cr_2O_7$ and $KMnO_4$ and their mixture using colorimetry. Further verify Beer's law for them. Also determine their unknown concentration in given sample solution.
8. To determine individual concentration of Cu^{2+} and Ca^{2+} in the mixture using EDTA.

4. Books Recommended:

1. G. M. Barrow, *Physical Chemistry*, 6th Edition, McGraw-Hill, New Delhi, 1996.
2. B. R. Puri, L. R. Sharma, M. S. Pathania, *Principles of Physical Chemistry*, 47th Edition, Vishal Publications, New Delhi, 2017.
3. G. Raj, *Advanced Physical Chemistry*, 4th Edition, Goel Publishing House, Meerut, 1990.
4. S. K. Maity, N. K. Ghosh, *Physical Chemistry Practical*, 1st Edition, New Central Book Agency (P) Ltd., Kolkata, 2012.
5. S. Glasstone, *An Introduction to Electrochemistry,* Maurice Press, 2011.

MODERN PHYSICS

L	T	P	C
3	0	0	3

Scheme

PH212

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Enumerate the limitations of Classical Physics and need for a new theory.
CO2	Identify the relevance of concepts of Modern Physics and their implications.
CO3	Interpret the results of Quantum Physics and relevant laws.
CO4	Explain the Black body radiation laws, duality of waves and matter and their significance.
CO5	Analyze the relevant problems of modern physics including Lasers.

2. Syllabus:

- **LIMITATIONS OF CLASSICAL PHYSICS AND INTRODUCTION TO QUANTUM PHYSICS** **(08 Hours)**
  Classical physics as an approximate of quantum physics, limitations of classical Physics at microscopic levels.

- **BASICS OF QUANTUM PHYSICS AND QUANTUM MECHANICS** **(08 Hours)**
  Black body radiation, Wein's, Rayleigh-Jeans, and Planck's laws, Dual nature, Atomic models, Exclusion principle, and quantum numbers, The wave equation.

- **PHOTOELECTRIC EFFECT AND COMPTON EFFECT** **(06 Hours)**
  Photoelectric effect and Einstein's explanation, Compton effect and equation of Wavelength.

- **X – RAYS** **(08 Hours)**
  Production and characteristics of X-rays, X-ray diffraction and Bragg's law.

- **LASERS, FIBRE OPTICS & APPLICATIONS** **(12 Hours)**
  Laser fundamentals, types of lasers, Basics of Fibre optics, types of fibres, applications.

(Total Lecture Hours: 42 Hours)

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3. Books Recommended:

1. A. Beiser, *Concept of the Modern Physics*, Tata McGraw Hill, 2008.
1. A. Ghatak, *Optics*, Tata McGraw Hill, 2005.
2. M. R. Wehr, J. A. Richards, T. W. Adair, *Physics of the Atom*, Addison – Wesley, 1984.
3. R. Harris, *Modern Physics*, Addison-Wesley/ Pearson,2/E ,2007
4. M. Born, E. Wolf, *Principles of Optics*, Cambridge Uni. Press, 2000.

COMPUTATIONAL CHEMISTRY LAB. – II

L	T	P	C
0	0	4	2

Scheme

CY212

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Calculate molecular spectroscopy
CO2	Enumerate excited state geometry and properties
CO3	Compare theoretical and experimental spectra
CO4	Express molecular dynamic simulations
CO5	Explain molecular docking with suitable examples

2. Syllabus:

- **CALCULATING SPECTROSCOPIC PROPERTIES** **(20 Hours)**
  IR and Raman spectra, DFT and TD-DFT calculations, UV-Vis and emission spectra, Excited states properties and structure, NMR spectra and spin-spin coupling constants, Vibrational circular dichroism (VCD), Raman optical activity (ROA), Electronic circular dichroism (ECD), Optical rotary dispersion (ORD), Hyperfine spectra (microwave spectroscopy).

- **MOLECULAR DYNAMIC SIMULATIONS** **(18 Hours)**
  Discussion on the basic theories and algorithms used for dynamic simulations, Dynamics of drugs, biomolecules, drug-receptor complexes, Molecular dynamics in performing conformational search and other applications. Estimation of free energy from dynamical methods, Hand-on experience with some standard software with suitable examples.

- **MOLECULAR DOCKING** **(18 Hours)**
  Discussion on the basic theories and algorithms used on docking, Rigid docking, flexible docking, manual docking. Hand-on experience with Autodock and other Dock software, Applications.

(Total Contact Hours: 56)

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3. Practical:

1. Introduction to use of computation tools in predicting molecular spectroscopy.
2. To calculate IR using the Gaussian 09W and to demonstrate the other importance of frequency calculations.
3. To calculate Raman and polarizability using the Gaussian 09W
4. To calculate the UV Vis spectrum of acrolein using CIS/TDDFT method.
5. To calculate the emission spectra of phenol using the Gaussian 09W.
6. Theoretical predicting 1H and 13C NMR spectra and spin-spin coupling constants of ethanol.
7. To calculate vibrational circular dichroism (VCD) and Raman optical activity (ROA) using the Gaussian 09W.
8. To calculate Electronic circular dichroism (ECD), Optical rotary dispersion (ORD) using the Gaussian 09W.

9. Demonstration to perform molecular dynamic simulation with Gromacs/Amber.
10. Demonstration to perform molecular docking with Autodock.

3. Books Recommended:

1. J. B. Foresman, A. Frisch, *Exploring Chemistry with Electronic Structure Methods*, 2nd Edition, Gaussian, Inc., Pittsburgh, 1996.
2. D. Young, *Computational Chemistry: A Practical Guide for Applying Techniques to Real World Problems;* 1st Edition, John Wiley & Sons, inc: USA, 2001.
3. A. R. Leach, *Molecular Modelling: Principles and Applications*, 2nd Edition, Prentice Hall, 2001.
4. E. G. Lewars, *Computational Chemistry: Introduction to the Theory and Applications of Molecular and Quantum Mechanics,* 3rd Edition, Springer, 2011.
5. A. Kukol, *Molecular Modelling of Proteins*, 2nd Edition, Springer, 2015.

THIRD YEAR OF FIVE YEARS INTEGRATED M. Sc. (CHEMISTRY)
M. Sc. - III, SEMESTER - V

Sr. No.	Subject	Code	Scheme	Credit	Examination Scheme				Total Marks
					Theory	Tutorial	Practical		
							Int.	Ext.	
1.	Organometallic Chemistry	CY-301	3-1-4	06	100	25	60	40	225
2.	Pericyclic Reactions and Photochemistry	CY-303	3-1-4	06	100	25	60	40	225
3.	Analytical Chemistry	CY-305	3-0-4	05	100	00	60	40	200
4.	Unit Process in Organic Chemistry Industries	CY-307	3-0-0	03	100	00	00	00	100
5.	Institute Elective-1	-	3-0-0	03	100	00	00	00	100
Total contact hours per week=29			**Total Credits=23**			**Total Marks=850**			

THIRD YEAR OF FIVE YEARS INTEGRATED M. Sc. (CHEMISTRY)
M. Sc. - III, SEMESTER - VI

Sr. No.	Subject	Code	Scheme	Credit	Examination Scheme				Total Marks
					Theory	Tutorial	Practical		
							Int.	Ext.	
1.	Interpretative Molecular Spectroscopy	CY-302	3-1-4	06	100	25	60	40	225
2.	Molecules in Motion and Reaction Dynamics	CY-304	3-1-4	06	100	25	60	40	225
3.	Polymer Chemistry	CY-306	3-0-4	05	100	00	60	40	200
4.	Chemistry in Industries	CY-308	3-0-0	03	100	00	00	00	100
5.	Institute Elective-2	-	3-0-0	03	100	00	00	00	100
Total contact hours per week=29			**Total Credits=23**			**Total Marks=850**			

ORGANOMETALLIC CHEMISTRY

CY301

L	T	P	C
3	1	4	6

Scheme

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain on fundamental principles of organ transition-metal chemistry.
CO2	Discuss the stability and reactivity of organometallic complexes.
CO3	Express into the use of modern methods to characterize organometallic compounds.
CO4	Distinguish between metal carbonyls, cages and rings.
CO5	Explore the applications of organometallics in catalysis.

2. Syllabus:

- **METALLOORGANIC CHEMISTRY-I** **(12 Hours)**
  Introduction, classification based on the nature of metal carbon bond including л-metal complexes, hapticity (η), general methods of preparations and properties, organometallic compounds of alkali metals, Be, Mg, Al, metal olefin complexes; Cyclopentadienyl complexes: Metallocenes, some properties of ferrocene, structure, bonding and reactions in ferrocene molecule, Ionic cyclopentadienyl compounds.

- **METALLOORGANIC CHEMISTRY-II** **(12 Hours)**
  Organometallic compounds: metal alkyls, metal aryls, electron deficient organometallic compounds, electron rich organometallics, Agostic interaction, stereochemicalnonrigidity and fluxional behaviour of organometallic compounds with typical examples, transition metal π complexes with unsaturated organic ligands, fluxional organometallic compounds: fluxionality and dynamic equilibria in compounds such as η2 olefins, η3 allyl and dienyl complexes, Metal hydrogen and metal halogen exchange reactions, Transmetallation reactions, important reactions of Grignard reagent.

- **METAL CARBONYL AND CLUSTERS** **(12 Hours)**
  Metal carbonyl, structure and bonding in mononuclear metal carbonyls, metal clusters, carbonyl clusters, low nuclearity carbonyl clusters, high nuclearity carbonyl clusters, electron counting scheme, Wade's rules, halide type clusters, chevrel phases, Zintlclusters, metal–metal single and multiple bonds, isolobal analogy, cages and rings.

- **ORGANOMETALLIC COMPOUNDS IN HOMOGENEOUS CATALYSIS** **(06 Hours)**
  Homogeneous catalysis: hydrogenation, hydroformylation and polymerization of olefins (Ziegler-Natta catalysis, metallocenes), Mechanism of homogeneous catalysis reactions – addition, elimination, migration and insertion reactions. Wacker's oxidation (Pd-catalyzed), Water gas shift reactions and Fischer-Tropsch process.

(Total Lecture Hours: 42)

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3. Practicals:

Identification of cations and simple anions in a mixture of salts containing four/six ions (cations and anions):
Cations : Pb^{2+}, Bi^{3+}, Cu^{2+}, Cd^{2+}, As^{3+}, Sb^{3+}, Sn^{2+} or Sn^{4+}, Fe^{2+}or Fe^{3+}, Al^{3+}, Cr^{3+},Co^{2+}, Ni^{2+}, Zn^{2+}, Mn^{2+}, Ba^{2+}, Sr^{2+}, Ca^{2+}, Mg^{2+}, NH^{4+} and K^{+}.
Anions : CO_3^{2-}, SO_3^{2-}, CO_2^{3}, SO_2^{-3}, S^{2-}, NO^{-2}, CH_3 COO^{-}, NO^{-3}, Cl^{-}, Br^{-}, I^{-}, SO_4^{2-}, PO_4^{3-}, BO_3^{3-}, F^{-} and $C_2O_2^{-4}$.

4. Books Recommended:

1. M. Bochmann, *Oxford Premier Series on Organometallics* Volume 1 & 2, 1st Edition, Oxford Press, Oxford, 2002.
2. A. F. Hill, *Organotransition Metal Chemistry*, The Royal Society of Chemistry, Cambridge, 2002.
3. R. H. Crabtree, *The Organometallic Chemistry of the Transition Metals*, 6th Edition, John Wiley & Sons, New York, 2014.
4. W. W. Porterfield, *Inorganic Chemistry: A Unified Approach*, 2nd Edition, Academic Press, Cambridge, 1993.
5. J. E. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi, *Inorganic Chemistry-Principles of Structure and Reactivity*, 4th Edition, Pearson Education, London, 2006.

PERICYCLIC REACTIONS AND PHOTOCHEMISTRY

L	T	P	C
3	1	4	6

Scheme

CY303

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Recognize molecular orbital symmetry and Frontier molecular orbitals approach.
CO2	Acquire the knowledge on the laws of photochemistry in various photochemical reactions.
CO3	Illustrate the mechanisms of free radical reactions.
CO4	Formulate molecular structure by using valence bond and molecular orbital theories.
CO5	Explain organic reaction mechanisms for synthesis of bioactive compounds.

2. Syllabus:

- **PERICYCLIC REACTIONS** **(08 Hours)**
  Molecular orbital symmetry, Frontier molecular orbitals approach, 1,3-butadiene, 1,3,5-hexatriene. Classification of pericyclic reactions, FMO and PMO approach, correlation diagrams, Woodward-Hoffman rules, Electrocyclic reactions-conrotatory and disrotatory motions, 4n and 4n+2 systems, Cycloadditions-antrafacial and suprafacial additions in 4n and 4n+2 systems. Sigmatropic rearrangements-suprafacial and antrafacial shifts of H.

- **PHOTOCHEMISTRY** **(15 Hours)**
  Quantum yields, techniques in photochemistry, photosensitization and quenching mechanism. Laws of photochemistry, thermal and photochemical reactions. Photochemistry of olefins: cis-trans isomerisation, dimerisation reactions, Di-π methane rearrangement, Photochemistry of aromatic compounds and its isomerisation.
  Photochemistry of carbonyl compounds: Representation of excited states of ketones, Reactivity of electrically excited ketones, Photo reduction, Norrish type I & II reactions, Reactions of cyclic ketones, oxetane formation (Paterno-Buchi reaction). Photochemistry of aromatic compunds and nitrogen containing organic compounds. Reaction of singlet-oxygen and photocatalytic oxygenation reactions.

- **FREE RADICAL REACTIONS** **(10 Hours)**
  Generation of free radicals - thermolysis, photolysis, redox methods, abstraction, addition and fragmentation; Generation of radical intermediates and its (a) addition to alkenes, alkynes (inter- and intra- molecular) for C-C bond formation and Baldwin's rules (b) fragmentation and rearrangements. Barton deoxygenation and decarboxylation, McMurry coupling. Electron transfer catalysis; Factors influencing radical reactivities- radical stability, polar influences, solvent and steric effects on radical reactions.

- **REAGENTS** **(09 Hours)**
  Mechanism of action, selectivity and utility of following reagents: Selenium dioxide, Aluminium isopropoxide, Diazomethane, Lead tetra acetate, Sodamide, N-Bromosuccinimide, Lithium aluminium hydride, Osmium tetraoxide, Raney nickel, Sodium borohydride, Manganese dioxide, Lithium diisopropylamide (LDA), DCC, DDQ, HIO_4.

(Total Lecture Hours: 42)

3. Practicals:

1. Separation and identification of organic components in binary mixture (Four Mixture).
2. Separation and Identification of organic components in ternary mixture (Four Mixture).

4. Books Recommended:

1. N. J. Turro, *Modern Molecular Photochemistry*, University Science Books, Sausalito, California, 1991.
2. A. Gilbert, J. Baggot, *Essentials of Molecular Photochemistry*, Blackwell Scientific Publications, Oxford & Boston, 1990.
3. I. Fleming, *Pericylic Reactions*, 2nd Edition, Oxford University Press, Oxford, 1998.
4. T. L. Gilchrist, R. C. Storr, *Organic Reactions and Orbital Symmetry*, 2nd Edition, Cambridge University Press, London, 1979.
5. H. Maskill (Ed.), *The Investigations of Organic Reactions and Their Mechanisms*, 1st Edition, Blackwell Publishing Ltd. Oxford, 2006.

5. Additional Reading Material:

1. B. S. Furniss, A. J. Hannaford, P. W. G. Smith, A. R. Tatchell, *Vogel's Textbook of Practical Organic Chemistry*, 5th Edition, Longman Scientific & Technical, England, 2005.
2. F. A. Carey, R. J. Sundburg, *Advance Organic Chemistry: Structure and Mechanism (Part A) (English)*, 5th Edition, Springer, 2007.

ANALYTICAL CHEMISTRY

L	T	P	C
3	0	4	5

Scheme

CY305

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Gain the basics of Numerical Analysis of analytical data.
CO2	Design the quantitative approaches through conventional methods of analysis.
CO3	Acquire knowledge on electrophoresis and its applications in multidisciplinary areas.
CO4	Develop the basic concepts and applications of atomic spectrometry.
CO5	Establish the correlation between conventional and modern approach for quantitative analysis.

2. Syllabus:

- **NUMERICAL ANALYSIS** **(08 Hours)**
  Presentation of analytical data: accuracy, precision, sensitivity, selectivity, robustness and ruggedness. Classification of errors, significant figures, mean deviation and standard deviations, gaussian distribution, treatment of small sets of data: range rejection of data - 2.5d rule, 4d rule and Q –test.

- **CONVENTIONAL METHODS FOR QUANTITATIVE ANALYSIS** **(14 Hours)**
  Precipitation methods, purity and optimum conditions for precipitation, precipitation from homogeneous solution, washing and ignition of the precipitate, role of organic precipitants in gravimetric analysis. Importance, classification of volumetric methods, acid-base titrations, acid-base titration curves, acid-base indicators, mixed and fluorescent indicators.
  Theory of redox titration curves, oxidizing agents as titrants, applications of iodine as a redox reagent, redox indicators, detection of end point in redox titrations. Theory of precipitation, titration curves, factors influencing solubility of precipitate, titration by turbidity without an indicator, Volhard"s and Mohr"s Methods, adsorption indicators in precipitation titrations. EDTA and complexones, complexometric titration curves, metallochromic indicators, kinetics and selectivity in complexometric titration, typical EDTA titrations, advantages of complexometric titrations.

- **ELECTROPHORESIS** **(08 Hours)**
  Introduction – migration rates and plate hights in CE – electroosmotic flow - various types of electrophoresis -instrumentation – detectors – microchip electrophoresis – CE-MS - applications.

- **ATOMIC SPECTROMETRY** **(12 Hours)**
  Flame spectrometry: introduction, elementary theory, instrumentation, type of burners, interferences, type of interferences, background correction method and applications.
  Atomic Absorption Spectrometry (AAS): Principle, instrumentation, production of atoms and ions, burners, detectors, advantage and disadvantage of AAS, standard addition method, internal standard method. Atomic Emission Spectrometry (AES): Principle, instrumentation, qualitative and quantitative analysis with AES, plasma emission spectrometry, direct current plasma, inductively coupled plasma, ICP-AES, high energy sources (plasma, arc, and spark), sample introduction and measurements.

(Total Lecture Hours: 42)

3. **Practicals:**

1. Gravimetric Determination of Calcium as $CaC_2O_4.H_2O$
2. Statistical Evaluation of Acid-Base Indicators.
3. Spectrophotometric Determination of Iron in Vitamin Tablets.
4. Spectrophotometric Measurement of an Equilibrium Constant.
5. Spectrophotometric Analysis of a Mixture: Caffeine and Benzoic Acid in Soft Drink
6. Measuring Manganese in Steel by Atomic Absorption Using a Calibration Curve.
7. Anion Content of Drinking Water by Capillary Electrophoresis.

4. **Books Recommended:**

1. S. M. Khopkar, *Basic Concepts of Analytical Chemistry*, 3rd Edition, New Academic Science, New Delhi, 2008.
2. D. A. Skoog, D. M. West, Holler, Crouch, *Fundamentals of Analytical Chemistry*, 8th Edition, Cengage Learning, USA, 2013.
3. J. H. Kennedy, *Analytical Chemistry: Principles*, 2nd Edition, Saunders College Publishers, Philadelphia, 1990.
4. G. D. Christian, P. K. Dasgupta, K.A. Schug, *Analytical Chemistry*, 7th Edition, John Wiley & Sons, New York, 2004.
5. R. A. Day, A.L. Underwood, *Quantitative Analysis*, 6th Edition, Prentice Hall, Inc. New Delhi, 1993.

5. **Additional Reading Material:**

1. R. M. Verma, *Analytical Chemistry: Theory and Practice*, 3rd Edition, CBS Publishers, New Delhi, 2004.
2. H. Kaur, *Instrumental Methods of Chemical Analysis (Analytical Chemistry)*, Pragati Prakashan, Meerut, 2012.

UNIT PROCESS IN ORGANIC CHEMISTRY INDUSTRY

L	T	P	C
3	0	0	3

Scheme

CY307

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Acquire an introductory knowledge of chemical industry and unit processes.
CO2	Build a bridge between theoretical and practical concept used in industry.
CO3	Explore the various synthetic methods of producing industrial chemicals and their applications.
CO4	Apply knowledge about the basic chemistry of production.
CO5	Appraise the industrial chemical process of transforming raw materials to desired products.

2. Syllabus:

- **NITRATION** **(06 Hours)**
  Introduction, Nitrating Agents, Aromatic Nitration, Process Equipment for Technical Nitration, Batch Nitration, Continuous Nitration, manufacturing of nitrobenzene by batch and continuous process using fortified spent acid, m-dinitrobenzene and p-nitro acetanilide.

- **AMINATION BY REDUCTION & AMMONOLYSIS AND HALOGENATION** **(08 Hours)**
  Amination: Introduction, Different types of reduction reactions, Schimdt and Biazzi nitrators, different reduced products of nitrobenzene, manufacturing of aniline by Bechamp reduction, m-nitro aniline and aniline by ammonolysis.
  Halogenation: Introduction, different halogenating agents and halogenation reactions, mechanism and manufacturing of BHC and chlorobenzene.

- **SULFONATION & SULFATION** **(05 Hours)**
  Introduction, Sulfonating & Sulfating agents, Sulfonation of Aromatic Compounds. Chemical and physical factors in sulfonation and sulfation, Commercial manufacturing of benzene sulfonic acid (Barbet process) and naphthalene sulfonic acid.

- **OXIDATION** **(06 Hours)**
  Introduction, Types of oxidizing agents and reactions, Oxidation of toluene with MnO_2. Manufacture of acetaldehyde from acetic acid and acetic acid from ethanol. Commercial manufacturing of benzoic acid and phthalic anhydride.

- **HYDROGENATION** **(5 Hours)**
  Introduction and scope, properties and sources of hydrogen, gas catalytic hydrogenation and hydrogenolysis, factors affecting hydrogenation, industrial hydrogenation of fat and oil, manufacture methanol from CO_2 and H_2.

- **ALKYLATION** **(05 Hours)**
  Introduction, Types of alkylation, alkylating agents, factors controlling alkylation, equipment for alkylation, manufacture of alkyl aryl sulphonates and ethylbenzene by continuous process.

- **ESTERIFICATION AND HYDROLYSIS** **(07 Hours)**
  Esterification: Introduction, Esterification of organic acids. Commercial manufacture of some important compounds.

Hydrolysis: Introduction, Hydrolysing agents, Equipment for hydrolysis, industrial hydrolysis of fat, manufacture of ethanol from ethylene (Shell process) and phenol from benzene sulfonic acid.

(Total Lecture Hours: 42)

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3. Books Recommended:

1. P. H. Groggins, *Unit Processing of Organic Synthesis*, 5th Edition, Tata-McGraw Hill, New Delhi, 2001.
2. C. E. Dryden, M. Gopalarao (Ed.), M. Sitting (Ed.), *Dryden's Outlines of Chemical Technology*, 2nd Edition, East-West Pub., New Delhi, 1997.
3. R. N. Shreve, G. T. Austin, *Shreve's Chemical Process Industries*, 5th Edition, McGraw-Hill Pub., New York, 1984.
4. R. M. Felder, R. W. Rousseau, *Elementary Principles of Chemical Processes*, 3rd Edition, John Wiley, New York, 2000.
5. J. A. Kent (Ed.) *Riegel's Handbook of Industrial Chemistry*, 10th Edition, Kluwer Academic / Plenum Publishers, New York, 1985.

THIRD YEAR OF FIVE YEARS INTEGRATED M. Sc. (CHEMISTRY)
M. Sc. - III, SEMESTER - VI

Sr. No.	**Subject**	**Code**	**Scheme**	**Credit**	**Examination Scheme**				**Total Marks**
					Theory	**Tutorial**	**Practical**		
							Int.	**Ext.**	
1.	Interpretative Molecular Spectroscopy	CY-302	3-1-4	06	100	25	60	40	225
2.	Molecules in Motion and Reaction Dynamics	CY-304	3-1-4	06	100	25	60	40	225
3.	Polymer Chemistry	CY-306	3-0-4	05	100	00	60	40	200
4.	Chemistry in Industries	CY-308	3-0-0	03	100	00	00	00	100
5.	Institute Elective-2	-	3-0-0	03	100	00	00	00	100
Total contact hours per week=29				**Total Credits=23**		**Total Marks=850**			

INTERPRETATIVE MOLECULAR SPECTROSCOPY

CY302

L	T	P	C
3	1	4	6

Scheme

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the theories and basic principles of spectroscopic techniques.
CO2	Acquire the effect of solvent and hydrogen bonding on vibrational frequencies.
CO3	Identify the organic functional groups by FT-IR.
CO4	Enumerate gas-phase reactions and to predict the fragmentation of organic molecules by mass spectrometry.
CO5	Elucidate an unknown structure, or to solve a structure-related problem by utilizing spectroscopic data.

2. Syllabus:

- **UV-VISIBLE ABSORPTION AND EMISSION SPECTROSCOPY** **(10 Hours)**
  Mechanism of absorption and emission of radiation by organic compounds, shape of absorption and emission bands and Franck-Condon principle. Various electronic transitions, Lambert-Beer law, effect of solvent on electronic transition, Ultraviolet bands for carbonyl compound, unsaturated carbonyl compounds, Woodward-Fiese's rules for conjugated dienes and carbonyl compounds, UV spectra of aromatic and heterocyclic compounds steric effect in biphenyls. Principles, origin of fluorescence and phosphorescence spectra, variables affecting fluorescence and phosphorescence spectra, instrumentation and applications. Delayed fluorescence, determination of fluorescence quantum yield, introductory Time-resolved fluorescence spectroscopy, types of relaxation processes.

- **INFRARED SPECTROSCOPY** **(07 Hours)**
  Instrumentation and sample handling, characteristic vibrational frequencies of alkanes, alkenes, alkynes, aromatic compounds, alcohols, ethers, phenols, amines, carbonyl compounds, esters, amides, anhydrides, lactones and lactams. Effect of solvent and hydrogen bonding on vibrational frequencies, overtones, IR of gaseous, solids and polymeric materials.

- **NUCLEAR MAGNETIC RESONANCE SPECTROSCOPY** **(15 Hours)**
  NMR phenomenon, spin ½ nuclei, (1H, 13C, 31P and 19F), Zeeman splitting, effect of magnetic field strength on sensitivity and resolution, chemical shift δ, inductive and anisotropic effects on δ, chemical structure correlations of δ, chemical and magnetic equivalence of spins, spin-spin coupling, structural correlation to coupling constant J, first order patterns, second order effects, examples of AB, AX and ABX systems, simplification of second order spectrum, selective decoupling, use of chemical shift reagents for stereochemical assignments. 13C NMR, introduction to FT technique, relaxation phenomena, NOE effects, 1H and 13C chemical shifts to structure correlations.

- **MASS SPECTROMETRY** **(10 Hours)**
  Basic principles, ionization techniques, isotope abundance, molecular ion, fragmentation processes of organic molecules, deduction of structure through mass spectral fragmentation, high resolution

MS, soft ionization methods, ESI-MS and MALDI-MS, illustrative examples from macromolecules and supramolecules, Fragment ions of odd and even electron types – rearrangement ions – factors affecting cleavage patterns –simple and multicentre fragmentation – McLafferty rearrangement – Retro Diels-Alder fragmentation. Mass spectra of hydrocarbons, alcohols, phenols, aldehydes, ketones, carboxylic acids, amines and their derivatives. Studies of inorganic / coordination and organometallic representative compounds.

(Total Lecture Hours: 42)

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3. Practicals:

1. UV-visible spectrometric determination of iron content in tablets OR nicotine content in cigarette tobacco.
2. UV-visible spectrometric determination of the concentration of KMnO4 and K2Cr2O7.
3. Kinetics of Hydrolysis of Acetic Anhydride by In-Situ FTIR Spectroscopy
4. Analysis of drugs (PCM, Crocin, Aspirin, Ibuprofen) from provided samples & determine using FTIR spectroscopy.
5. Determination of caffeine content in coffee using Fourier transform infra-red spectroscopy in combination with attenuated total reflectance technique.
6. Determination of acid dissociation constant by ^{1}H-NMR spectroscopy.
7. Measuring alcohol content in cough syrup using ^{1}H-NMR spectroscopy.
8. Synthesis of Aspirin and characterization of its purity by FTIR and 1H-NMR.

3. Books Recommended:

1. K. W. Silverstein, F. X. Webster, D. J. Kiemle, D. L. Bryce, *Spectrometric Identification of Organic Compounds*, 8th Edition, John Wiley & Sons, New York, 2014.
2. J. R. Lakowicz, *Principles of Fluorescence Spectroscopy*, 3rd Edition, Springer, USA, 2006.
3. M. Sauer, J. Hofkens, J. Enderlein, *Basic Principles of Fluorescence Spectroscopy*, Wiley-VCH, New York, 2011.
4. J. H. Gross, *Mass Spectrometry*, 2nd Edition, Springer Berlin Heidelberg, Germany, 2011.
5. G. M. Lampman, D. L. Pavia, G. S. Kria, J. R. Vyvyan, *Spectroscopy International Edition*, 4th Edition, Cengage Learning India Pvt. Ltd., New Delhi, 2012.

MOLECULES IN MOTION AND REACTION DYNAMICS

CY304

L	T	P	C
3	1	4	6

Scheme

1. Course Outcomes (Cos):

At the end of the course students will be able to:

CO1	Interpret rate of reactions through various kinetic theories and understand mechanism of enzyme catalysis.
CO2	Explain the advances in electrodes and electrolytic reactions.
CO3	Demonstrate the deep theoretical knowledge of colloidal chemistry.
CO4	Accumulate the theoretical basics of statistical thermodynamics
CO5	Perform the experiments related to physical chemistry approach which includes Kinetics, Conductometry, Colorimetry, pH-metry, Potentiometry and Titration.

2. Syllabus:

- **CHEMICAL KINETICS - II** **(12 Hours)**
  Collision theory, Arrhenius equation, rate determining step (RDS), activation energy concept, transition state theory, steady state and equilibrium approximation, parallel and consecutive reactions, reversible reactions. Temperature dependence and the Arrhenius theory of reaction rates, Collision theory of bi-molecular gaseous reaction, collision and the steric effects, limitations, The transition-state theory, statistical mechanical approach to the transition state theory, derivation of rate equation, Thermodynamic formulation of transition state theory, Unimolecular gas reactions: Lindeman-Christiansen hypothesis, the Hinshelwood's theory, Rice-Ramsperger-Kassel theory. Mechanism and Kinetics of Enzyme catalysis and Surface Reactions. Numericals.

- **ELECTROCHEMISTRY-III** **(12 Hours)**
  Different types of electrodes and electrolyte concentration cell, liquid junction potential (LJP), methods for elimination of LJP, salt bridge, concentration cell with and without transference (with derivation of equation for EMF of cell and LJP). Electrode-electrolyte interface and its mechanism of charge transfer. Electrolytic polarization, Decomposition potential, over voltage, concentration polarization, Measurement of over voltage, influence of current density and temperature on over voltage, Ionic discharge as the slow process at cathodes. Tafel and proton transfer theory of hydrogen and oxygen over voltage, applications of EMF in the determination of: solubility product and solubility of sparingly soluble salts, ionic product of water by galvanic cell, transport number of ions, equilibrium constant, pH by hydrogen, glass and quinhydrone electrodes. Numericals.

- **COLLOIDAL CHEMISTRY – II** **(08 Hours)**
  Donnan membrane equilibrium, Qualitative understanding of electro-kinetic phenomenon: Electrokinetic phenomena, Electrophoresis, Electro osmosis, Sedimentation potential and streaming potential. Electrical double layer (Stern and DLVO theory), Zeta potential, Mechanism of coagulation, Schulze-Hardy rule, Gold number. Dialysis, electro-dialysis, Ultrafiltration, Ultramicroscope, Charge on colloidal particles, Coagulation of colloidal solution, Flocculation values, Determination of size and colloidal particles. Applications.

- **STATISTICAL THERMODYNAMICS** **(10 Hours)**
  Limitations of Classical thermodynamics, Distribution laws: Boltzmann, Bose-Einstein, and Fermi-Dirac, limitations of applicability of various distribution laws. Partition function and its

significance. Translational, rotational, vibrational, and electronic partition functions of diatomic molecules and their evaluation. Relation between partition and their thermodynamic function, average internal energy, heat capacity, Helmholtz free energy and entropy of mono- and di-atomic molecules, Sekur-Tetrode equation. Numericals.

(Total Lecture Hours: 42)

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3. Practicals:

1. Determine the order and rate constant of the reaction between $K_2S_2O_8$ and KI. Also study the influence of ionic strength on the rate constant.
2. Study of the effect of substituent on the dissociation constant of weak acid by conductance (Acetic acid, mono-, di-, and tri-chloro acetic acid).
3. Determine the dissociation constants (pK_a values) of tribasic acid by pH-metry (e.g. ortho Phosphoric acid).
4. Preparation of Phenol-Formaldehyde (PF) resin.
5. To determine the solubility product of $BaSO_4$ conductometrically.
6. Study the phase diagram of a binary system (Phenol + water) and the effect of impurities (e.g. NaCl).
7. Verify the Onsager equation using KCl, K_2SO_4 and $BaCl_2$ as electrolytes and determine their equivalent conductivity at different dilutions and from them find out the equivalent conductivity of a weak electrolyte at infinite dilution.
8. To determine the CMC of any surfactant at room temperature in aqueous solution by conductance method.

4. Books Recommended:

1. S. Glasstone, *Thermodynamics for Chemists*, 1st Edition, Affiliated East-West Press Pvt. Ltd., New Delhi, 2009.
2. R. P. Rastogi, R. R. Misra, *An Introduction to Chemical Thermodynamics*, 4th Edition, Vikas Publishing House Pvt. Ltd., New Delhi, 1986.
3. B. R. Puri, L. R. Sharma, *Principles of Physical Chemistry*, 8th Edition, Vishal Publications, New Delhi, India, 2001.
4. S. Maity, N. Ghosh, *Physical Chemistry Practical*, 1st Edition, New Central Book Agency (P) Ltd., India, 2012.
5. M. C. Gupta, *Statistical Thermodynamics*, 2nd Edition, New Age International Pvt. Ltd., 1995.

POLYMER CHEMISTRY

L	T	P	C
3	0	4	5

Scheme

CY306

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the general reaction course and reaction mechanism for common polymerizations.
CO2	Describe and compare the polymerization principles.
CO3	Calculate parameters and outcomes of polymerizations.
CO4	Evaluate polymerizations from a green chemistry perspective.
CO5	Practically perform different types of polymerizations.

2. Syllabus:

- **INTRODUCTION** **(04 Hours)**
  Introduction, classification of polymers, general characteristics of polymers in comparison with organic compound, distinction between plastics, elastomers, fibres and liquid resins, properties of polymers.

- **CHAIN POLYMERIZATION** **(10 Hours)**
  Preparative methods, properties and application: Low density (branched) polyethylene, polypropylene, high density (linear), polyethylene, polypropylene, natural rubber, rubbers derived from butadiene–acrylic acid copolymers, stereo-regular polybutadienes, polychloroprene (neoprene), styrene- butadiene –acrylonitrile copolymers.
  Carbon–carbon polymers- polystyrene, copolymers of polystyrene, acrylic polymers–acrylic fibers, acrylic adhesives, poly acrylates, polymethyl methacrylate(PMMA), polyvinyl acetate (PVA), polyvinyl alcohol, poly vinylchloride, fluorocarbon polymers.

- **CONDENSATION POLYMERIZATION** **(10 Hours)**
  Preparative methods, properties and application: Polyamides, Nylon 6, Nylon 66, Nylon 610, polyesters, polyether and related polymers – poly ethylene terephthalate (PET), polybutyllene, terphthalate (PBT), aromatic polyesters, polycarbonate, polyurethanes – Flexible and rigid polyurethane, polyurethane elastomers, coatings, adhesives, sulphur, containing polymers. Thermosetting resins – phenolic resins, amino resins epoxy resins.

- **POLYMER PROCESSING** **(06 Hours)**
  Basic processing operations, extrusion, calendaring, sheet forming, stamping, casting, fibre spinning, injection moulding, thermoforming, vulcanisation of elastomers.

- **POLYMER CHARACTERIZATION** **(12 Hours)**
  Identification and characterization of polymers: tensile strength, impact strength, elongation at break, water resistance, hardness, heat distortion temperature, brittleness, flexural strength, molecular weight and molecular weight distribution-number, weight and viscosity average molecular weights of polymers, methods of determining, molecular weight, Rheology of polymer, Fractionation of polymers, chemical analysis of polymers, mechanical properties of polymers glassy state, glass transition temperature, factor's affecting glass transition temperature, degradation of polymers by thermal, oxidative, mechanical and chemical methods.

(Total Lecture Hours: 42)

3. Practicals:

1. To study synthesis of Polyester resin.
2. To study synthesis of Polyurethane resin.
3. To study synthesis of acrylic polymer.
4. To study synthesis of poly styrene by emulsion polymerization.
5. To study synthesis of poly styrene by suspension polymerization.
6. To perform FTIR analysis of synthesized polymers.
7. To perform TGA/DSC analysis of synthesized polymers.
8. To prepare composite from Unsaturated Polyester Resin using Jute / Glass fiber as reinforcing material.

4. Books Recommended:

1. F. W. Billmeyer, *Textbook of Polymer Science*, 3rd Edition, Wiley-Interscience, 2007.
2. D. D. Deshpande, *Physical Chemistry of Macromolecules*, Vishal Publications, New Delhi, 1985.
3. V. R. Gowariker, N. V. Viswanathan, J. Sreedhar, *Polymer Science*, Wiley Eastern Ltd., 1986.
4. V. K. Ahluwalia, Anuradha Mishra, *Polymer Science: A Textbook*, 1st Edition, CRC Press, 2008.
5. R. Seymour, *Introduction to Polymer Chemistry*, Wiley-Interscience, 1981.

5. Additional Reading Material:

1. P. J. Flory, *Principles of Polymer Chemistry*, 1st Edition, Cornell University Press, 1953.
2. G. Odian, *Principles of Polymerization*, 4th Edition, Wiley – Interscience, 2004.
3. K. J. Saunders, *Organic Polymer Chemistry*, 2nd Edition, Chapman and Hall, London, 1973.
4. R. B. Seymour, G. S. Kirshenbaum, *High Performance Polymer: Their Origin and Development*, 1st Edition, Elsevier, 1986.
5. P. W. Morgen, *Condensation Polymers by Interfacial and Solution Methods*, 1st Edition, Interscience publishers, New York 1965.

CHEMISTRY IN INDUSTRIES

L	T	P	C
3	0	0	3

Scheme

CY308

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain process technologies of various organic and inorganic process industries.
CO2	Prepare the process flow diagram and various process parameters.
CO3	Explore various synthetic methods of producing industrial chemicals, their applications.
CO4	Recognize the basic chemistry of production.
CO5	Acquire knowledge about laboratory and plant safety and management.

2. Syllabus:

- **NITROGEN INDUSTRY** **(05 Hours)**
  Introduction, manufacture of synthetic nitrogen products and miscellaneous chemicals such as ammonia, hydro amine, fluorocarbon and various types of nitrogenous fertilizers such as urea, ammonium sulphate, ammonium nitrate, calcium ammonium nitrate.

- **FERMENTATION INDUSTRY** **(05 hours)**
  Introduction, culture development, inoculum preparation, nutrients for microorganisms, toxic effects on culture, manufacture of industrial alcohol, absolute alcohol, vinegar, downstream processing.

- **PERFUMERY INDUSTRY** **(05 hours)**
  Compounds used for different perfumes, essential oils, preparation of phenyl ethanol, Yara-Yara, musk ketone, musk xylene, benzyl acetate, synthetic musk, jasmine.

- **AGROCHEMICAL AND PESTICIDE INDUSTRY** **(05 Hours)**
  Classification of agrochemicals, classification of insecticide, ammonium phosphate, super phosphate, BHC, Uses of agrochemicals and environments.

- **INDUSTRIAL GASES** **(05 Hours)**
  Industrial Gases – Manufacture of hydrogen, oxygen, nitrogen, carbon dioxide and sulphur dioxide.

- **LABORATORY SAFETY AND PROCESS SAFETY** **(06 Hours)**
  Personal protective equipment, nature of the hazard and the task, compatibility with other PPE, chemicals being used, including concentration and quantity, hazards posed by the chemicals, routes of exposure for the chemicals, material the PPE is constructed of, safety signs, hazard assessment.

- **QUALITY MAAGEMENT TOOLS AND METHODS** **(05 Hours)**
  Flow Chart, histogram, cause-and-effect diagram, check sheet, scatter diagram, control charts, pareto charts.

- **BASIC CHEMICAL ENGINEERING CONCPT FOR CHEMISTS** **(06 Hours)**
  Initial design steps – identifying a process route, basic conceptual process design and flow-sheeting, Mass and energy balances, reactor design, separation processes, process control, scale-up/ commercialization.

(Total Lecture Hours: 42)

3. **Books Recommended:**

1. G. T. Austin, *Shreve's Chemical Process Industries*, 5th Edition, Tata McGraw Hill, 2017.
2. J. P. Agrawal, *High Energy Materials: Propellants, Explosives and Pyrotechnics*, 1st Edition, Wiley-VCH, 2015.
3. B. K. Sharma, *Industrial Chemistry*, 3rd Edition, Krishna Prakashan Media (P) Ltd., Meerut, 2001.
4. M. Ash, I. Ash, *Formulary of Cosmetic Preparations*, 1st Edition, Chemical Publishing, 1977.
5. F. V. Wells, M. Billot, *Perfumery Technology*, 2nd Edition, Longman Higher Education, 1981.

4. **Additional Reading Materials:**

1. J. A. Kent, *Riegel's Hand Book of Industrial Chemistry*, 6th Edition, CBS Publishers & Distributors, New Delhi, 1986.
2. M. L. Srivastava, *Fermentation Technology*, Narosa Publisher, 2008.

FOURTH YEAR OF FIVE YEARS INTEGRATED M. SC. (CHEMISTRY)
M. SC. - IV, SEMESTER - VII

Sr. No.	**Subject**	**Code**	**Scheme**	**Credit**	**Examination Scheme**				**Total Marks**
					Theory	**Tutorial**	**Practical**		
							Int.	**Ext.**	
1.	Advanced Inorganic Chemistry	CY-401	3-1-4	06	100	25	60	40	225
2.	Methods in Organic Synthesis	CY-403	3-1-4	06	100	25	60	40	225
3.	Quantum Chemistry	CY-405	3-1-4	06	100	25	60	40	225
4.	Core Elective-1	CY-4XX	3-0-0	03	100	00	00	00	100
Total contact hours per week=27			**Total Credits=21**			**Total Marks=775**			

Elective-1 (CY-4XX)

Sr. No.	Code	Subject
1.	CY-421	Corrosion Science and Technology
2.	CY-423	Surfactant Chemistry
3.	CY-425	Petrochemicals
4.	CY-427	Chemistry of Nanomaterials

FOURTH YEAR OF FIVE YEARS INTEGRATED M. Sc. (CHEMISTRY)
M. Sc. - IV, SEMESTER - VIII

Sr. No.	**Subject**	**Code**	**Scheme**	**Credit**	**Examination Scheme**				**Total Marks**
					Theory	**Tutorial**	**Practical**		
							Int.	**Ext.**	
1.	Symmetry, Spectra & Magnetism	CY-402	3-1-4	06	100	25	60	40	225
2.	Chemistry of Natural Products	CY-404	3-1-4	06	100	25	60	40	225
3.	Physical Aspects of Molecular spectroscopy	CY-406	3-1-4	06	100	25	60	40	225
4.	Core Elective-2	CY-4YY	3-0-0	03	100	00	00	00	100
Total contact hours per week=27			**Total Credits=21**		**Total Marks=775**				

Elective-2 (CY-4YY)

Sr. No.	Code	Subject
1.	CY-422	Purification and Separation Methods in Chromatography
2.	CY-424	Fluorescence Spectroscopy
3.	CY-426	Polymer and Coating Technology
4.	CY-428	Organic Materials
5.	CY-432	Drugs and Dyes
6.	CY-434	Green Chemical Processing

ADVANCED INORGANIC CHEMISTRY

L	T	P	C
3	1	4	6

Scheme

CY401

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explore thermodynamic and kinetic of complex formation in solution.
CO2	Study on reaction mechanisms of complexation in solution.
CO3	Discuss on possible electronic transitions in metal complexes.
CO4	Write photochemical reaction of metal complexes.
CO5	Summarize polymeric inorganic compounds.

2. Syllabus:

- **THERMODYNAMIC AND KINETIC BEHAVIOR OF METAL COMPLEXES (14 Hours)**
  Stability, step wise formation constants and overall formation constants. Kinetic versus Thermodynamic stability, labile and inert octahedral complexes according to valence bond and crystal field theory. factors affecting stability constants, Chelates and macrocyclic effects, Irving Williams order, determination of stability constant by various methods (spectrophotometric and pH-metric), conditional stability constants and their importance in complexometric EDTA titration of metal ions, statistical and non-statistical factors affecting stability of complexes in solution.

- **REACTION MECHANISMS IN TRANSITION METAL COMPLEXES (12 Hours)**
  Substitution reactions in octahedral and square planar complexes, Reaction mechanism of ligand substitution reactions in octahedral complexes: SN_1 (D-process), SN_2 (A-process), solvent intervention, ion pair formation, conjugate base formation SN_1CB. Solvolysis reactions: acid and base hydrolysis, Trans effect, theories of Trans effect, Redox (one and two-electron transfer) reactions, inner sphere and outer sphere processes, Creutz-Traube complexes.

- **INORGANIC PHOTOCHEMISTRY (08 Hours)**
  Introduction of inorganic photochemistry, Photochemically excited states and excited state processes for transition metal complexes, Types of photochemical reactions in transition metal complexes, Ligand-field photochemistry of chromium(III) complexes, Photo substitution reactions, Adamson's rules, photochemistry of Cobalt(III) complexes, Mechanism of photoreduction: photophysics and photochemistry of Ruthenium-polypyridine complexes, Applications of photochemical inorganic reactions in synthesis, Catalysis, Biological processes, chemical actinometer and in laser.

- **POLYMERIC INORGANIC COMPOUNDS (08 Hours)**
  Types of inorganic polymers, comparison with organic polymers, synthesis, structural aspects and applications of silicones and siloxanes. Borazines, silicates and phosphazenes, and polysulphates.

(Total Lecture Hours: 42)

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3. **Practicals:**

Preparation and characterization (UV-Vis, FT-IR, thermal analyses, etc.) of the following complexes:

1. Potassium tris(oxalato)aluminate(III)
2. Potassium tris(oxalaato) chromate(III)
3. Sodium hexa(nitro)cobaltate(III)
4. Hexa(ammine)cobalt(III)
5. Tetrapyridinecopper(II)persulphate
6. Dinitrotetrapyridinenickel(II)
7. Hexamminenickel (II) chloride
8. Bis(acetylacetonato)copper(II)
9. Tris(acetylacetonato)iron(III)
10. Tris(acetylacetonato)manganese(III).

4. **Books Recommended:**

1. J. E. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi, *Inorganic Chemistry - Principles of Structure and Reactivity*, 4th Edition, Pearson Education, 2006.
2. J. D. Lee, *Concise Inorganic Chemistry*, 5th Edition, Blackwell Science, 1996.
3. H. J. Emeleus, A. G. Sharpe, *Modern Aspects of Inorganic Chemistry*, 4th Edition, Routledge & Kegan Paul, London, 1973.
4. W. W. Porterfield, *Inorganic Chemistry: A Unified Approach*, 2nd Edition, Elsevier Publishers, 2005.
5. A. W. Adamson, P. D. Fleschaner, *Concepts of Inorganic Photochemistry*, Wiley, 1975.

5. **Additional Reading Material:**

1. V. Balzani, Carassiti, *Photochemistry of Coordination Compounds*, Academic press, 1970.

METHODS IN ORGANIC SYNTHESIS

CY403

L	T	P	C
3	1	4	6

Scheme

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Show the role of protecting groups in organic synthesis.
CO2	Extend the knowledge in the mechanisms of various named reactions and their significance in synthesis of drugs.
CO3	Explain the mechanistic and stereo chemical aspects in the reactions of carbon-carbon and carbon-hetero multiple bonds molecules.
CO4	Illustrate the mechanistic details of various rearrangement reactions in organic molecules.
CO5	Demonstrate drugs discovery, diversity and their classification, and to understand their mode of action.

2. Syllabus:

- **PROTECTING GROUPS** **(03 Hours)**
  Protection and deprotection methodology for functional groups. Synthetic applications in peptide synthesis, biology and medicine.

- **REARRANGEMNTS IN CARBON SKELETON** **(06 Hours)**
  Classification and general mechanistic treatment of nucleophilic, free radical and electrophilic rearrangements, Pinacol-Pinacolone, Semipinacol, Wagner Meerwein, Favorskii Curtius, Hoffmann, Schmidt, Beckmann's, Wittig, Benzil-Benzilic acid, Demjanov, Claisen-Johnson-Ireland and Oxy-Cope rearrangements.

- **REMODELING OF CARBON SKELETON** **(04 Hours)**
  Cleavage of C-C bonds. Decarboxylation, Baeyer-Villiger oxidation, and 1,2-diol cleavage in a total synthesis, synthetic utilization of the double bond cleavage reactions.

- **ASSYMMETRIC SYNTHESIS** **(06 Hours)**
  Stereochemistry of larger rings, fused and bridged rings, synthesis of Taxol and strychnine, Sharpless asymmetric epoxidation, Jacobsen epoxidation, Shi epoxidation. Alkenes to diols, Sharpless asymmetric dihydroxylation, metathesis reactions.

- **ADDTION TO CARBON-CARBON AND CARBON-HETEROATOM MULTIPLE BONDS** **(12 Hours)**
  Mechanistic and stereochemical aspects of additon reactions involving electrophiles, nuclophiles and free radicals, regio- and chemoselectivity, orientation and reactivity, addtion to cyclopropane ring, hydrogenation of double and triple bonds, hydrogenation of aromatic rings, hydroboration, Michael reaction, ene reaction, Wittig reaction, Perkin reaction, Claisen – Schmidt condensation, Peterson's synthesis. Cannizaro and cross Cannizaro reactions, Benzoin condensation, Wolff-Kishner reduction, Clemmenson reduction, MPV reduction, Birch reduction. Riemer-Tiemann reaction, Gattermaan reaction, Chichibabin reaction. Uses of organoboron compounds in organic synthesis. Addition of Grignard reagent, organo zinc, organo copper, and organo lithium reagents to carbonyl and unsaturated carbonyl compounds. Mechanism of considensation reactions involving

enolates- Knoevenagel, Mannich and Stobbe reactions. Hydrolysis of esters and amides, ammonolysis of esters.

- **DRUGS** **(11 Hours)**
  Drug discovery and drug diversity, classification of drugs, chemistry of sulfa drugs, antipyretics and analgesics, antibiotics, antituberculor, antifungal and anti-inflammatory drugs.

(Total Lecture Hours: 42)

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3. Practicals:

1. Backmann's rearrangement. #
2. Synthesis of caprolactum. #
3. Cannizzaro reaction. #
4. Sandmayer's reaction. #
5. Asymmetric synthesis (ketone reduction/epoxidation). #
6. Diazocoupling.#
7. Nitration.#
8. Acetyl salicylicacid from Asprin tablets.
9. Ibuprofen from Ibuprofen tablets

#Identification by spectroscopic methods.

Synthesis of various organic compounds by various chemical approaches.

4. Books Recommended:

1. W. Carruthers, I. Coldham, *Modern Methods of Organic Synthesis*, 4th Edition, Cambridge University, 2005.
2. F. A. Carey, R. J. Sundburg, *Advance Organic Chemistry: Structure and Mechanism (Part A) (English)*, 5th Edition, Springer, 2007.
3. B. Reinhard, *Advance Organic Chemistry: Reaction Mechanisms*, 1st Edition, Elsevier, 2002.
4. G. S. Zweifel, M. H. Nantz, *Modern Organic Synthesis*, 1st Edition, W. H. Freeman, 2006.
5. H. O. House, *Modern Synthetic Reactions*, 2nd Edition, W. A. Benjamin, 1972.

5. Additional Reading Material:

1. R. O. C. Norman, J. M. Coxon, *Principles of Organic Synthesis*, 3rd Edition, Nelson Thornes, 2005.
2. S. Warren, *Designing Organic Syntheses: A programmed Introduction to the Synthon Approach,* John Wiley and Sons, 2009.
3. T. L. Lamke, D. A. Williams, V. F. Roche, S. W. Zito, *Foye's Medicinal Chemistry*, 7th Edition, Lippincott Williams and Wilkin's Publisher, 2012.
4. B. S. Furniss, A. J. Hannaford, P. W. G. Smith, A. R. Tatchell, *Vogel's Textbook of Practical Organic Chemistry*, 5th Edition, Pearson India, 2005.
5. R. K. Bansal, *Laboratory Manual of Organic Chemistry*, 5th Edition, New Age International Pvt. Ltd. Publishers, 2008.

QUANTUM CHEMISTRY

L	T	P	C
3	1	4	6

Scheme

CY405

1. Course Outcomes (Cos):

At the end of the course students will be able to:

CO1	Appraise the fundamentals of classical quantum chemistry.
CO2	Gain basics of various operators with their applications.
CO3	Calculate eigen values and eigen functions for various systems.
CO4	Solve mathematical problems based on quantum mechanics.
CO5	Perform the experiments related to physical chemistry approach which includes Kinetics, Conductometry, Colorimetry, pH-metry, Potentiometry and titration.

2. Syllabus:

- **QUANTUM MECHANICS – I** **(14 Hours)**
  Black body radiation, Classical Theory of Rayleigh-Jean, and Planck's theory, Photoelectric effect, Einstein's Quanta, Compton effect, Dual nature of electromagnetic radiation, de Broglie's hypothesis, Wave particle duality, Matter wave, Concept of wave packets, Uncertainty principle, its various mathematical forms and its justifications.

- **QUANTUM MECHANICS – II** **(14 Hours)**
  Operators, Linear operators, Hermitian operators, Postulates of Quantum Mechanics, Schrödinger wave equation (Time dependent and time independent), Solution of Schrödinger equation as wave function and energy (eigen values and eigen functions), Commutators and their implication with respect to x, px, Expectation values, Properties of eigen functions, Energy quantization for hydrogen atom. Numericals.

- **QUANTUM MECHANICS – III** **(14 Hours)**
  Simple systems: 1-D, 2-D, 3-D box (eigen values, eigen functions, expectation values, quantum numbers, degeneracy, probability density), Simple Harmonic Oscillator: Setting the Schrödinger equation, derivation, eigen values and eigen functions, zero point energy, Basics of hydrogen atom and rigid rotar.

(Total Lecture Hours: 42)

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3. Practicals:

1. Determine the equivalent conductance of weak electrolyte at infinite dilution using Kohlraush law.
2. To determine the concentration of HCl/ H_2SO_4, acetic acid, Copper sulphate in given solution by conductometric titration.
3. To determine the hydrolysis constant of aniline hydrochloride.
4. Potentiometric titration of halide mixture (Chloride, Bromide and Iodide) with standard $AgNO_3$.
5. Determination of the equilibrium constant of the reaction $KI + I_2 = KI_3$ (Partition Coefficient).
6. Polymer synthesis of poly vinyl alcohol (PVA) from poly vinyl acetate (PVAc) and estimate molecular weight from solution viscosity.

7. Determination of dissociation constant pK_{in} of methyl red indicator spectrophotometrically.
8. Preparation of Urea-Formaldehyde (UF) resin.

4. Books Recommended:

1. G. M. Barrow, *Physical Chemistry*, 6th Edition, McGraw-Hill, Kogakusha Ltd., New Delhi, 1973.
2. D. A. Skoog, F. J. Hooes, T. A. Nieman, *Principles of Instrumental Analysis*, 5th Edition, Saunders College Publishing, Philadelphia, 1998.
3. S. Glasstone, *Thermodynamics for Chemists*, Affiliated East-West Press Pvt. Ltd., New Delhi, 2009.
4. N. Levine, *Quantum Chemistry*, 4th Edition, Prentice Hall, Englewood Cliffs, New Jersey, 1991.
5. S. Maity, N. Ghosh, *Physical Chemistry Practical*, 1st Edition, New Central Book Agency (P) Ltd., India, 2012.

CORROSION SCIENCE AND TECHNOLOGY

CY421

L	T	P	C
3	0	0	3

Scheme

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the basics of corrosion.
CO2	Relate to the corrosion principles with its significance.
CO3	Correlate about the proposed corrosion theory with their applications.
CO4	Interpret and correlate various corrosion parameters.
CO5	Collaborate several corrosion control approaches.

2. Syllabus:

- **FUNDAMENTALS OF CORROSION** **(05 Hours)**
  Introduction to Corrosion, its forms and classification, cost of corrosion, environments, corrosion engineering, and future outlook.

- **CORROSION PRINCIPLES** **(10 Hours)**
  Corrosion rate expressions, electrochemical aspects-electrochemical reactions, polarization, passivity, environmental effects- effect of oxygen and oxidizers, effects of velocity, effect of temperature, effects of corrosive concentration, effect of galvanic coupling, metallurgical and other aspects- metallic properties, economic considerations, importance of inspection.

- **MIXED POTENTIAL CORROSION THEORY AND ITS APPLICATIONS** **(12 Hours)**
  Free energy, cell potentials, EMF and galvanic series, exchange current density, activation, concentration and combined polarizations, mixed potential theory, mixed electrodes, passivity, mechanism of the growth and break-down of passive film, predicting corrosion behaviour, effect of oxidizers and velocity, galvanic coupling, alloy evaluation, noble metal alloying, corrosion rate measurements by Tafel extrapolation and linear polarization methods.

- **CORROSION CONTROL** **(15 Hours)**
  Material selection- Selection of proper corrosion resistant metals and alloys for specific environment, metal purification, non-metallics, Alteration of environment- Changing medium, temperature, inhibitors- adsorption type inhibitors, scavengers, oxidizers, vapor-phase inhibitors, Proper design, Cathodic protection- primary protection, secondary protection by impressed current and sacrificial anode methods, selection of anodes, backfills, protective currents, stray current effects and applications, anodic protection- active- passive behavior of materials and structures, heat treatments- annealing, hardening, carburizing, nitriding, potentiostat, electrodes, environments and their comparison, Coatings.

(Total Lecture Hours: 42)

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3. Books Recommended:

1. J. T. N. Atkinson, H. Van Droffelaar, *Corrosion and its Control: An Introduction to the Subject*, 2nd Edition, NACE, Houston, TX, 1995.

2. G. Fontana Mars, *Corrosion Engineering*, 3rd Edition, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2005.
3. J. C. Scully, *The Fundamentals of Corrosion*, 3rd Edition, Pergamon Press, Oxford, UK, 1990.
4. K. R. Trethewey, J. Chamberlain, *Corrosion for Students of Science and Engineering*, 2nd Edition, Longman Scientific and Technical, Harlow, UK, 1996.
5. H. H. Uhlig, R. W. Revie, *Corrosion and Corrosion Control: An Introduction to Corrosion Science and Engineering*, 3rd Edition, John Wiley, New York, 1985.

SURFACTANT CHEMISTRY

L	T	P	C
3	0	0	3

Scheme

CY423

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the basics of surfactants and their importance in various fields of engineering.
CO2	Appraise a deep knowledge on their phase study and micellization process.
CO3	Correlate the solution behavior surfactants.
CO4	Evaluate various models defining surfactant solutions.
CO5	Collaborate the skill to apply the advances of surfactants.

2. Syllabus:

- **INTRODUCTION** **(07Hours)**
  Molecular structure of surfactants, Classification of surfactants, Properties and other criteria influencing surfactant choice, Surface activity, Surface tension, Interfacial and dynamic surface tension, Reduction of Surface, interfacial and dynamic tension by Surfactants, Efficiency and Effectiveness in surface tension Reduction: Krafft point (KP). Test methods for surface and interfacial tension measurements: Wilhelmy Plate, Pendent Drop, Du Nouy's Ring, Drop Volume (Weight), and Spinning Drop. The Economic Importance of Surfactants, Surfactants in the Environment, Biodegradation of Surfactants.

- **ADSORPTION OF SURFACTANTS** **(07 Hours)**
  Gibbs Monolayers, Surface Pressure, Surface Potential, Surface Rheology, Gibbs Surface Excess, Electrical Double layer, Gibbs Adsorption Isotherm, Equation of State Approach, Classification of Solid–Vapor Adsorption Isotherms: Langmuir, Freundlich, Brunauer–Emmett–Teller (BET) Isotherm for Surface Area calculation.

- **PHASE BEHAVIOR OF SURFACTANT SYSTEMS** **(07 Hours)**
  Solubility-Temperature relationship for Ionic surfactants, surfactant self-assembly, structure of Liquid Crystalline Phases: Hexagonal, Micellar Cubic, Lamellar, Bicontinuous Cubic. Phase Diagrams of Ionic and Nonionic Surfactants.

- **MICELLE FORMATION BY SURFACTANTS** **(07 Hours)**
  The Critical Micelle Concentration (CMC), Packing Parameter, Micellar structure and shape, Aggregation number (N_{agg}), Factors Affecting the CMC in aqueous media: Structure of the Surfactant, the Hydrophobic and Hydrophilic group, the Counterion in Ionic surfactants, Degree of Binding to the Micelle, Electrolyte (inorganic/ organic), and Temperature.

- **SOLUTION PROPERTIES OF SURFACTANTS** **(07 hours)**
  Solubility–Temperature relationship for Surfactants, Thermodynamics of Micellization, Kinetic aspects, Equilibrium aspects, Phase Separation Model, Mass Action Model, Enthalpy and Entropy of Micellization, Driving force for micelle formation, Micellization in Polar and Non-Polar solvents, synergistic or antagonistic micellization in surfactant mixtures (Mixed Micelles). Rheology of surfactant solutions: Introduction to various rheological terms, Rheological behavior of

monomeric solutions and non-interacting micelles, Entanglement networks of rod-like micelles, the rheological behavior of bilayer phases.

- **MULTIDISCIPLINARY APPLICATIONS OF SURFACTANTS** **(07 hours)**
  Surfactants as Foaming and Antifoaming agents, as Dispersants, in Wetting (Contact angle), Spreading and Adhesion, in Nano-emulsions and Microemulsification, in Stabilization of suspensions, in Detergency, in Aerosols, in Personal Care and Cosmetics, in Pharmaceutical Formulations, in Agrochemicals, in the Food Industry.

(Total Lecture Hours: 42)

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3. Books Recommended:

1. T. F. Tadros, *Applied Surfactants - Principles and Applications*, 2nd Edition, Wiley VCH, Verlag GmbH & Co., Germany, 2005.
2. M. R. Porter, *Handbook of Surfactants*, 2nd Edition, Academic and Professional Publishers, 1994.
3. J. Falbe, *Surfactants in Consumer Products Theory, Technology and Applications*, 1st Edition, Springer Verlag, 1987.
4. D. Myers, *Surfaces, Interfaces, and Colloids - Principles and Applications*, 2nd Edition, John Wiley & Sons, Inc., New York, 1999.
5. M. J. Rosen, *Surfactants and Interfacial Phenomena*, 3rd Edition, John Wiley & Sons, Inc., Hoboken, New Jersey, 2004

PETROCHEMICALS

L	T	P	C
3	0	0	3

Scheme

CY425

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Acquire deep knowledge of various theories of petroleum products.
CO2	Demonstrate of the unit processes in manufacture of petrochemicals.
CO3	Explain variety of petrochemical feedstock and products.
CO4	Identify the specifications required for good quality petroleum products.
CO5	Extend the knowledge of the process of purification and fractionation of crude oil.

2. Syllabus:

- **THEORIES OF PETROLEUM PRODUCTS** **(07 Hours)**
  Theories of petroleum formation, composition of petroleum, refining and rectification process of petroleum, light petroleum products – their specification and test methods, cracking and reforming process, reaction taking place in cracking, cracking catalyst, cracking plants.

- **DISTILLATION OF CRUDE PETROLEUM** **(07 Hours)**
  Preparation of petroleum for processing, destruction of petroleum emulsion, electrical desalting plants, methods of petroleum distillation, distillation of crude petroleum, treatment of residual liquid, processing of liquid fuel for petroleum and petroleum products.

- **FRACTIONATION OF PETROLEUM** **(08 Hours)**
  Chemicals derived from C1, C2, C3 and C4 fractions, separation of components of petroleum by using techniques like- compression, absorption, adsorption, low temperature distillation, special and combined techniques. Manufacture of HCN, CS2, Maleic anhydride, Caprolactum and Phthalic anhydride.

- **MANUFACTURE OF PETROCHEMICALS BY FOLLOWING UNIT PROCESS** **(08 Hours)**
  Alkylation: ethyl benzene and isopropyl benzene from benzene. Dehydrogenation: butadiene from butane/butane. Hydration: acetaldehyde from acetylene. Hydrolysis: ethanol from ethylene. Esterification: commercial manufacturing of vinyl acetate. Oxidation: ethylene oxide from ethylene and phenol from cumene Hydroformylation: propionaldehyde from ethylene and synthesis gas.

- **PURIFICATION OF PETROLEUM PRODUCTS** **(06 Hours)**
  Absorptive and adsorptive purification, sulphuric acid purification, alkaline purification, hydrofining, purification in DC electric field-demercaptanisation, stabilisation.

- **PETROLEUM AROMATICS** **(06 Hours)**
  Occurrence, Benzene derivatives, production of aniline, products from toluene, cholorotoluene, sulphonation of toluene, oxidation product of toluene, chemicals from xylene.

(Total Lecture Hours: 42)

3. **Books Recommended:**

1. S. Matar, L. F. Hatch, *Chemistry of Petrochemical Processes*, 2nd Edition, Gulf Professional Publishing, 2001.
2. J. G. Speight, *The Chemistry and Technology of Petroleum*, 5th Edition, CRC Press, 2014.
3. B. K. Rao, *Modern Petroleum Refining Process*, 2nd Edition, Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, 1990.
4. B. K. Rao, *A Textbook on Petrochemicals*, 5th Edition, Khanna Publishers, New Delhi, 2010.
5. T. A. George, *Shreve's Chemical Process Industries*, 5th Edition, McGraw-Hill International Edition, 1985.

CHEMISTRY OF NANOMATERIALS

CY427

L	T	P	C
3	0	0	3

Scheme

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Adapt synthetic procedure for processing of nanomaterials as per needs and specifications.
CO2	Acquire knowledge about the electronic, mechanical and thermal properties of nanomaterials.
CO3	Illustrate the structure and morphology of nanomaterials.
CO4	Know the applications of nanomaterials in sustainable developments and technology.
CO5	Extend the knowledge on the synthetic routes for synthesis of nanomaterials

2. Syllabus:

- **STRUCTURES &CLASSIFICATION OF NANOMATERIALS** **(10 Hours)**
  Definition of Nano, Atomic Structure and atomic size, emergence and challenges of nanoscience and nanotechnology, carbon age-new form of carbon (CNT to Graphene), influence of nano over micro/macro, size effects and crystals, large surface to volume ration, surface effects on the properties.
  Types of nanostructure and properties of nanomaterials: One dimensional, Two dimensional and Three dimensional nanostructured materials, Quantum Dots shell structures, metal oxides, semiconductors, composites, mechanical-physical-chemical properties.

- **SYNTHETIC ROUTES OF NANOMATERIALS** **(18 Hours)**
  Principle and relative merits of each technique for production of Nano-structures including ultra-thin films and multilayer by: (a) Laser Ablation technique, (b) Arc Discharge technique and (c) Mechanical Milling. Physico-chemical methods such as Chemical Vapor Deposition (CVD), Plasma, Sputtering, Hot-Wire Plasma Enhanced CVD method, and Self-assembly technique.
  Chemical methods: Synthesis of nanomaterials by precipitation and co-precipitation methods, Sol-Gel synthesis, Microemulsions synthesis, Hydrothermal and Solvothermal methods. Microwave assisted synthesis, Sonochemical assisted synthesis. Metal nanocrystals synthesis by polyol, and borohydrate reduction methods, Photochemical synthesis, Synthesis in supercritical fluids and Electrochemical synthesis, Synthesis of Core-Shell nanostructure, Organic –Inorganic Hybrids, Quantum dots (QDs), Carbon Nanotubes, Graphenenanosheets. Biological methods: Use of bacteria, and fungi. Role of plants in nanoparticle synthesis.

- **PROPERTIES, CHARACTERIZATION AND APPLICATIONS OF NANOMATERIALS** **(14 Hours)**
  Properties and size effect of nanomaterials, electrical, Mechanical, Magnetic, Optical and catalytic properties, Characterization methods, Applications of nanotechnology in sustainable development and technology.

(Total Lecture Hours: 42)

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3. Books Recommended:

1. G. A. Ozin, A. C. Arsenault, L. Cademartiri, *Nanochemistry: A Chemical Approach to Nanomaterials*, 2nd Edition, The Royal Society of Chemistry, Cambridge, 2009.

2. C. N. R Rao, A. Muller, A. K Cheetham, *Nanomaterials Chemistry*, 1st Edition, Wiley-VCH, 2007.
3. G. Cao, *Nanostructures & Nanomaterials: Synthesis, Properties, and Applications*, 1st Edition, Imperial College Press, London, 2004.
4. M. Hosokawa, K. Nogi, M. Naito, Y. Yokoyama, *Nanoparticles Technology Handbook*, 1st Edition, Elsevier, 2007.
5. T. Pradeep, *NANO The Essentials: Understanding Nanoscience and Nanotechnology*, 1st Edition, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2007.

4. Additional Reading Material:

1. K. Klabunde, *Nano-chemistry*, 2nd Edition, Elsevier Publishers, 2013.

FOURTH YEAR OF FIVE YEARS INTEGRATED M. Sc. (CHEMISTRY)

M. Sc. - IV, SEMESTER - VIII

Sr. No.	Subject	Code	Scheme	Credit	Examination Scheme				Total Marks
					Theory	Tutorial	Practical		
							Int.	Ext.	
1.	Symmetry, Spectra & Magnetism	CY-402	3-1-4	06	100	25	60	40	225
2.	Chemistry of Natural Products	CY-404	3-1-4	06	100	25	60	40	225
3.	Physical Aspects of Molecular spectroscopy	CY-406	3-1-4	06	100	25	60	40	225
4.	Core Elective-2	CY-4YY	3-0-0	03	100	00	00	00	100
Total contact hours per week=27			**Total Credits=21**			**Total Marks=775**			

Elective-2 (CY-4YY)

Sr. No.	Code	Subject
1.	CY-422	Purification and Separation Methods in Chromatography
2.	CY-424	Fluorescence Spectroscopy
3.	CY-426	Polymer and Coating Technology
4.	CY-428	Organic Materials
5.	CY-432	Drugs and Dyes
6.	CY-434	Green Chemical Processing

SYMMETRY, SPECTRA & MAGNETISM

CY402

L	T	P	C
3	1	4	6

Scheme

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain principles and concepts of symmetry and group theory.
CO2	Justify the use of character tables and projection operator techniques.
CO3	Recognize the importance of symmetry and group theory in spectroscopy.
CO4	Illustrate inorganic electronic spectra.
CO5	Describe inorganic magnetism.

2. Syllabus:

- **SYMMETRY AND GROUP THEORY** **(20 Hours)**
  Group theory: The concept of group, Symmetry elements and symmetry operations, Assignment of point groups to inorganic molecules, Features of point groups and their character tables, Representations (matrices, matrix representations for C_2V and C_3V point groups irreducible representations), Character and character tables for C_2V and C_3V point groups. Symmetries of molecular orbitals in BF_3, C_2H_4 and B_2H_6. Applications of group theory to chemical bonding.

- **SPECTRA & MAGNETISM OF TRANSITION METAL COMPLEXES** **(22 Hours)**
  The energy terms, coupling schemes, spin-spin coupling, orbital coupling, spin-orbital coupling, R-S coupling, J-J coupling scheme, selection rules, relaxation of selection rules. Energy levels in an atom, Calculation of the number of the microstates Determining the Ground State, Term Symbols, Terms-Hunds Rule, Hole formulation (derivation of the Term Symbol for a closed sub-shell, derivation of the terms for a d2 configuration), Orgel diagrams and its application to electronic spectra of transition metal complexes, Charge transfer spectra, electronic absorption spectra of spin paired complexes, Jahn-Tellar effect and electronic spectra of complexes; properties of paramagnetic complexes, magnetic moment, antiferromagnetism and ferromagnetism.

(Total Lecture Hours: 42)

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3. Practicals:

1. Given a solution of $BaCl_2$ and $CaCl_2$ determine the amount of Ba gravimetrically and Ca volumetrically by oxalate method.
2. Estimation of Cu and Ni in the given solution containing $CuSO_4$ and $NiSO_4$.
3. To prepare the tetraamminecopper(II) sulphate monohydrate complex $[Cu(NH_3)_4(H_2O)]SO_4$ from copper sulphate ($CuSO_4.5H_2O$). To estimate the amount of Cu in the prepared sample volumetrically.
4. To estimate gravimetrically, the amount of lead present in the whole of the given solution of lead acetate (or lead nitrate) by precipitating it as lead chromate.
5. Determination of lanthanide by complexometric titrations.
6. Determination of actinides by complexometric titrations.
7. To prepare potassium trisoxalatochromate (III), $K_3[Cr(C_2O_4)_3]$.
8. To determine concentration of PO_4^{3-} ion spectrophotometrically.

4. **Books Recommended:**

1. J. E. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi, *Inorganic Chemistry: Principles of Structure and Reactivity*, 4th Edition, Pearson Education India, 2006.
2. F. A. Cotton, *Chemical Applications of Group Theory*, 3rd Edition, Wiley, 2008.
3. B. Durrant, P. J. Durrant, *Introduction to Advanced Inorganic Chemistry*, 12th Edition, Longmans Green and Co., 1962.
4. H. H. Jaffe, M. Orchin, *Symmetry in Chemistry*, Dover Publications, 2003.
5. R. H. Crabtree, *The Organometallic Chemistry of Transition Metals*, 5th Edition, John Wiley and Sons, 2009.

5. **Additional Reading Material:**

1. J. D. Lee, *Concise Inorganic Chemistry*, 5th Edition, Blackwell Science, 1996.
2. C. J. Jones, *d - and f - block Chemistry*, 1st Edition, RSC, 2006.
3. R. S. Drago, *Physical Methods in Inorganic Chemistry*, 1st Edition, International Edn. East-West Press Pvt. Ltd., 1971.

CHEMISTRY OF NATURAL PRODUCTS

L	T	P	C
3	1	4	6

Scheme

CY404

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Identify and characterize various classes of natural products.
CO2	Review the biogenesis of various important natural products.
CO3	Acquire the skills to isolate and purify natural plant products.
CO4	Demonstrate the knowledge on the role of biomolecules and their importance.
CO5	Illustrate the properties, composition and biosynthesis of the natural products like terpenoids, steroids, phenylpropanoids and alkaloids.

2. Syllabus:

- **NATURAL PRODUCTS OF CHEMISTRY** **(25 Hours)**
  Primary and secondary metabolites, general methods for isolation and structural determination of natural products,
  Terpenoids: Classification, occurrence, isoprene rule, structure determination, stereochemistry, biosynthesis and synthesis of citral, geraniol, α-terpeneol, menthol. Vitamins A, D and E.
  Steroids: Classification, occurrence, basic skeleton, Diel's hydrocarbon and stereochemistry, synthesis of cholestrol, progestrone and testosterone.
  Alkaloids: Structure determination, stereochemistry, biosynthesis and synthesis of nicotine, quinine and morphine.

- **NATURAL PIGMENTS** **(05 Hours)**
  Classification of natural pigments, structure determination of porphine, porphyrin, Hb, Chl, flavones, and flavonoids.

- **AMINO ACIDS, PEPTIDES AND PROTEINS** **(06 Hours)**
  Classification, acid-base behaviour, Isoelectric point and electrophoresis. Structure and confirmation of peptides and proteins, Determination of structure of peptide, classical peptide synthesis solid phase peptide synthesis, Structure of peptide and proteins, Classification and function of proteins, denaturation of proteins.

- **BIO-ORGANIC CHEMISTRY** **(06 Hours)**
  Organic reactions in laboratory and in biological systems. Nature of biomolecular interactions. Stereo-specificity and rate enhancement in enzyme catalysed reactions. Mechanism of hydrolysis of esters, amides, phosphoesters in biological systems; C-C and C=C bond formation, oxidation, reduction and decarboxylation. Remote functionalisation cyclisation reactions. Hydrophobicity and organized assemblies.

(Total Lecture Hours: 42)

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3. Practicals:

1. Separation of aminoacids by paper and thin layer chromatography.
2. Isolation of Embellin from Embeliaribes.
3. Isolation of peperanol from piperine.
4. Isolation of nicotine from tobacco.
5. Isolation of Eucalyptus oil from Eucalyptus leaves.
6. Isolation of Curcumin from Turmeric powder.
7. Estimation of phenol, acetone and aniline.
8. Soxhlet extraction of caffeine from tea leaves.
9. Separation of *ortho* and *para*nitroanilines by column chromatography.

4. Books Recommended:

1. I. L. Finar, *Organic Chemistry: Stereochemistry and the Chemistry of Natural Products*, Volume 1 & 2, 5th Edition, Person Education India, 2002.
2. M. Cox, D. L. Nelson, *Lehninger Principles of Biochemistry*, 6th Edition, W. H. Freeman and Company, 2013
3. H. Dugas, *Bioorganic Chemistry: A Chemical Approach to Enzyme Action*, 3rd Edition, Springer-Verlag, 2005.
4. D. E. Metzler, *Biochemistry - The Chemical Reactions of a Living Cell*, 2nd Edition, Academic Press, 2003.
5. K. Nakanishi, T. Goto, S. Ito, S. Natori, S. Nozoe, *Natural Products Chemistry*, Volume 3, 1st Edition, University Science Books, USA, 1991.

5. Additional Reading Material:

1. D. H. R. Barton, K. Nakanishi, O. Meth-Cohn, *Comprehensive Natural Products Chemistry*, Volume 1-9, 1st Edition, Pergamon, 2001.
2. H. Dugas, *Bioorganic Chemistry Frontiers*, Volume 2, Page1-252, Springer-Verlag, 1991.
3. B. S. Furniss, A. J. Hannaford, P. W. G. Smith, A. R. Tatchell, *Vogel's Textbook of Practical Organic Chemistry*, 5th Edition, Pearson India, 2005.
4. R. K. Bansal, *Laboratory Manual of Organic Chemistry*, 5th revised Edition, New Age International Pvt. Ltd. Publishers, 2008.

PHYSICAL ASPECTS OF MOLECULAR SPECTROSCOPY

L	T	P	C
3	1	4	6

Scheme

CY406

1. Course Outcomes (Cos):

At the end of the course students will be able to:

CO1	Gain fundamental knowledge of symmetry and symmetry operations.
CO2	Employ concepts of molecular spectroscopy and selection rules.
CO3	Explain the structural elucidation by molecular spectroscopy.
CO4	Demonstrate structural characterization of a molecule through spectroscopy.
CO5	Perform the experiments related to physical chemistry approach which includes Kinetics, Conductometry, Colorimetry, pH-metry, Potentiometry and titration.

2. Syllabus:

- **MOLECULAR SYMMETRY** **(12 Hours)**
  Symmetry elements and operations, Group postulates, Point Groups, Great Orthogonality Theorem (G.O.T.), Character Table for point groups, Crystallographic symmetry. Standard reduction formula, Normal Modes of Vibration of H_2O, NH_3 and BF_3 molecules.

- **MOLECULAR SPECTROSCOPY- I** **(15 Hours)**
  Spectroscopy - Nature of electromagnetic radiation, range of wavelength, Transition moment integral (qualitative idea) and allowed transitions, Separation of electronic and nuclear motion, Born-Oppenheimer approximation, Signal to noise ratio, Width and intensity of transition, line broadening Rotational spectroscopy, Rigid rotor (diatomic only), Selection rule, Spectrum: position and intensity of spectral lines. Non-rigid rotor and its effect on energy levels, Selection rule and spectrum, Applications, Isotope effect.

- **MOLECULAR SPECTROSCOPY – II** **(15 Hours)**
  Electromagnetic radiation with wavelength and energy. Molar refraction, polarizability, dipole moment, molecular structure and dipole moment, Radio frequency, Microwave, IR, UV/ visible region, pure rotational spectra, Vibrational and Vibrational-Rotational spectra, Raman spectra. Calculation of bond-length. Vibrational rotational spectra, Hooke's law, vibrational energy level. Anharmonic Vibration. Numericals.

(Total Lecture Hours: 42)

3. Practicals:

1. To study the triangular phase diagram (solubility curve) for a ternary system of liquids: Acetic acid + Chloroform + water.
2. To study the effect of substituents of dissociation constant of benzoic acid (weak acid) by conductance method.
3. To determine the composition of the complex formed by the reaction between Zn (II) with $K_4Fe(CN)_6$ potentiometrically.
4. Determination of complex formation between Cu^{2+} and NH_3 by distribution method.

5. To determine the rate constant of saponification of ethyl acetate at two different temperatures and calculate the energy of activation of the reaction.
6. To determine the CMC of a surfactant (SDS) at three different temperatures in aqueous solution by conductance method & calculate Gibb's energy for micellization.
7. To determine the amount of Fe^{2+} by adding EDTA using spectrophotometrically.
8. Determination of radius of a molecule (glycerol) by Viscosity method.

4. Books Recommended:

1. J. M. Hollas, *Modern Spectroscopy*, 4th Edition, Wiley, 2004.
2. C. N. Banwell, Elaine M. Mc Cash, *Fundamentals for Molecular Spectroscopy,* 4th Edition, McGraw-Hill, 1994.
3. N. Levine, *Quantum Chemistry*, 4th Edition, Prentice Hall, Englewood Cliffs, New Jersey, 1991.
4. G. M. Barrow, *Physical Chemistry*, 6th Edition, McGraw-Hill, Kogakusha Ltd., New Delhi, 1973.
5. S. Maity, N. Ghosh, *Physical Chemistry Practical*, 1st Edition, New Central Book Agency (P) Ltd., India, 2012.

PURIFICATION AND SEPARATION METHODS IN CHROMATOGRAPHY

CY422

L	T	P	C
3	0	0	3

Scheme

1. Course Outcomes (Cos):

At the end of the course students will be able to:

CO1	Interpret the role of analytical techniques in separation and identification of various chemical species.
CO2	Acquire a deep knowledge on chromatography.
CO3	Apply the basics of the separation and chromatographic techniques in multidisciplinary areas.
CO4	Develop the skill to apply the advances in chromatography in separation.
CO5	Propose the importance of purity of product in industrial use.

2. Syllabus:

- **SEPARATION TECHNIQUES** **(09 Hours)**
  Distribution law, thermodynamic derivation, application, process of extraction, factors affecting extraction, techniques for solvent extraction, conventional, liquid membranes, bulk, supported and emulsified, solid phase extraction (SPE), ion-exchange, conventional membranes. quantitative treatment of solvent extraction equilibria, classification of solvent extraction system, types of extraction system, advantages of solvent extraction system, applications of liquid extraction, solvent extraction methods in metallurgy, solid liquid extraction.

- **CHROMATOGRAPHY** **(08 Hours)**
  Principle, methods of elution, ideal and non-ideal chromatography, plate theory, rate theory, reasons for broadening of lands, Van-Deemter equation and significance of terms involved, optimum velocity, resolution, methods to improve resolution. introduction to chromatographic techniques: paper chromatography, Thin Layer Chromatography (TLC) and Column Chromatography.

- **GAS CHROMATOGRAPHY (GC)** **(09 Hours)**
  Principle, different types of GC, mobile phase and criteria for its selection, stationary phase, sample introduction system, columns, Stationary phases used in GSC and GLC, difference between GSC and GLC, supports for liquid stationary phases, Selection of columns, packed, WCOT, SCOT, FSOT, Detectors: FID, TCD, FPB, ECD, TID - merits and demerits, temperature programming in GC, derivatisation in GC, Qualitative analysis from retention parameters, Quantitative analysis.
  GC-Mass Spectroscopy Waston-Biemann Separator, Ryhage Separator, Llewellyn Separator, Instrumentation, Applications.

- **LIQUID CHROMATOGRAPHY** **(09 Hours)**
  Principle of LC, instrument and significance of each component, Pumps, Guard column, Stationary phases (solid, liquid), Mobile Phases, Bonded phase supports, Detectors - Fluorescence detector, RI detector, electrochemical detector, Normal phase and Reversed phase. Introduction to HPLC and UPLC.
  LC Mass Spectroscopy
  LC/MS interfaces, solvent removal and ionization, atmospheric-pressure interfaces, electro spray Interface, ion spray interface, secondary detectors.

- **ION-EXCHANGE CHROMATOGRAPHY** **(07 Hours)**
  Introduction: principle of exchange, resins used swelling, capacity of resin and its determination, effect of different parameters on exchange behavior, techniques of IEC, eluent suppressor column. Applications.

(Total Lecture Hours: 42)

3.__**Books Recommended**__:

1. D. Harvey, *Modern Analytical Chemistry*, 3rd Edition, McGraw Hill Publication, New York, 2000.
2. R. M. Verma, *Analytical Chemistry – Theory and Practice*, 3rd Edition, CBS Publication, New Delhi, 2004.
3. J. M. Miller, *Chromatography Concepts and Contrasts*, 2nd Edition, Wiley-Interscience, 2001.
4. D. A. Skoog, F. J. Holler, T. A. Nieman, *Principles of Instrumental Analysis*, 6th Edition, 2006.
5. R. L. Grobe, *Modern Practice of Gas Chromatography*, 4th Edition John Wiley Interscience, 2004.

FLUORESCENCE SPECTROSCOPY

L	T	P	C
3	0	0	3

Scheme

CY424

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain basics of fluorescence spectroscopy.
CO2	Explore the applications of fluorescence spectroscopy.
CO3	Acquire knowledge on fluorescent sensing mechanisms.
CO4	Identify in-vivo use of fluorescence microscopy.
CO5	Describe various advanced techniques of fluorescence spectroscopy.

2. Syllabus

- **INTRODUCTION TO FLUORESCENCE SPECTROSCOPY** **(12 Hours)**
  Introduction: Jabloski diagram, Stokes shift, delayed fluorescence, emission and excitation spectra, quantum yield; solvents and environmental effects; Instrumentation, fluorophores: intrinsic and extrinsic fluorophores, red and NIR fluorophores, fluorescent organic and inorganic nanoparticles, lanthanides and metal complexes as fluorophore, Fluorescent Proteins, Miscellaneous Probes; time-domain lifetime measurements.

- **FLUORESCENCE QUENCHING** **(08 Hours)**
  Quenching of fluorescence, collision quenching, static and dynamic quenching, Stern-Volmer equation, intramolecular quenching, Quenching and Membrane Systems, application of quenching to proteins.

- **ENERGY TRANSFER** **(08 Hours)**
  Characteristics of resonance energy transfer (RET), theory of energy transfer, Determination of distances using RET, RET in ensembles of donors and acceptors, RET in three dimensions, Effect of viscosity, Effects of dimensionality on RET, Effects of restricted geometries on RET, RET between like molecules. Excitation energy migration in assemblies of chromophores, RET within a pair of like chromophores, RET in assemblies of like chromophores, Weber's red-edge effect, RET sensors, Biochemical and other applications.

- **POLARIZATION AND ANISOTROPY** **(08 Hours)**
  Polarized Light and Photoselection of Absorbing Molecules, Characterization of the Polarization State of Fluorescence, Instantaneous and Steady-State Anisotropy, Additivity Law of Anisotropy, Relation between Emission Anisotropy and Angular Distribution of the Emission Transition Moments, Case of Motionless Molecules with Random Orientation, Effect of Rotational Motion, Applications.

- **FLUORESCENT SENSING** **(06 Hours)**
  Introduction: design and applications of fluorescence sensing, Mechanism of sensing: sensing by collision quenching, Energy-transfer sensing, aggregation-induced emission based sensing, PET probes, excimer-monomer based probes, probes with other sensing mechanisms, sensing with fluorescent nanomaterials, biosensors, Molecular Beacons, Introduction of Fluorophores into Living Cells, Bioimaging.

(Total Lecture Hours: 42)

3. **Books Recommended:**

1. J. R. Lakowicz, *Principle of Fluorescence Spectroscopy*, 3rd Edition, Springer, 2006.
2. B. Valeur, *Molecular Fluorescence: Principles and Applications*, 2nd Edition, Wiley, 2012.
3. D. M. Jameson, *Introduction to Fluorescence*, 1st Edition, CRC Press, 2014.
4. J. R. Albani, *Principles and Applications of Fluorescence Spectroscopy*, 1st Edition, Wiley-Blackwell, 2007.
5. A. Sharma, S. G. Schulman, *Introduction to Fluorescence Spectroscopy*, 1st Edition, Wiley, 1999.

POLYMER AND COATING TECHNOLOGY

L	T	P	C
3	0	0	3

Scheme

MC426

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Provide a broad and fundamental knowledge of the synthetic polymers.
CO2	Emphasis on the processing techniques, along with the production of polymers.
CO3	Identify general and up-to-date information on raw materials, coating formulation, properties, and application.
CO4	Gain knowledge about the emerging technologies in polymers and coatings, and convey the latest developments demonstrating practical aspects and utility of recent developments and discoveries.
CO5	Explain about ingredients and composition of industrial, automotive, aerospace, wood finishes, road marking paint, novelty finishes and powder coatings.

2. Syllabus:

- **INTRODUCTION** **(08 Hours)**
  History of surface coating, current situation in coating technology, future forecast, economic importance of coatings, classification and structure of coatings.

- **COATING SYSTEM** **(12 Hours)**
  Raw Materials for coatings: film formers, solvents, pigments and fillers, additives, composition of coating materials, substrates, pre-treatment, coating process.

- **ANTICORROSIVE COATING** **(06 Hours)**
  Anticorrosive pigments, inhibitive pigments, sacrificial pigments, barrier pigments, organic inhibitors, sol-gel and hybrid coating, polymeric anticorrosive coatings.

- **POWDER COATING** **(06 Hours)**
  Resins used in powder coatings, additives, powder production and application.

- **SPECIAL PURPOSE COATING** **(10 Hours)**
  Automotive coatings, marine coatings, aerospace and aircraft coatings, self-cleaning and self-healing coatings.

(Total Lecture Hours: 42)

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3. Books Recommended:

1. T. Brock, M. Groteklaes, P. Mischke, *European Coatings Handbook*, 2nd Revised Edition, Vincentz, 2010.
2. G. Gunduz, Chemistry, *Materials and Properties of Surface Coatings: Traditional and Evolving Technologies*, Destech Publications, Inc., 2016
3. P. Deligny, N. Tuck, *Resin for Surface Coatings*, Volume 1, 2 and 3, 2nd Edition, John Wiley and Sons, 2001.

4. T. J. Miranda, *Surface Coatings: Raw Materials and Their Usage*, Volume 1, 3rd Edition, Springer, 1993.
5. Z. W. Wicks, Jr., F. N. Jones, S. P. Pappas, D. A. Wicks, *Organic Coatings: Science and Technology*, Wiley Interscience, 2007.

4. Additional Reading Material:

1. NIIR Board, *Modern Technology of Paints, Varnishes and Lacquers*, 2nd Edition, Asia Pacific Business Press Inc., 2007.
2. P. Oldring, P. Lam, *Waterborne and Solvent Based Surface Coatings Resins and Their Applications: Acrylics*, Volume 1, 1st Edition, SITA Technology, 1996.

ORGANIC MATERIALS

CY428

L	T	P	C
3	0	0	3

Scheme

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Impart knowledge in fundamental aspects of organic materials.
CO2	Acquire knowledge on the preparation and properties of organic materials.
CO3	Gain knowledge on the synthetic strategies for preparation of multifunctional organic materials.
CO4	Recognize the basic knowledge on the role of organic materials in drug delivery.
CO5	Have an appreciation on the unique properties of organic materials and their applications.

2. Syllabus:

- **ORGANIC MATERIALS** **(16 Hours)**
  Introduction, definition, structure, types of organic materials, general method of preparation, properties, detection, and characterization of organic nanoparticles: hydrophobic drugs, protein, peptide, lipid, cyclodextrin, polysaccharides. Nanocochleates, prospects and future challenges.carbon molecules – nature of the carbon bond – new carbon nanostructures; carbon nanoclusters. molecular self-assemblies, surface engineering. Preparation of bionanomaterials, nanoparticles and microorganisms, microbial synthesis of nanomaterials, biological methods for synthesis of nano-emulsions using bacteria, fungi and actinomycetes, plants based nanoparticle synthesis, nanocomposite biomaterials – fibres, devices and structures, nanobio-systems.

- **SMART MATERIALS** **(06Hours)**
  Synthesis of smart materials, types of smart materials, micro sensors, hybrid smart materials, electro-Rheological (fluids) smart materials, and piezoelectric smart materials.

- **FUNCTIONAL ORGANIC MATERIALS** **(08Hours)**
  3-D-carborich pi-systems - nanotubes and segments; strategic advances in chromophore and materials syntheses; self-assembly strategies towards multifunctional materials; molecular muscles, switches and electronics; electronic interaction and structure.

- **NANOTECHNOLOGY IN DRUG DELIVERY** **(12Hours)**
  Nanoparticle in drug delivery, controlled release, organic materials future application understanding for treatment. Nanopowder and nanocrystals, targeting ligands applications of nanoparticle in drug delivery, cancer treatment, mediated delivery of sirna, nanonephrology, nanosystems in inflammation, targeting macrophages to control inflammation, tissue regeneration, growth and repair, tissue bioengineering; future understanding for treatment, drug delivery technology significance, impact of drug discovery and development. Applications of nanobiotechnology: organic materials cytotoxicity, green organic particle production; biocompatbility; Applications of green nanotechnology; use of organic materials impact on nanotechnologies, biodiversity, resource conservation, ecosystems.

(Total Lecture Hours: 42)

3. Books Recommended:

1. M. Schwartz, *Smart Materials*, CRC Press, 1st Edition, 2008.
2. S. V. Bhat, *Biomaterials*,Springer Netherlands, 1st Edition 2002.
3. G. L. Hornyak, J. Dutta, H. F. Tibbals, A. K. Rao, *Introduction to Nanoscience*, CRC Press, 1st Edition, 2008.
4. G. A. Ozin, A.C. Arsenault, L. Cademartiri, *Nanochemistry: A Chemical Approach to Nanomaterials*, The Royal Society of Chemistry, Cambridge, 2nd Edition, 2009.
5. G. Cao, *Nanostructures & Nanomaterials: Synthesis, Properties, and Applications*, Imperial College Press, London, 2004.

4. Additional Reading Material:

1. T. Vo-Dinh, *Nanotechnology in Biology and Medicine: Methods, Devices and Application*, CRC Press, 2007.
2. A. M. Hillery, *Drug Delivery and Targeting*, CRC Press, 2002.
3. J. J. T. Müller, U. H. F. Bunz (Eds), *Functional Organic Materials: Syntheses, Strategies and Applications*, Wiley-VCH, 2007.

DRUGS AND DYES

CY432

L	T	P	C
3	0	0	3

Scheme

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Acquire deep knowledge of theories of colour and chemical constitution.
CO2	Describe various dyestuff and categorize their applications.
CO3	Explain procedures followed in drug design and various theories of drug activity.
CO4	Interpret pharmacokinetics and pharmacodynamics.
CO5	Describe the concept of the therapeutic concentration range.

2. Syllabus:

- **THEORY OF COLOUR AND CHEMICAL CONSTITUTION** **(06 Hours)**
  Auxochrome, chromogen, chromophore of colour chemistry, colour and chemical constitutions. Theories to explain relation between colour and chemical constitutions: Witt's theory, Armstrong theory, Baeyer's theory, Nietzki's theory, Watson's theory. Modern theories: Valence bond theory (resonance theory) and Molecular orbital theory.

- **SYNTHESIS OF DYESTUFF AND PIGMENT OF VARIOUS CLASSES** **(05 Hours)**
  Chemical Synthesis of Nitro and Nitroso dyes; Azo dyes such as Direct, Acid, Basic, Mordant, Disperse dye. Diphenyl methane dyes (DPM); Triphenyl Methane Dyes (TPM); Phthalocyanine; Xanthene dyes; Heterocyclic dyes such as acridine dyes; Indigo and Thioindigo; Solubilised vat dyes; Anthraquinon dyes such as Mordant vat, disperse and acid dyes; Reactive dyes such as procion dyes and vinyl sulphone dyes.

- **NON-TEXTILE APPLICATION OF DYES** **(03 Hours)**
  Food colours, cosmetic dyes, dyes for paper and printing inks, dyes for paints, High tech dyes.

- **FLUORESCENT BRIGHTENING AGENTS** **(04 Hours)**
  General account, classification of FBA base on chemical constitution with examples, Stilbene and Coumarin derivatives of FBA, synthesis of Tinopal BV, Blankophor -B, Blankophor-G , 3-phenyl-7 methoxy coumarin, 4 methyl –3 phenyl-7-aminocoumarin.

- **DRUG DESIGN** **(06 Hours)**
  Procedure followed in drug design, Concept of prodrugs and soft drugs, Theories of drug activity: Occupation theory, rate theory, induced fit theory. Concepts of drug receptors, Elementary treatment of drug receptor interactions, LD-50, ED-50.

- **PHARMACOKINETICS** **(06 Hours)**
  Introduction of drug absorption, disposition, elimination using pharmacokinetics, important pharmacokinetics parameters in drug disposition and in therapeutics, Importance of pharmacokinetics in drug design.

- **PHARMACODYNAMICS** **(06 Hours)**
  Introduction, elementary treatment of enzyme stimulation, enzyme inhibition, drug metabolism, phase-I, Phase-II reactions, biotransformation.

- **SYNTHESIS OF SELECTIVE DRUGS** **(06 Hours)**
  Ciprofloxacin, Ibuprofen, Atenolol, Captopril, Diazepam, Chloroquine, Barbiturates, Miconazole, Biotin, Ethambutol, Ranitidine, and Omeprazole.

(Total Lecture Hours: 42)

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3. Books Recommended:

1. R. Christie, *Colour Chemistry*, 2nd Edition, Royal Society of Chemistry, 2015.
2. G. R. Chatwal, *The Synthetic Dyes*, 4th Edition, Himalaya Publishing House, 2016.
3. M. Sitting, *Pharmaceutical Manufacturing Encyclopaedia*, 3rd Edition, William Andrew Publishing, 2006.
4. S. D. Seth, V. Seth, *Textbook of pharmacology*, 3rd Edition, Elsevier 2009.
5. A. Korolkovas, *Essentials of Medicinal Chemistry*, John Wiley & sons, 2nd Edition, 2008.

GREEN CHEMICAL PROCESSING

CY434

L	T	P	C
3	0	0	3

Scheme

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain green chemistry concepts and its significance for environment sustainability.
CO2	Differentiate between conventional and green raw materials.
CO3	Design green process and analyze sustainability of materials.
CO4	Analyze sustainability of chemical processes.
CO5	Establish application of green chemistry in multidisciplinary areas including pharmaceutical, petrochemical, storage and green fuel production.

2. Syllabus:

- **ENVIRONMENT SUSTAINABILITY OF CHEMICAL PROCESSES** **(05 Hours)**
  Introduction to green chemistry, criteria for selection of green technologies, renewable feedstock, sustainable solvents and auxiliaries,waste minimization and design for degradation.

- **GREEN SYNTHETIC ROUTES** **(10 Hours)**
  Chemie Douce approach of material synthesis, Intercalation, Anchoring, Pillaring, Sonochemical method, Microwave synthesis, Mechanochemical synthesis, Electrochemical synthesis and Photochemical synthesis.

- **GREEN MATERIALS** **(10 Hours)**
  Zeolites, hydrocalcites, heteropoly acids, metal organic frameworks, sulfated zirconia and ionic liquids as catalysts.

- **APPLICATIONS OF GREEN PROCESSES** **(17 Hours)**
  (i) For active pharma ingredients (API)
  (ii) For polymers
  (iii) For green fuel production and polymer membrane fuel cells
  (iv) For CO_2 utilization and carbon credit
  (v) For biomass to value added products

(Total Lecture Hours: 42)

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3. Books Recommended:

1. M. Lancaster, *Green Chemistry: An Introductory Text*, 1st Edition, RSC, 2002.
2. E. Lichtfouse, J. Schwarzbauer, *Green Materials for Energy, Products and Depollution (Environmental Chemistry for a Sustainable World)*, 1st Edition, Springer, 2013.
3. P. Wasserscheid, A. Stark, *Handbook of Green Chemistry*, Volume 6, Ionic liquids, 1st Edition, Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim, 2013.
4. G. Rothenberg, *Catalysis: Concepts and Green Applications*, 2nd Edition, Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim, 2008.
5. V. K. Ahluwalia, *Green Chemistry: Environmentally Benign Reactions*, 2nd Edition, Ane Books Pvt. Ltd, 2009.

4. Additional Materials

1. P. T. Anastas, J. C. Warner, J. Warner, *Green Chemistry: Theory and Practice*, 1st Edition, Oxford University Press, 2000.
2. R. XU, W. Pang, O. Huo, *Modern Inorganic Synthetic Chemistry*, 2nd Edition, Elsevier, 2010.

FIFTH YEAR OF FIVE YEARS INTEGRATED M. Sc. (CHEMISTRY)
M. Sc. - V, SEMESTER – IX

Sr. No.	Subject	Code	Scheme	Credit	Examination Scheme				Total Marks
					Theory	Tutorial	Practical		
							Int.	Ext.	
1.	Seminar	CY-501	0-0-2	01	00	00	20	30	50
2.	Dissertation Preliminaries	CY-503	0-0-16	08	00	00	80	120	200
3.	Industrial Visit(s)	CY-505	0-0-0	01	00	00	20	30	50
4.	Elective-3	CY-5XX	3-0-0	03	100	00	00	00	100
	Elective-4	CY-5YY	3-0-0	03	100	00	00	00	100
	Total contact hours per week=24		**Total Credits=16**			**Total Marks=500**			

Elective-3 (CY-5XX)

Sr. No.	Code	Subject
1.	CY-521	Synthetic Dyes for Textile Processing
2.	CY-523	Green Solvents
3.	CY-525	Catalysis
4.	CY-527	Spectroscopic Techniques in Inorganic Chemistry

Elective-4 (CY-5YY)

Sr. No.	Code	Subject
1.	CY-529	Heterocycles and Organic Synthesis
2.	CY-531	C-H Functionalization
3.	CY-533	Supramolecular Chemistry
4.	CY-535	Physical Methods of Structure Determination

FIFTH YEAR OF FIVE YEARS INTEGRATED M. SC. (CHEMISTRY)
M. SC. - V, SEMESTER – X

Sr. No.	Subject	Code	Scheme	Credit	Examination Scheme				Total Marks
					Theory	Tutorial	Practical		
							Int.	Ext.	
1.	Dissertation	CY-502	0-0-24	12	00	00	160	240	400
Total contact hours per week=24				**Total Credits=12**				**Total Marks=400**	

SYNTHETIC DYES FOR TEXTILE PROCESSING

L	T	P	C
3	0	0	3

Scheme

CY521

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the chemistry of colouring matters, its origin, types and importance.
CO2	Provide basic principle and chemistry of various dyes with their properties.
CO3	Identify the fundamentals aspects of colour, relation between colour and chemical constitution of dyes.
CO4	Explore the use of synthetic dyes to develop and familiarize with basic dyeing techniques.
CO5	Provide technical knowhow for coloration and printing of different textiles.

2. Syllabus:

- **TEXTILE DYEING** **(08 Hours)**
  Introduction, Dyeing Technology, Principles of Dyeing, bath Dyeing Technology, Continuous and Semi Continuous Dyeing, printing, Dispensing Dyes and Chemicals, Standardization of Textile Dyes, Laboratory Dyeing Techniques.

- **REACTIVE DYES AND DIRECT DYES ON CELLULOSE FIBERS** **(06 Hours)**
  Reactive dyes: Introduction, Chemistry, synthesis, Dyeing Techniques for Cellulose, Reactive Dyes on Wool, Silk and Polyamide Fibers, Reactive Dyes for Printing on Cellulose.
  Direct Dyes: Dyeing Principle, Dyeing Parameters, Dyeing Techniques, After treatment, Direct Dyes for Fiber Blends.

- **ANTHRAQUINONE VAT DYES ON CELLULOSIC FIBERS** **(04 Hours)**
  Introduction, Chemistry and synthesis of anthraquinone vat dyes, Principles of Vat Dyeing, The Vat Dyeing Process, Vatting, Dye Absorption in the Exhaustion Process, Oxidation, After treatment (Soaping), Dyeing Techniques, Vat Dyes for Fiber Blends, leuco Esters of Vat Dyes on Cellulosic Fibers.

- **DYEING WITH INDIGO AND SULFUR DYE** **(06 Hours)**
  Indigo dye: Introduction, Chemistry, synthesis, Dyeing Technique on Cotton, Indigo on Wool, : Sulphur dye: Introduction, Chemistry, synthesis, Sulfur Dyes on Cellulosic Fibers: Types and Mode of Reaction, Additives to the Dye Bath, The Dyeing Process, Dyeing Techniques, Combination with Other Dyes.

- **AZO DYES ON CELLULOSIC FIBERS** **(06 Hours)**
  Introduction, Chemistry, synthesis, Application of Azo Dyes, Dyeing Processes on Cellulosic Fibers, Printing with Azo Dyes on Cellulosic Fibers.

- **DISPERSE DYES ON POLYESTER AND OTHER MAN-MADE FIBERS** **(06 Hours)**
  Introduction, Chemistry, synthesis, General Aspects, dyeing in Aqueous Liquor, Thermosol Process, Dyeing Processes for Polyester Fibers with Disperse Dyes, Suitability of Disperse Dyes for Different Applications, Dyeing from Aqueous Dye Baths, special Dyeing Processes, Continuous and Semicontinuous Dyeing Processes, Dyeing of PES Microfibers, Dyeing of Modified PES

Fibers, Printing with Disperse Dyes on Man-Made Fibers, After treatment, dyeing Blends Containing Polyester Fibers, Polyester Cellulose Blends, Polyester Wool Blends.

- **FASTNESS OF COLOURED TEXTILES** **(06 Hours)**
  Colour and light fastness, fastness test and properties, fastness test towards processing conditions and condition in use.

(Total Lecture Hours: 42)

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3. Books Recommended:

1. R. M. Christie, *Colour Chemistry*, 2nd Edition, The Royal Society of Chemistry, 2015.
2. K. Hunger, *Industrial Dyes: Chemistry, Properties, Applications*, 3rd Revised Edition, Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim. 2003.
3. V. A. Shenai, *Chemistry of Dyes and Principles of Dyeing*, Sevak Publications, 1983.
4. H. A. Lubs, *The Chemistry of Synthetic Dyes and Pigments*, 4th Edition, Krieger Publishing Company, 1977.
5. K. Venkatraman, *Chemistry of Synthetic Dyes*, Volume 1-5, 1st Edition, Academic Press, New York and London, 1972.

4. Additional Reading Materials:

1. K. M. Shah, *"Handbook of Synthetic Dyes and Pigments*", Volume 1-2, 2nd Edition, Multi-tech Publishing Co., 1998.
2. G. R. Chatwal, *Synthetic Dyes*, 3rd Edition, Himalaya Publishing House, 2007.

GREEN SOLVENTS

CY523

L	T	P	C
3	0	0	3

Scheme

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Gain knowledge in fundamental aspects of Green Chemistry.
CO2	Acquire knowledge on the preparation and properties of Green Solvents.
CO3	Develop the synthetic strategies for the preparation of tailor made Ionic Liquids, Deep Eutectic Solvents and Supercritical Fluids.
CO4	Demonstrate the basic knowledge on the role of Green Solvents in diverse applications.
CO5	Have a knowledge on the unique properties of Green Solvents and their industrial applications.

2. Syllabus:

- **GREEN CHEMISTRY PRINCIPLES** **(06 Hours)**
  Principles of green chemistry, Green pathways for chemical syntheses, designing safer and energy efficient solvents, real time analysis for pollution prevention, and inherently safer chemistry for accident prevention.

- **IONIC LIQUIDS** **(14 Hours)**
  Introduction, Synthesis and Purification of Ionic Liquids (ILs), Physicochemical properties of ILs, ILs as Catalysts, Bio-ILs, ILs in synthesis, Green Synthesis of ILs for Green Chemistry, Thermodynamic Properties of liquid mixtures containing ILs, Surface Active ILs, ILs in Drugs, Biotransformations in ILs, Challenges to the Commercial production of ionic liquids.

- **DEEP EUTACTIC SOLVENTS** **(14 Hours)**
  Introduction – Composition of Deep Eutectic Solvents (DES), Physicochemical Properties of DESs, natural DESs, Applications of DES in Removal of Surface Contaminants, DES as Unconventional Media for Multicomponent Reactions, Applications of DESs in Metal Processing, Bio-transformations in DESs.

- **SUPERCRITICAL FLUIDS** **(08 Hours)**
  Introduction, Properties of Supercritical Fluids, Supercritical Fluids as Media for Chemical Reactions, Phase Equilibria in Near-Critical Solutions, Solvation in Supercritical Fluids, Homogeneous Organic Reactions as Mechanistic Probes in Supercritical Fluids, Supercritical Fluids in Heterogeneous Catalysis, Super critical Fluids in nanotechnology, Supercritical Carbon Dioxide and its applications.

(Total Lecture Hours: 42)

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3. Books Recommended:

1. P. Wasserscheid. T. Welton, *Ionic Liquids in Synthesis*, 2nd Edition, Wiley-VCH Verlag GmbH & Co. KGaA, 2008.
2. R. D. Rogers, K. R. Seddon, *Ionic Liquids as Green Solvents: Progress and Prospects*, American Chemical Society: Washington, DC (Distributed by Oxford University Press), 2003.

3. M. Yizhak, *Deep Eutectic Solvents*, 1st Edition, Springer International Publishing, Springer Nature Switzerland AG, 2019.
4. P. G. Jessop, W. Leitner, *Chemical Synthesis Using Supercritical Fluids*, 2nd Edition, Wiley-VCH Verlag GmbH VCH, Weinheim, 1999
5. E. Kiran, P. G. Debenedetti, C. J. Peters, *Supercritical Fluids: Fundamentals, and Applications*, 2nd Edition, Springer Netherlands, Springer Science, Business Media Dordrecht, 2000.

4. Additional Reading Material:

1. M. F. Kemmere, T. Meyer, *Supercritical Carbon Dioxide: In Polymer Reaction Engineering* (Green Chemistry), Wiley-VCH, 2005.
2. J. R. Williams, A. A. Clifford, *Supercritical Fluid Methods and Protocols*, Springer, Humana Press, 2000.

CATALYSIS

CY525

L	T	P	C
3	0	0	3

Scheme

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Summarize basics and principle of catalysis and their potential use to produce environmental and industrial catalysts.
CO2	Apply fundamentals of catalyst preparation, develop characterization skills and evaluate catalyst
CO3	Interpret surface characterization data of catalysts, correlate structure and properties of catalysts and how this insight can be used to design new catalysts.
CO4	Discuss various spectroscopic and thermal techniques can be used to characterize catalytic materials.
CO5	Compile and propose new applications of catalysis in multidisciplinary areas including pharmaceutical, petrochemical, alternative energy, biorefineries etc.

2. Syllabus:

- **INTRODUCTION TO CATALYSIS CONCEPTS AND CLASSIFICATION (06 Hours)**
  Activation energy, activity, selectivity, stability, enantioselectivity, promoter, concept of TON and TOF, catalyst deactivation, life cycle of catalysts, Introduction to homogeneous catalysis, heterogeneous catalysis, homogenized heterogeneous catalysis, environmental catalysis, phase transfer catalysis, biocatalysis, photocatalysis, etc.

- **CATALYST TYPES (07 Hours)**
  Metal based catalysts, metal oxides, metal nanoparticles, supported catalysts, solid acid catalysts, shape selective catalysts.

- **CATALYSTS PREPARATION METHODS (10 Hours)**
  Precipitation, Impregnation, Sol-gel method, dry-gel method, template method, hydrothermal method, vapour phase method, microwave method, solid state crystallization method, ion exchange and catalyst preparation by functionalization and an overview of commercial manufacturing of catalysts.

- **METHODS FOR CATALYST CHARACTERIZATION (12 Hours)**
  Catalyst characterization by thermal methods, Surface area characterization by BET method, acidity and basicity measurements by NH_3-TPD method and CO_2 adsorption method, catalyst characterization by spectral (X-Ray, IR, NMR) and electron microscopic methods (SEM and TEM).

- **ENVIRONMENTAL AND INDUSTRIAL APPLICATIONS OF HETEROGENOUS CATALYSIS (07 Hours)**
  Applications of catalysis inorganic transformations, petrochemical and fertilizer industries, bio-energy production from biomass, etc.

(Total Lecture Hours: 42)

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3. Books Recommended:

1. G. C. Bond, *Catalysis by Metals*, 2nd Edition, Academic Press: London, 1962.
2. J. W. Niemantsverdriet; *Spectroscopy in Catalysis*, 3rd Edition, Wiley-VCH Publications, Netherlands, 2007.
3. J. Cejka, A. Corma, S. Zones, *Zeolites and Catalysis Synthesis, Reactions and Applications*, 1st Edition, Wiley-VCH Verlag GmbH & Co. KGaA, 2009.
4. N.M. Gupta, V. B. Kartha, R. A. Rajadhyakha, *Spectroscopic Methods in Heterogeneous Catalysis*, TATA McGraw Hill, 1989.
5. G. Rothenberg, *Catalysis: Concepts and Green Applications*, 2nd Edition, Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim, 2008.

4. Additional Reading Material:

1. C. N. R. Rao and K. Biswas, *Essentials of Inorganic Materials Synthesis*, Wiley –Blackwell, 1st Edition, 2015.
2. B. Pottathara, S. Thomas, V. Kokol, *Nanomaterials Synthesis, Design, Fabrication and Applications*, A volume in Micro and Nano Technologies, Elsevier, 2019.

SPECTROSCOPIC TECHNIQUES IN INORGANIC CHEMISTRY

CY527

L	T	P	C
3	0	0	3

Scheme

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explore some spectroscopy techniques for inorganic compounds.
CO2	Study on applications of NMR spectroscopy in inorganic compounds.
CO3	Explain on electron spin resonance spectroscopy.
CO4	Gain knowledge on nuclear quadrupole resonance spectroscopy.
CO5	Differentiate on infrared and Raman Spectroscopy for inorganic compounds.

2. Syllabus:

- **NMR SPECTROSCOPY** **(10 Hours)**
  Use of Chemical shifts and spin-spin couplings for structural determination, Double resonance and dynamic processes in NMR, Decoupling phenomenon, Nuclear Overhauser Effect, DEPT spectra and structural applications in 13C NMR, Use of Chemicals as NMR auxillary reagents (shift reagents and relaxation reagents), 1H NMR of paramagnetic substances, NMR of Metal nuclei. Stereochemical non-rigidity and fluxionality: Introduction, use of NMR in its detection, its presence in trigonalbipyramidal molecules (PF_5), Systems with coordination number six ($Ti(acac)_2Cl_2$, Ti(acac)2Br_2, $Ta_2(OMe)_{10}$).

- **ELECTRON SPIN RESONANCE SPECTROSCOPY** **(08 Hours)**
  Basic principle, Hyperfine Splitting (isotropic systems); the **g** value and the factors affecting thereof; interactions affecting electron energies in paramagnetic complexes (Zero-field splitting and Kramer's degeneracy); Electron-electron interactions, Anisotropic effects (the **g** value and the hyperfine couplings); Structural applications to transition metal complexes.

- **NUCLEAR QUADRUPOLE RESONANCE SPECTROSCOPY** **(08 Hours)**
  Basic concepts of NQR (Nuclear electric quadrupole moment, Electric field gradient, Energy levels and NQR frequencies), Effect of magnetic field on spectra, Factors affecting the resonance signal (Line shape, position of resonance signal) Relationship between electric field gradient and molecular structure. Interpretation of NQR data, Structural information of the following: PCl_5, $TeCl_4$, $Na(GaCl_4)$, BrCN, HIO_3 and Hexahalometallates.

- **MÖSSBAUER SPECTROSCOPY** **(08 Hours)**
  Basic principle, conditions for Mossbauer spectroscopy, Spectral parameters (Isomer shift, electric quadrupole interactions, magnetic interactions), temperature dependent effects, structural deductions for iron and tin complexes, miscellaneous applications.

- **INFRARED AND RAMAN SPECTROSCOPY** **(08 Hours)**
  Applications of vibrational spectroscopy in investigating (i) symmetry and shapes of simple AB2, AB3 and AB4 molecules on the basis of spectral data, (ii) mode of bonding of ambidentate ligands (thiocyanate, nitrate, sulphate and urea). Distinction between Ionic and coordinate anions such as NO^{3-}, SO_4^{2-} and SCN^-, Lattice and coordinated water. Mode of bonding of ligands such as urea, dimethylsulphoxide and hexamethylphosphoramide.

(Total Lecture Hours: 42)

3. Books Recommended:

1. R. S. Drago, *Physical Methods in Inorganic Chemistry*, 4th Edition, Affiliated East-West Press, New Delhi, 2012.
2. G. Aruldhas, *Molecular Structure and Spectroscopy*, 2nd Edition, Prentice Hall of India Pvt. Ltd., New Delhi, 2001.
3. E. D. Olsen, *Modern Optical Methods of Analysis*, 1st Edition, McGraw-Hill Inc., US, 1975.
4. K. Nakamoto, *Infrared Spectra of Inorganic and Coordination Compounds*, 6th Edition, John Wiley & Sons, 2008.
5. D. N. Sathyanarayana, *Introduction to Magnetic Resonance Spectroscopy ESR, NMR, NQR*, 2nd Edition, I. K. International Publishing House Pvt. Ltd., 2009.

HETEROCYCLES AND ORGANIC SYNTHESIS

L	T	P	C
3	0	0	3

Scheme

CY529

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Discuss synthesis, reactivity and significance of various types of heterocycles.
CO2	Demonstrate the importance of microwave assisted synthesis over conventional methods.
CO3	Acquaint with synthetic strategies.
CO4	Analyze multicomponent reactions and discuss its advantage over traditional approach.
CO5	Explain synthesis, reactivity and significance of various types of heterocycles.

2. Syllabus:

- **FIVE AND SIX MEMBERED HETEROCYCLES WITH ONE AND TWO HETERO ATOMS (07 Hours)**
  Synthesis, reactivity, aromatic character and importance of following heterocyclic rings:, Pyrazole, Imidazole, Oxazole, Thiozole, Iosoxazole, Pyridine, Pyrimidine, Pyrazine, Oxazine and thiazine.

- **CONDENSED FIVE AND SIX MEMBERED HETEROCYCLES (07 Hours)**
  Synthesis, reactivity, aromatic character and importance of Benzofuran, Benzothiophene, Coumarins and Chromones, Condensed five membered heterocycles- Benzoxazole, Benzthiazole, Benzimidazole.

- **FIVE AND SIX MEMBERED HETEROCYCLES WITH MORE THAN TWO HETERO ATOMS (07 Hours)**
  Synthesis, reactivity, aromatic character and importance of following heterocycles:1,2,3-triazole, 1,2,4-triazole, 1,2,4- oxadiazole, 1,3,4- oxadiazole, 1,2,5- oxadiazole,tetrazole, 1,2,3-triazine, 1,2,4-triazine, 1,3,5-triazine,tetrazine, purines, pyrimidines and pteridines.

- **MICROWAVE ASSITED ORGANIC SYNTHESIS (07 Hours)**
  Microwave effect vs thermal effect, microwave reactors, reactions in homogeneous media and solvent, reactions of reagent supported on mineral acids, solvent free phase transfer catalysis.

- **MULTI-COMPONENT REACTIONS (06 Hours)**
  Relative reactivities of functional group to MCR, selected reactive functionalies in MCR like carbonyl, isocyanide; types of MCR, Diversity in MCR: Ugi, Passerini, Biginelli and Mannich reactions.

- **SYNTHETIC STRATGIES (08 Hours)**
  Reterosynthetic approach, Umpolung strategy, Ring formation reactions: Pausan- Khand, Bergman and Nazerov cyclization, Click chemistry: criterion for click chemistry, Enamines in Organic synthesis.

(Total Lecture Hours: 42)

3. **Books Recommended:**

1. J. A. Joule, K. Mills, *Heterocyclic Chemistry*, 5th Edition, Wiley Blackwell, 2010.
2. A. R. Katritzky, J. M. Lagowski, *The Priniciples of Heterocyclic Chemistry*, 1st Edition, Academic Press, 1968.
3. L. Kurti, C. Barbara, *Strategic Applications of Named Reactions in Organic Synthesis*, 1st Edition, Elsevier Academic Press, 2005.
4. T. J. J. Muller, *Science of Synthesis: Multicomponent Reactions,* Volume 1, 1st Edition, Thieme publishers, 2014.
5. D. Bogdal, *Microwave-assisted Organic Synthesis: One Hundred Reaction Procedures*, Volume 25, 1st Edition, Elsevier, 2005.

C-H FUNCTIONALIZATION

L	T	P	C
3	0	0	3

Scheme

CY531

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Acquire deep knowledge of advanced organometallic chemistry
CO2	Identify how these individual reactions make up a catalytic cycle
CO3	Appreciate C–H interactions with transition metals and how C–H activation can occur at a transition metal center.
CO4	Explain the role of photo catalysis in modern synthetic methodology
CO5	Propose the importance of catalysis in industrial processes.

2. Syllabus

- **Advanced Organometallic Chemistry of Transition Elements** **(18 Hours)**
  Introduction to the fundamentals of homogeneous catalysis and the mechanisms in organometallic chemistry: Oxidative addition, sigma bond metathesis, reductive elimination, insertion and elimination. Metal mediated C-C and C-X coupling reactions Heck, Negishi, Suzuki, and Stille, Sonogashira, Nozaki-Hiyama, Kumada, Buchwald-Hartwig, Catellani, Fujiwara-Moritani reactions and their synthetic utility in drug synthesis. Directed orthometalation, Metal (Pd, Rh) catalyzed C-H activation reactions and their synthetic utility, Copper and rhodium based carbene and nitrene complexes, Cyclopropanation, Rh catalyzed C-H insertion and aziridination reactions including asymmetric version, Noyori asymmetric hydrogenation. Introduction to N-heterocyclic carbene metal complexes. Tebbe's reagent, Pauson-Khand reaction, Hydroformylation, Carbonylation reactions.

- **C-H Bond Activation and Functionalization** **(14 Hours)**
  Interaction of metal centres with C-H bonds, agostic interactions and C-H activation, electrophilic and metalloradical activation. Organic synthesis involving chelation-assisted C-H activation, *ortho*-C-H activation, Distal C-H activation, C-H activation in heterocycles synthesis. C-H, C=C and C≡C activated annulation reactions. Important synthetic approaches *via* C-X (X= C, N, O, S etc.) bond activation. Role of non-metallic activation of bonds in organic synthesis.

- **Visible Light Photocatalysis in Organic Chemistry** **(10 Hours)**
  Introduction, Basics of the photocatalytic cycle, Generation of radicals, C—X (X = N, O, S etc.) bond formation, C-C bond formation, Atom transfer radical addition reactions, Cycloaddition reactions, Arene functionalization, Application of visible-light-mediated reactions to the synthesis of pharmaceutical compounds.

(Total Lecture Hours: 42)

3. Books Recommended:

1. A. Yamamoto, *Organotransition Metal Chemistry, Fundamental Concept and Applications*, 1st Edition, John Wiley, 1986
2. R.H. Crabtree, *The Organometallic Chemistry of Transition Metals*, 2nd Edition, John Wiley, 1994
3. D. W. C. MacMillan, *Visible Light Photocatalysis in Organic Chemistry*, 1st Edition, John Wiley, 2018

4. J. Yu Z. Shi, *C-H Activation (Topics in Current Chemistry Book 292)*, 1st Edition, Springer, 2010
5. J. Yu, *Science of Synthesis: Catalytic Transformations via C-H Activation*, Volume 1, 1st Edition, Thieme, 2016.

SUPRAMOLECULAR CHEMISTRY

CY533

L	T	P	C
3	0	0	3

Scheme

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Acquire basic and need of supramolecular chemistry.
CO2	Study on thermodynamic and kinetic aspects of host-guest chemistry.
CO3	Gain advance knowledge on artificial host molecules.
CO4	Explain molecular self-assembly.
CO5	Explore the application of supramolecular chemistry in device fabrication.

2. Syllabus

- **FUNDAMENTALS OF SUPRAMOLECULAR CHEMISTRY** **(06 Hours)**
  Molecules, super molecules and supramolecular Chemistry, non-covalent interactions, complementarity and cooperativity, supramolecular chemistry of life.

- **HOST-GUEST CHEMISTRY** **(14 Hours)**
  Host-guest complexation, Thermodynamics of host-guest complexation, Molecular recognition – factors involved, Molecular receptors/ Ionophores – design principles; Molecular receptors for cations, anions and neutral molecules, Crown ethers, cryptands, spherands, cyclodextrins, cucurbituril, and calixarenes, cavitands, molecular clips, clefts and tweezers, Threading of a linear molecule through a cyclic molecule, Creation of rotaxanes and catenanes.

- **SELF-ASSEMBLY** **(12 Hours)**
  Biological self-assembly, self-assembly in synthetic systems, self-assembling coordination compounds, capsules, helicates and molecular knots, organic and inorganic nanomaterials, Crystal nucleation and growth, understanding crystal structures, supramolecular gels, supramolecular polymers, Amphiphiles and their aggregation, Aggregation induced emission and quenching.

- **MOLECULAR DEVICES** **(10 Hours)**
  Supramolecular photochemistry and devices, chemosensors, molecule-based electronics: Molecular wires, molecular switches, molecular logic, molecular rectifiers and molecular electronic devices.

(Total Lecture Hours: 42)

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3. Books Recommended:

1. J. W. Steed, J. L. Atwood, *Supramolecular Chemistry*, 2nd Edition, John Wiley, 2009.
2. K. Ariga, T. Kunitake, *Supramolecular Chemistry, Fundamentals and Applications*, 1st Edition, Springer, 2006.
3. J. W. Steed, D. R. Turner, K. J. Wallace, *Core Concepts in Supramolecular Chemistry and Nanochemistry*, 1st Edition, Wiley, 2007.
4. H. Dodziuk, *Introduction to Supramolecular Chemistry*, Springer, 1st Edition, 2002.
5. J. M. Lehn, *Supramolecular Chemistry,* 1st Edition, Wiley-VCH, 1995.

PHYSICAL METHODS OF STRUCTURE DETERMINATION

L	T	P	C
3	0	0	3

Scheme

CY535

1. Course Outcomes (Cos):

At the end of the course students will be able to:

CO1	Explain fundamentals of crystal growth and crystal habits.
CO2	Acquire profound knowledge in crystal systems.
CO3	Execute X-ray crystallographic knowledge for solving structures.
CO4	Enumerate the spectral behaviour of a molecule with unpaired electrons.
CO5	Interpret magnet properties of a molecule.

2. Syllabus:

- **CRYSTAL GROWTH** **(08 Hours)**
  Nucleation phenomenon – Homogenous and Heterogeneous nucleation, Theories of crystal growth. Defects, Classification of crystal growth methods: Melt, solution and Vapour Growth Techniques. Crystal habits and aggregates.

- **CRYSTAL STRUCTURE** **(20 Hours)**
  Crystal symmetry, Cell parameters and Crystal systems, Cubic crystal system & lattices; Density & Packing Fraction; Miller indices of crystallographic planes & directions; interplanar distance, Determination of crystal structure using X-ray diffraction techniques viz. Laue method, rotating crystal method (Bragg method) & powder method. X-ray Diffraction pattern of a cubic system: Indexing of powder diffraction patterns. Coordinates of Points, Structure factor calculation, Diffraction Intensity, preparation of structure plots including ORTEP and lattice structures including packing diagrams. Crystal packing and **Visualisation through MERCURY and DIAMOND software,** diffractometer instrumentation, Practical exercise of structure determination using standard packages. Basic Refinement exercise.

- **EPR SPECTROSCOPY AND MAGNETIC PROPERTIES** **(14 Hours)**
  Basic principles, zero field splitting and Kramer's degeneracy, factors affecting the 'g' value. Isotropic and anisotropic hyperfine coupling constants spin Hamiltonian, spin densities and Mc Connell relationship, applications. Structure characterization of Cu(II) complexes using EPR spectroscopy, Isotropic, axial and rhombic EPR spectra and interpretation.
  Magnetic properties -Determination of Magnetic moments and their applications to the elucidation of structures of inorganic compounds – temperature independent paramagnetism, Field-dependent magnetization, Magnetic properties of transition metals. Spin crossover in coordination compounds – Single molecule magnets, Plotting MPMS Data.

(Total Lecture Hours: 42)

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3. Books Recommended:

1. M. M. Woolfson, *An Introduction to X-ray Crystallography*, 2nd Edition, Cambridge University Press; 1997.
2. J. C. Brice, *Crystal Growth Processes*, John Wiley and Sons, New York, 1986
3. J. W. Mullin, *Crystallization*, 4th Edition, Elsevier Butterworth-Heinemann, London, 2001.

4. A. W. Vere, *Crystal Growth: Principles and Progress*, 1st Edition, Plenum Press, New York, 1987.
5. R. S. Drago, *Physical Methods in Inorganic Chemistry*, 2nd Edition, International Edition East-West Press, 2016.

FIFTH YEAR OF FIVE YEARS INTEGRATED M. SC. (CHEMISTRY)
M. SC. - V, SEMESTER – X

Sr. No.	Subject	Code	Scheme	Credit	Examination Scheme				Total Marks
					Theory	Tutorial	Practical		
							Int.	Ext.	
1.	Dissertation	CY-502	0-0-24	12	00	00	160	240	400
Total contact hours per week=24				**Total Credits=12**		**Total Marks=400**			

Total hours: 280 Total Credits: 212

On Successful Completion of the course, the candidate will be awarded 5-Years Integrated M. Sc. Degree in Chemistry.

Five years integrated M. Sc. (Mathematics)

Revised Curriculum

Applied Mathematics & Humanities Department
S. V. National Institute of Technology Surat
Gujarat-395007

Five years Integrated M. Sc. (Mathematics)
Teaching Scheme

Semester-III

Sr. No.	Course	Code	Teaching Scheme Hours per week			Credits	Examination Scheme				Total Marks
			L	T	P		Theory	Tutorial	Practical		
									Cont. Eval.	End Sem	
1	English & Professional Communication -II	HU 201	3	0	0	3	100	0	0	0	100
2	Elements of Analysis	MA 201	3	2	0	5	100	50	0	0	150
3	Analytical Geometry	MA 203	3	2	0	5	100	50	0	0	150
4	Discrete Mathematical Structure	MA 205	3	1	0	4	100	25	0	0	125
5	Interdisciplinary Subject (Physics/Chemistry) : Electromagnetics and Relativity	PH 207	3	1	0	4	100	25	0	0	125
6	Computer Lab: Mathematical Software Lab	MA 207	0	0	4	2	0	0	60	40	100
			15	6	4	23					

Total contact Hours per week = 25 **Total Credits = 23** **Total Marks = 750**

Semester-IV

Sr. No.	Course	Code	Teaching Scheme Hours per week			Credits	Examination Scheme				Total Marks
							Theory	Tutorial	Practical		
			L	T	P				Cont. Eval.	End Sem	
1	Communication Skills for Employability	HU 202	3	0	0	3	100	0	0	0	100
2	Numerical Analysis	MA 202	3	1	2	5	100	25	30	20	175
3	Linear Algebra	MA 204	3	2	0	5	100	50	0	0	150
4	Elementary Number Theory	MA 206	3	1	0	4	100	25	0	0	125
5	Computational Life Science	MA 208	3	0	0	3	100	0	0	0	100
6	Data Structures	CS 210	3	1	2	5	100	25	25	25	175
			18	5	4	25					

Total contact Hours per week = 27 **Total Credits = 25** **Total Marks = 825**

HU 201: English and Professional Communication-II

L	T	P	Credit
3	0	0	03

1. Course Outcomes (COs)

At the end of the course the students will be able to :

CO1: express themselves using appropriate vocabulary and grammar

CO2: draft scientific reports and formal proposals

CO3: comprehend scientific and general content more skilfully and meaningfully

CO4: predict human transactions and behavioural modes

CO5: communicate effectively through various means and at varied levels

2. Syllabus

- **FUNCTIONAL ENGLISH GRAMMAR** **(08 Hours)**

  Language functions, Modals, Tenses, Active and Passive Voice, Conditional sentences, Concord errors.

- **TECHNICAL WRITING** **(06 Hours)**

  Formal and informal report- Information and recommendation reports, Progress and Periodic report, Feasibility and trip report. Proposal writing- types, logistics of proposals, the deliverables of proposals persuasion and proposal, the structure of the proposal.

- **LISTENING AND READING COMPREHENSION** **(10 Hours)**

  Listening and note taking, Paraphrasing, Reading using SQ3R, Predicting, Understanding Gist reading and listening general and scientific texts and developing vocabulary

- **LANGUAGE THROUGH LITERATURE** **(08 Hours)**

  Short Stories:

  1. The Remarkable Rocket by Oscar Wild.
  2. An Astrologer's Day by R. K. Narayan.
  3. The Case of the Lower Case Letter by Jack Delany.

- **GROUP COMMUNICATION & ACADEMIC WRITING** **(10 Hours)**

  Transactional analysis; SOP; LOR; Research paper, Dissertation, Thesis; Types of group communication- Seminar, Conferences, Convention, Symposium, Panel discussion etc.

Total Lecture Hours: 42

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3. Books Recommended

1. M. Markel, Practical Strategies for Technical Communication, 2nd Edition, Bedford/St. Martin's, 2016.
2. R. V. Lesikar and M. E. Flatley, Basic Business Communication Skills for Empowering the Internet Generation, Tata McGraw Hill Publishing Company Limited, New Delhi, 2005.

3. L. J. Gurak and J. M. Lannon, Strategies for Technical Communication in The Workplace, Pearson, 2013.
4. C. L. Bovee, J. V. Thill and M. Chaturvedi, Business Communication Today, 9th Edition, Pearson, 2009.
5. W. S. Pfeiffer and T. V. S. Padmaja, Technical Communication: A Practical Approach, 6th Edition, Pearson, 2013.

MA 201: Elements of Analysis

L	T	P	Credit
3	2	0	05

1. Course Outcomes (COs)

At the end of the course the students will be able to :

CO1: discuss the convergence and divergence of sequences and series

CO2: predict the existence of Riemann integral with their properties

CO3: demonstrate the convergence of improper integral

CO4: examine the uniform convergence using different tests

CO5: develop the Fourier series in different intervals

2. Syllabus

- **REAL SEQUENCES** **(06 Hours)**

  Sequences, Limit points of a sequence, Limits inferior and superior, Convergent sequences, Non Convergent sequences, Cauchy's general principle of convergence, Algebra of sequences, Some important theorems, Monotonic sequences.

- **INFINITE SERIES** **(06 Hours)**

  Introduction, Positive term series, Comparison test, Cauchy's root test, D'Alembert's test, Raabe's test, Logarithmic test, Integral test, Gauss's test, Series with arbitrary terms, Rearrangement of terms.

- **THE RIEMANN INTEGRAL** **(10 Hours)**

  Definitions and existence of the integral, Refinement of partitions, Darboux's theorem, Conditions of integrability, Integrability of the sum and difference of integrable functions, The integral as a limit of sums, Some integrable functions, Integration and differentiation, The fundamental theorem of calculus, Mean value theorem, Integration by parts, Change of variable in an integral, Second mean value theorem.

- **VECTOR OPERATORS** **(04 Hours)**

  Green's, Gauss' & Stokes' theorem with proof.

- **IMPROPER INTEGRAL** **(06 Hours)**

  Introduction, Integration of unbounded functions with finite limit of integration, Comparison tests for convergence of $\int_a^b f(x)\; dx$, Infinite range of integration, Integrand as a product of functions.

- **UNIFORM CONVERGENCE** **(06 Hours)**

  Pointwise convergence, Uniform convergence on an interval, Tests for uniform convergence, Properties of uniformly convergent sequences and series, The Weierstrass approximation theorem.

- **FOURIER SERIES** **(04 Hours)**

  Trigonometric series, Some preliminary theorems, The main theorem, Intervals other than $[-\pi, \pi]$.

Total Lecture Hours: 42

3. Books Recommended

1. W. Rudin, Principles of Mathematical Analysis, 3rd Edition, McGraw Hill, New York, 1976.
2. R. R. Goldberg, Methods of Real Analysis, Oxford and IBH Publishing, 1970.
3. T. Apostol, Mathematical Analysis, 2nd Edition, Narosa Publishers, 2002.
4. H. L. Royden, Real Analysis, 4th Edition, Macmilan Publishing Co. Inc., New York, 1993.
5. S. Narayan and M. D. Raisinghania, Elements of Real Analysis, 7th Edition, S. Chand Publication, New Delhi, 1980.

MA 203: Analytical Geometry

L	T	P	Credit
3	2	0	05

1. Course Outcomes (COs)

At the end of the course the students will be able to :

CO1: demonstrate the fundamentals of analytical geometry in Cartesian and polar coordinates

CO2: discuss the the equation of straight line in different forms and related properties

CO3: solve the problems related to plane and sphere

CO4: evaluate the equation of cone and cylinder and their tangent plane

CO5: elaborate the equations and other properties related to plan section and conicoids

2. Syllabus

- **ORIENTATION OF COORDINATE GEOMETRY** **(08 Hours)**

  Distance between two points, Coordinates of a point which divides the line joining the given points in a given ratio, Equation of surfaces, Cylindrical coordinates, Polar coordinates, Angle between two lines, Direction cosines of a line, Direction ratios of a line, Projections, Projection of a line segment.

- **STRAIGHT LINE** **(08 Hours)**

  General equation of straight line, Equations of a line in symmetrical form, Reduction of general equation of a line into symmetrical form, Angles between two lines, Angle between line and plane, Line intersecting two given lines, Locus of a line, Distance of a point from a line, Shortest distance between two lines, Equations of two skew lines in simplified form, Intersection of three planes.

- **PLANE AND SPHERE** **(08 Hours)**

  General equation of a plane, Normal form of the equation of a plane, Projection of a segment, Angles between two planes, Equation of a plane in various forms, Length of perpendicular from a point to a plane, General equation of a plane passing through the line of intersection of two planes, General equation of sphere, Equation of sphere passing through four points, Sphere on the join of two points as diameter, Intersection of two sphere, Intersection of sphere and plane, Intersection of sphere and line, Angle of intersection of two sphere, Orthogonal sphere, Radical sphere.

- **THE CYLINDER AND CONE** **(10 Hours)**

  Equation of a cylinder, Right circular cylinder and its equation, Interpretation of equations, Equation of tangent plane to a given cylinder, Cone and its equation, Cone with vertex at origin, Right circular cone, Condition for general equation of second degree to represent a cone, Tangent plane to a cone and condition of tangency, Reciprocal cone, Cone with three mutually perpendicular generators, Number of mutually perpendicular generators, Intersection of a plane through the vertex and a cone.

- **PLANE SECTION AND CONICOIDS** **(08 Hours)**

  Some standard equation of central conicoids, Diametral planes and principal planes, Tangent lines and tangent plane at a point, Condition of tangency of a plane, Section with a given centre, Locus of the mid-points of a system of parallel chords, Polar plane, Polar lines, Enveloping cone, Classification of central conicoids, Normal to an ellipsoid, Conjugate diametral plane and diameters of ellipsoid, Paraboloids: Equation, Classification and Properties, Conicoids: General equation and examples.

Total Lecture Hours: 42

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3. Books Recommended

1. R. Ballabh, A Textbook of Coordinate Geometry, 3rd Edition, Prakashan Kendra, Lucknow, 1965.
2. S. Narayan and P. K. Mittal, Analytical Solid Geometry, 17th Revised Edition, S.Chand & Company, New Delhi, 2007.
3. R. J. T. Bell, An Elementary Treatise on Coordinate Geometry of Three Dimensions, MacMillon & Co. Ltd., 1960.
4. C. Smith, An Elementary Treatise on Solid Geometry, MacMillon & Co. Ltd., 1931.
5. P. K. Jain and K. Ahmad, A Text Book of Analytical Geometry of Three Dimensions, New Age International Publishers, New Delhi, 2005.

MA 205: Discrete Mathematical Structure

L	T	P	Credit
3	1	0	04

1. Course Outcomes (COs)

At the end of the course the students will be able to :

CO1: apply knowledge of Mathematical Logic in programming

CO2: analyze the problems for developing the solution, its correctness and performance using graphs

CO3: analyze the real world problems using group theory, relations, lattices and Boolean algebra

CO4: develop an algorithm using Asymptotic analysis

CO5: design solutions for various types of problems in different disciplines like information security, optimization, mathematical analysis

2. Syllabus

- **MATHEMATICAL LOGIC AND PROGRAM VERIFICATION** **(10 Hours)**

  Propositions, logical operators and propositional algebra, Predicates and quantifiers, Interaction of quantifiers with logical operators, Logical interference & proof techniques, Formal verification of computer programs (elements of Hoare logic).

- **GRAPH THEORY** **(08 Hours)**

  Graphs, Definition and basic concepts of finite and infinite graph, Incidence and Degree, Isomorphism, Subgraph, Walk, Path & Circuits, Operations on graphs, Connected Graph, Disconnected graph and Components, Complete graph, Regular graph, Bipartite graph, Euler's graph, Hamiltonian paths and Circuits, Weighted graphs, Applications, Directed & Undirected graphs, Connectivity of graphs.

- **TREES** **(06 Hours)**

  Definition & properties of trees, Pendent vertices in a tree, Distance between two vertices, Centre, Radius and diameter of a tree, Rooted and binary trees, Representation of Algebraic structure by Binary trees, Binary search trees, Spanning trees and fundamental circuits.

- **LATTICES** **(05 Hours)**

  Definition and properties of lattice, Sublattice, Distributive and modular lattices, Complemented and bounded lattices, Complete lattices.

- **BOOLEAN ALGEBRA** **(06 Hours)**

  Introduction, Definition, Properties of Boolean algebra, Boolean variables, Boolean expression, Boolean function, Min term, Max term, Canonical forms, Switching network from Boolean expression, Karnaugh map method.

- **ASYMPTOTIC ANALYSIS** **(07 Hours)**

  Complexity analysis, Time and storage analysis, Big-oh, Big-Omega, Big–Theta notation, Illustration and application to real problems.

Total Lecture Hours: 42

3. Books Recommended

1. K. H. Rosen, Discrete Mathematics and its Applications, 6^{th} Edition, McGraw-Hill, 2006.
2. B. Kolman, R. C. Busby, and S. Ross, Discrete Mathematical Structure, 5^{th} Edition, Prentice Hall Inc., 2003.
3. J. P. Tremblay and R. Manohar, Discrete Mathematical Structure with Applications to Computer Science, McGraw Hill Book Co., 1999.
4. N. Deo, Graph Theory with Applications to Engineering & Computer Science, Prentice Hall of India Pvt. Ltd., 2000.
5. D. F. Stanat and D. F. McAllister, Discrete Mathematics in Computer Science, Prentice-Hall, Englewood Cliffs, New Jersey, 1977.

PH 207: Electromagnetics & Relativity

L	T	P	Credit
3	1	0	04

1. Course Outcomes (COs)

At the end of the course the students will be able to :

CO1: interpret the Coulomb's and Gauss's law and their applications in electrostatics

CO2: interpret the Lorenz force, Biot-Savert's an Ampere's law and their applications in magnetostatics

CO3: elaborate the Legendre polynomials and Bessel function and related applications

CO4: explain magnetization in materials and magnetic fields in matter

CO5: demonstrate the basic of theory of relativity

2. Syllabus

- **ELECTROSTATICS** **(06 Hours)**

  Coulomb's Law, Intensity of electric field, Gauss' law and its applications, Divergence and curl of electric field, Electric potential, Work and energy in electrostatics.

- **ELECTRIC FIELDS IN MATTER** **(06 Hours)**

  Conductors, Dielectrics, Polarization, The field of Polarized object, The electric displacement, Boundary Conditions, Conduction and convection currents, Ohm's law.

- **BOUNDARY VALUE PROBLEMS** **(08 Hours)**

  Laplace equation in one, two, and three-dimensions, 1^{st} and 2^{nd} uniqueness theorem, Classic image problem, Induced surface charge, Force and energy, Other image problems, Separation of variables, Multipole expansion.

- **MAGNETOSTATICS** **(08 Hours)**

  The Lorentz force law, Biot-Savert's law, The divergence and curl of magnetic field, Magnetic vector potential, Magnetic flux density, Ampere circuital law and its applications.

- **MAGNETIC FIELDS IN MATTER** **(08 Hours)**

  Magnetization in materials, The field of a magnetized object, The auxiliary field H, Linear and non-linear media, Magnetic boundary conditions.

- **THEORY OF RELATIVITY** **(06 Hours)**

  Principles of relativity, Length contraction, Time dilation, Lorentz transformations, Mass-Energy equivalence.

Total Lecture Hours: 42

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3. Books Recommended

1. D. J. Griffiths, Introduction to Electrodynamics, 3^{rd} Edition, Prentice-Hall of India Private Limited, 1999.
2. M. N. O. Sadiku, Elements of Electromagnetics, 3^{rd} Edition, Oxford University Press, 2003.

3. J. V. Stewart, Intermediate Electromagnetic Theory, Allied Publishers (with World Scientific), 2005.
4. J. D. Jackson, Classical Electrodynamics, Wiley Eastern, 2012.
5. A. Beiser, S. Mahajan and S. R. Choudhary, Concepts of Modern Physics, 7th Edition, McGraw Hill, 2015.

MA 207: Mathematical Software Lab

L	T	P	Credit
0	0	4	02

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1: create a scientific and technical document using Latex

CO2: design user defined commands and environment in Latex

CO3: develop a computer code using MATLAB/Sci-Lab/Octave for mathematical algorithm

CO4: adapt Python library Numpy and SciPy for scientific computations

CO5: analyze the effectiveness and uses of different mathematical software

2. Syllabus

- **WORKING IN LATEX** **(12 Hours)**

  Document types in LaTex, Packages in LaTex: Useful elementary packages such as geometry, amsmath, amssymb, ragged2e, graphic, xcolor, amsthm, Math formatting in LaTex, Environments in LaTex: tables, figure, minipage, Article, Report and Book writing in LaTex, Creating graphics, Bibliography in Latex, User defined commands and environments, Introduction to the Beamer package.

- **MATLAB/SCI-LAB/OCTAVE** **(22 Hours)**

  Scope of MATLAB in matrix computations, Creating vectors and matrices, Vector and matrix operations, Operators: arithmetic, relational, logical, Element-wise operations, Built-in logical functions, Some matrix related command and functions, Creating and running M-Files, Loops and Controls, Creating user defined functions, plotting in 2D and 3D, Data import and export.

- **INTRODUCTION TO PYTHON** **(22 Hours)**

  Introduction to Python: Shell/Terminal programming and Interactive python (IPython), Saving Scripts, Basic Data Types, Core Data Structure in Python, Control Flow, List Comprehension, Dictionary Comprehension, Functions, Files, Modules, Plotting graph in Python, Numpy Arrays, Introduction to SciPy, Exception Handling, Closures, Decorators, Classes and Object-Oriented Programming: Abstract Data Types and Classes, Inheritance.

Total Contact Time(Practical): 56

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3. Books Recommended

1. S. Apostolos, T. Antonis and S. Nick, Digital Typography Using LaTeX, Springer-Verlag, New York, 2003
2. R. Pratap, Getting Started with MATLAB: A Quick Introduction for Scientists & Engineers, Oxford Publication, 2010.
3. S. J. Chapman, MATLAB Programming for Engineers, 6^{th} Edition, Cengage Learning, 2019.
4. M. Dawson, Python Programming for the Absolute Beginner, 3^{rd} Edition, Cengage Learning, 2011.
5. B. Lubanovic, Introducing Python: Modern Computing in Simple Packages, 2^{nd} Edition, O'Reilly Media, 2019.

HU 202: Communication Skills for Employability

L	T	P	Credit
3	0	0	03

1. Course Outcomes (COs)

At the end of the course the students will be able to :

CO1: exhibit professional communication skills and cognitive skills

CO2: demonstrate ability to communicate efficiently for employability

CO3: show enhanced reception towards the use of English language

CO4: develop awareness and acumen in netiquette

CO5: adapt to the use of digital media in professional setting

2. Syllabus

- **WORKPLACE COMMUNICATION** **(06 Hours)**

  Introduction to workplace communication, Understanding ethical and legal obligations, Planning and drafting documents, Analysing your audience and purpose, Researching your subject, Writing collaboratively, Introduction to Intellectual property rights (IPR).

- **WRITTEN CORRESPONDENCE** **(08 Hours)**

  Understanding the process of written correspondence: Presenting yourself effectively in correspondence, Writing letters, Emails, Writing correspondence to multicultural readers.

- **STRATEGIES IN THE JOB SEARCH PROCESS** **(10 Hours)**

  Building a network of contacts, Introduction to employability skills, Identifying appropriate jobs, Finding your employer, Writing job application materials-Establishing your professional brand, Understanding four major ways to look for a position, Writing resumes, Writing job application letters, Writing follow up letters or emails after an interview, Process of interviews, Answering techniques in interviews, Mock interviews, Other job search messages- continuing job search activity.

- **READING AND LISTENING AND WORKPLACE** **(08 Hours)**

  Reading documents using comprehension techniques, Reading to summarise, Understanding the audience and purpose of summaries, Writing summary step by step, Special types of summaries, Listening to comprehend and respond in workplace.

- **DIGITAL MEDIA AND PRESENTATIONS** **(07 Hours)**

  Email and text messages, Blogs, Wikis and social networks, Web pages and online videos, Designing online documents, Designing print documents.

Total Lecture Hours: 42

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3. Books Recommended

1. M. Markel, Practical Strategies for Technical Communication, 2nd Edition, Bedford/St. Martin's, 2016.

2. R. V. Lesikar and M. E. Flatley, Basic Business Communication Skills for Empowering the Internet Generation, Tata McGraw Hill Publishing Company Limited, New Delhi, 2005.
3. L. J. Gurak and J. M. Lannon, Strategies for Technical Communication in The Workplace, Pearson, 2013.
4. C. L. Bovee, J. V. Thill and M. Chaturvedi, Business Communication Today, 9th Edition, Pearson, 2009.
5. W. S. Pfeiffer and T. V. S. Padmaja, Technical Communication: A Practical Approach, 6th Edition, Pearson, 2013.

MA 202: Numerical Analysis

L	T	P	Credit
3	1	2	05

1. Course Outcomes (COs)

At the end of the course the students will be able to :

CO1: design an algorithm to solve a mathematical problem numerically

CO2: analyze an algorithm's accuracy, efficiency and convergence properties

CO3: develop a computer code for the designed algorithm

CO4: analyze classical techniques and recognize common pitfalls in numerical analysis

CO5: solve initial value problems using computational methods

2. Syllabus

- **PRELIMINARIES OF COMPUTING** **(3 Hours)**

  Errors, Types of errors, Propagation of Error, Floating point arithmetic, Approximation using Taylor's series.

- **SOLUTION OF NONLINEAR EQUATIONS** **(7 Hours)**

  Bisection Method, Methods of false position, Newton's method, Modified Newton's method, Fixed point iterative method, Newton's and fixed point iterative method for system of nonlinear equations. Roots of polynomials, Error and convergence analysis of these methods.

- **SOLUTION OF SYSTEM OF LINEAR EQUATIONS** **(8 Hours)**

  Direct Methods: Gauss elimination with pivoting, LU decomposition method, Cholesky decomposition method, Error analysis for direct methods, Iterative methods: Jacobi, Gauss Seidel method, SOR method, Vector and matrix norm, Convergence of iterative methods, Eigenvalue problems: Jacobi's and Power method.

- **INTERPOLATION** **(12 Hours)**

  Finite difference operators, Divided difference operators, Relation between difference operators, Application of difference operators, Polynomial Interpolation, Existence and uniqueness of interpolating polynomials, Lagrange and Newton's interpolation, Newton's forward and backward difference formula, Error in interpolation.

- **DIFFERENTIATION AND INTEGRATION** **(6 Hours)**

  Numerical differentiation: Methods based on interpolation and finite differences, Error in approximation, Order of approximation, Numerical Integration: Quadrature formula, Newton Cotes Methods, Trapezoidal and Simpson's rules with error analysis. Gauss quadrature methods with error analysis.

- **INITIAL VALUE PROBLEMS (ODE)** **(6 Hours)**

  Picard's method, Taylor's series method, Euler and Runge-Kutta methods for initial value problems of order one and higher and system of first order ODEs with error analysis.

Total Lecture Hours: 42

3. Practicals

Students can use MATLAB, PYTHON, Octave, SciLab, to write computer program.

1. To solve nonlinear equations.
2. To solve a system of nonlinear equations.
3. To solve a system of linear equations using direct methods.
4. To solve a system of linear equations using indirect methods.
5. To find the eigenvalue of a matrix.
6. To make a difference table.
7. For interpolating arbitrary spaced and equally spaced data.
8. To approximate the derivative numerically.
9. To integrate a function numerically.
10. To solve the initial value problems of order one and more and system of first order ODEs.

4. Books Recommended

1. K. E. Atkinson, An Introduction to Numerical Analysis, 2^{nd} Edition, John Wiley & Sons, 2008.
2. R. L. Burden and J. D. Faires, Numerical Analysis, 9^{th} Edition, Cengage Learning, 2011.
3. S. D. Konte and C. de-Boor, Elementary Numerical Analysis: An Algorithmic Approach, 3^{rd} Edition, McGraw-Hill, 1981.
4. M. K. Jain, S. R. K. Iyengar and R. K. Jain, Numerical Methods : For Scientific And Engineering Computation, 6^{th} Edition, New Age International Publishers, 2014.
5. J. H. Mathews and K. D. Fink, Numerical Methods using MATLAB, 4^{th} Edition, Pearson India Education Services Pvt. Ltd., 2015.

MA 204: Linear Algebra

L	T	P	Credit
3	2	0	05

1. Course Outcomes (COs)

At the end of the course the students will be able to :

CO1: evaluate the solution of system of linear equation through elimination and decomposition procedure

CO2: determine the basis and dimension of vector spaces and subspaces

CO3: discuss the matrix representation of a linear transformation given bases of the relevant vector spaces

CO4: adapt the knowledge of eigenvalues and eigenvectors for matrix diagonalization

CO5: interpret the the applications of linear algebra and special matrices

2. Syllabus

- MATRICES (04 Hours)

  Properties of matrices, Non-singular Matrices, Reduced Row-Echelon form, Consistency and Solution of system of linear equations.

- VECTOR SPACES (08 Hours)

  Fields, Vector spaces over a field, Subspaces, Linear Independence and Dependence, Coordinates, Bases and Dimension.

- LINEAR TRANSFORMATIONS (08 Hours)

  Rank Nullity Theorem, Duality and transpose, Isomorphism, Matrix representation of linear transformation, Change of basis, Similar matrices, Linear functional and Dual Space.

- INNER PRODUCT SPACES (08 Hours)

  Cauchy-Schwarz's inequality, Gram-Schmidt orthonormalization, Orthonormal basis, Orthogonal projection, Projection theorem, Fundamental subspaces and their relations.

- DIAGONALIZATION (08 Hours)

  Eigenvalues and eigenvectors, Characteristic polynomials, Minimal polynomials, Cayley-Hamilton theorem, Diagonalizability, Invariant subspaces, Adjoint of an operator, Normal, Unitary and Self-Adjoint operators, Schur's lemma, Diagonalization of normal matrices, Triangularization, Rational canonical form, Jordon canonical form.

- SOME APPLICATIONS (06 Hours)

  Lagrange interpolation, QR and SVD decompositions, Least square solutions, Least square fittings, Pseudo-inverses, Rayleigh quotients, Special matrices and their properties.

Total Lecture Hours: 42

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3. Books Recommended

1. K. Hoffman and R. Kunze, Linear Algebra, PHI Publication, 2015.

2. G. Strang, Linear Algebra and its Applications, 4th edition. Cengage Learning, 2007.
3. S. Lang, Linear Algebra: Undergraduate Texts in Mathematics, Springer-Verlag, New York, 1989.
4. G. William, Linear Algebra with Applications, 6th Revised Edition, Jones and Bartlett Publishers Inc., 2007.
5. H. E. Rose, Linear Algebra: A Pure Mathematical Approach, Birkhauser, 2002.

MA 206: Elementary Number Theory

L	T	P	Credit
3	1	0	04

1. Course Outcomes (COs)

At the end of the course the students will be able to :

CO1: explain congruence relations and number theoretic functions

CO2: demonstrate Fermat's theorem and its applications

CO3: solve Diophantine equations

CO4: elaborate primitive roots and quadratic reciprocity

CO5: adapt the knowledge of various techniques in cryptography

2. Syllabus

- **INTRODUCTION** **(06 Hours)**

  Divisibility, Greatest Common Divisor (gcd), Euclidean Algorithm, Primes and their elementary properties, Fundamental theorem of Arithmetic.

- **CONGRUENCE RELATION** **(08 Hours)**

  Congruence and their Basic properties, Chinese Remainder Theoerm, Euler's phi-function, Fermat's Little Theorem, Wilson's Theorem, Euler's theorem.

- **NUMBER THEORETIC FUNCTIONS** **(12 Hours)**

  Greatest integer function, Arithmetic functions, Mobiüs inversion formula, Fibonacci numbers, Representation of an integer as sum of two and four squares, Diophantine Equations: $ax + by = c$, $x^2 + y^2 = z^2$ and $x^4 + y^4 = z^4$.

- **PRIMITIVE ROOTS, INDICES AND RESIDUES** **(12 Hours)**

  Order of an integer modulo n, Primitive roots for primes, Theory of indices, Residue classes and Residued residue classes, Quadratic residues, Legendre symbol, Gauss's Lemma about Legendre symbol, Law of quadratic reciprocity, Jacobi symbol.

- **INTRODUCTION TO CRYPTOGRAPHY** **(04 Hours)**

  Basic definitions of plaintext, ciphertext, cipher, enciphering (encrypting), deciphering (decrypting), The Caesar cipher, Monoalphabetic and Polyalbhabetic ciphers, Nonalphabetic ciphers, Exponential cryptosystem, Applications of Euler's theorem in cryptography, Introduction to public-key cryptography and RSA cryptosystems.

Total Lecture Hours: 42

3. Books Recommended

1. T. Apostol, Introduction to Analytic Number theory, Springer-Verlag, 1976.
2. A. Baker, A Concise Introduction to the Theory of Numbers, Cambridge University Press, 1990.
3. D. M. Burton, Elementary Number Theory, 6th Edition, McGraw Hill, 2007.
4. G. H. Hardy, and E. M. Wright, An Introduction to the Theory of Numbers, 6th Edition, Oxford University Press, 2008.
5. I. Niven, H. S. Zuckerman and L. Montgomery, An Introduction to the Theory of Numbers, 6th Edition, Wiley, New York, 2003.

MA 208: Computational Life Sciences

L	T	P	Credit
3	0	0	03

1. Course Outcomes (COs)

At the end of the course the students will be able to :

CO1: exhibit enhanced knowledge of evolution theory

CO2: assess biological inferences that depend on population genetics

CO3: demonstrate knowledge of biological systems and microbiology

CO4: utilize the concepts of network models in biology

CO5: apply biological mechanisms in technology

2. Syllabus

- **THEORY OF EVOLUTION** **(07 Hours)**

  Evolution of life: Origin of Life, Structure and types of cell, Cell organelles, Biomolecules of cell, Evolutionary Invasion Analysis: Introduction to Game Theory, Concept of evolutionary stability, General technique for invasion analysis.

- **POPULATION GENETICS** **(07 Hours)**

  Stochastic models of genetics, Genetic structure and selection in subdivided populations, Kin selection and limited dispersal.

- **BIOLOGICAL SYSTEMS** **(07 Hours)**

  Body systems required to sustain human physiology, Special sense organs including hearing, taste, smell and visual receptors. Diffusion in biology: Constructing diffusion models, Diffusion as approximation of stochastic systems, Biological waves, Pattern formation and Turing bifurcations, Chemo-taxis.

- **MICROBIOLOGY** **(07 Hours)**

  Microbiology, Microbial taxonomy: principle and its types, Classical approach: numerical, chemical, serological and genetic, Diversity analysis Methods, Nutrition, Microbiological media and Microbial growth curve.

- **NETWORK MODELS IN BIOLOGY** **(07 Hours)**

  Networks in biology: Spread of disease in contact networks, Random graphs, moment closure techniques in complex graphs.

- **MOLECULAR BIOLOGY** **(07 Hours)**

  Molecular Sequences: Nucleotide and protein, Sequence comparisons: Dynamic programming, heuristic methods, Pattern and profile, Small molecules and Protein structures and geometry optimization.

Total Lecture Hours: 42

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3. Books Recommended

1. A. R. Leach, Molecular Modelling: Principles and Applications, Addison-Wesley Pub. Co., 1997.
2. J. L. Tymoczko, J. M. Berg and L. Stryer, Biochemistry, 8^{th} Edition, W. H. Freeman & Co., 2015.

3. N. Hopkins, J. W. Roberts, J. A. Steitz, J. Watson and A. M. Weiner, Molecular Biology of the Gene, 7th Edition, Benjamin Cummings, 1987.
4. C. R. Cantor and P. R. Schimmel, Biophysical Chemistry (Parts I, II and III), W.H. Freeman & Co., 1980.
5. C. C. Chatterjee, Human Physiology, 13th revised Edition, Vol 1 & 2, CBS Publisher, 2020.

Further Reading

1. B. K. Hall, Evolution, Principles and Processes, Jones & Bartlett, 2011.
2. O. A. Hougen, K. M. Watson and R. A. Ragatz, Chemical Process Principles Part-I: Material and Energy Balances, CBS Publishers New Delhi, 2nd Edition, 2004.
3. D. Baxevanis, and B. F. F. Ouellette, Bioinformatics – A Practical Guide to the Analysis of Genes and Proteins, 2nd Edition, John Wiley and Sons Inc., 2001.
4. B. Bernd, K. Juergen, S. Lewi, Complex Population Dynamics: Nonlinear Modeling in Ecology, Epidemiology And Genetics, World Scientific Publishing Co. Pvt. Ltd., 2007.

CS 210: Data Structures

L	T	P	Credit
3	1	2	05

1. Course Outcomes (COs)

At the end of the course the students will be able to :

CO1: recognize the need of different data structures and understand its characteristics

CO2: apply different data structures for given problems

CO3: design and analyse different data structures, sorting and searching techniques

CO4: evaluate data structure operations theoretically and experimentally

CO5: solve the complex engineering problems

2. Syllabus

- INTRODUCTION TO DATA STRUCTURES (02 Hours)

  Review of Concepts: Information and meaning, Abstract data types, Internal representation of primitive data structures, Arrays, Strings, Structures, Pointers.

- LINEAR LISTS (06 Hours)

  Sequential and linked representations of linear lists, Comparison of insertion, Deletion and search operations for sequential and linked lists, Doubly linked lists, Circular lists, Lists in Standard Template Library (STL), Applications of lists.

- STACKS (06 Hours)

  Sequential and linked implementations, Representative applications such as Recursion, Expression evaluation viz., Infix, Prefix and Postfix, Parenthesis matching, Towers of Hanoi, Wire routing in a circuit, Finding path in a maze.

- QUEUES (06 Hours)

  Operations of queues, Circular Queue, Priority Queue, Dequeue, Applications of queues, Simulation of time sharing operating systems, Continuous network monitoring system, etc.

- SORTING AND SEARCHING (04 Hours)

  Sorting methods, Bubble sort, Selection sort, Quick sort, Radix sort, Bucket sort, Dictionaries, Hashing, Analysis of collision resolution techniques, Searching methods, Linear search, Binary search, Character strings and different string operations.

- TREES (08 Hours)

  Binary trees and their properties, Terminology, Sequential and linked implementations, Tree traversal methods and algorithms, Complete Binary trees, General trees, AVL trees, Threaded trees, Arithmetic expression evaluation, Infix-prefix-postfix notation conversion, Heaps as priority queues, Heap implementation, Insertion and deletion operations, Heapsort, Heaps in Huffman coding, Tournament trees, Bin packing.

- MULTIWAY TRESS (04 Hours)

  Issues in large dictionaries, M-way search trees, B-trees, Search, insert and delete operations, Height of B-tree, 2-3 trees, Sets and multisets in STL.

- GRAPHS (06 Hours)

  Definition, Terminology, Directed and undirected graphs, Properties, Connectivity in graphs, Applications, Adjacency matrix and linked adjacency chains, Graph traversal, Breadth first and depth first traversal, Spanning trees, Shortest path and transitive Closure, Activity networks, Topological Sort and critical paths.

Total Lecture Hours: 42

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3. Tutorials

1. Problems on Array
2. Problems on Stack and Queue
3. Problems on Linked List
4. Problems on Trees
5. Problems on Graph

4. Practicals

1. Implementation of Array and its applications
2. Implementation of Stack and its applications
3. Implementation of Queue and its applications
4. Implementation of Link List and its applications
5. Implementation of Trees and its applications
6. Implementation of Graph and its applications
7. Implementation of Hashing functions and collision resolution techniques
8. Mini Project (Implementation using above Data Structure)

5. Books Recommended

1. J. P. Trembley and P. G. Sorenson, An Introduction to Data Structures with Applications, 2^{nd} Edition, Tata McGraw Hill Education, 1991.
2. Y. Langsam, M. J. Augenstein and A. M. Tanenbaum, Data Structures using C and C++, 2^{nd} Edition, Pearson Education India, 2007.
3. E. Horowitz and S. Sahani, Fundamentals of Data Structures in C, 2^{nd} Edition, Silicon Press, 2007.
4. T. H. Cormen, C. E. Leiserson and R. L. Rivest, Introduction to Algorithms, 3^{rd} Edition, MIT Press, 2009.
5. R. L. Kruse, C. L. Tondo and B. Leung, Data Structures and Program Design in C, 2^{nd} Edition, Pearson Education, 2001.

Five years Integrated M. Sc. (Mathematics)
Teaching Scheme

Semester-V

Sr. No.	Course	Code	Teaching Scheme Hours per Week			Credits	Examination Scheme				Total Marks
			L	T	P		Theory	Tutorial	Practical		
									Cont. Eval.	End Sem.	
1	Probability & Statistics- I	MA 301	3	2	0	5	100	50	0	0	150
2	Mechanics	MA 303	3	1	0	4	100	25	0	0	125
3	Ordinary Differential Equations	MA 305	3	2	0	5	100	50	0	0	150
4	Computer Networks	CS 303	3	1	2	5	100	25	25	25	175
5	*Institute Elective – 1*		3	0	0	3	100	0	0	0	100
	Advanced Mathematical Methods	MA 361									
	Stochastic Differential Equations	MA 363									
			15	6	2	22					

Total contact Hours per week = 23 **Total Credits = 22** **Total Marks = 700**

Semester-VI

Sr. No.	Course	Code	Teaching Scheme Hours per Week			Credits	Examination Scheme				Total Marks
			L	T	P		Theory	Tutorial	Practical		
									Cont. Eval.	End Sem.	
1	Complex Analysis	MA 302	3	2	0	5	100	50	0	0	150
2	Continuum Mechanics	MA 304	3	1	0	4	100	25	0	0	125
3	Metric Spaces	MA 306	3	1	0	4	100	25	0	0	125
4	Artificial Intelligence	CS 308	3	0	2	4	100	0	25	25	150
5	*Institute Elective-2*		3	0	0	3	100	0	0	0	100
	Integral and Wavelet Transform	MA 362									
	Mathematical Finance	MA 364									
	Fuzzy Set Theory	MA 366									
6	Mini Project	MA 308	0	0	4	2	0	0	40	60	100
			15	4	6	22					

Total contact Hours per week = 25 **Total Credits = 22** **Total Marks = 750**

MA 301: Probability and Statistics-I

L	T	P	Credit
3	2	0	05

1. Course Outcomes (COs)

At the end of the course the students will be able to :

CO1: explain the basic ideas of measures of central tendency, dispersion and their applications

CO2: adapt the knowledge of various Probability distributions and their applications

CO3: evaluate correlation, regression and confidence intervals to formulate hypotheses

CO4: apply statistical techniques for sampling of big data

CO5: select the appropriate statistical techniques for estimation of data

2. Syllabus

- **REVIEW ON PROBABILITY AND DESCRIPTIVE MEASURES** **(07 Hours)**

  Historical development, Basic Concepts, Measures of Central Tendency, Measures of Dispersion, Tchebycheff's theorem and Empirical rule, Measures of relative standing, some principles of statistical model. Random variables, Probability, conditional probability and Bayes' theorem. Expected value, Moment generation function and variance of a random variable, covariance.

- **PROBABILITY DISTRIBUTIONS** **(08 Hours)**

  Probability Distributions: binomial and multinomial distribution, geometric distribution, hypergeometric distribution, normal distribution, gamma distribution, exponential distribution, negative binomial distribution, Two dimensional distribution, Joint and Marginal distribution.

- **CENTRAL LIMIT THEOREM** **(04 Hours)**

  Central limit theorem for Bernoulli trails, Normal approximation to binomial, The general central limit theorem.

- **SAMPLING METHODS** **(07 Hours)**

  Random Sampling and Methods of Sampling, Sampling Distribution and Standard Error, Sampling Distribution of the Sample Mean, Central Limit Theorem, Sampling Distribution of the Sample Proportion, Sampling Distribution of the difference between two sample means and Sampling Distribution of the difference between two sample proportions.

- **ESTIMATION METHODS** **(08 Hours)**

  Point Estimation, Interval Estimation, Confidence Interval, Large Sample Confidence Interval for a Population Mean μ, Large Sample Confidence Interval for a Population Proportion, estimating the difference between two Population means, estimating the Difference between two Binomial proportions, Maximum Likelihood Estimation.

- **CORRELATION AND REGRESSION** **(08 Hours)**

  Correlation, Multiple correlation, Linear Regression, Properties of the Least Square Estimators, Inferences concerning the Regression coefficients, Analysis of variance for Linear Regression, Testing the usefulness of the Linear Regression Model. Multiple regression, Testing the significance of the regression coefficients, Testing of linear hypothesis, Bias in the regression estimators due to choice of wrong model.

Total Lecture Hours: 42

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3. Books Recommended

1. W. Mendenhall, R. J. Beaver and B. M. Beaver, Introduction to Probability & Statistics, 15^{th} Edition, Cengage Learning, 2020.
2. C. M. Grinstead and J. L. Snell, Introduction to Probability, American Mathematical Society, 2^{nd} Revised Edition, 1997
3. D. C. Montgomery, Applied Statistics and Probability for Engineers, 6^{th} Edition, Wiley India Pvt Ltd., 2016
4. R. E Walpole, R. H. Myers, S. L. Myers and K. E. Ye, Probability & Statistics for Engineers & Scientists, 8^{th} Edition, Pearson, 2006
5. K. Black, Business Statistics: For Contemporary Decision Making, 9^{th} Edition, Wiley, 2016.

MA 303: Mechanics

L	T	P	Credit
3	1	0	04

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1. Course Outcomes (COs)

At the end of the course the students will be able to :

CO1: explain the concepts of plane statics

CO2: apply fundamental laws of Newtonian mechanics and conservation principles to practical applications.

CO3: explain the motion of a particle in resisting medium and General motion under a central force

CO4: illustrate the motion of a rigid body rotating about a fixed axis and its practical applications

CO5: demonstrate motion of a rotating frame and motion of a particle relative to a rotating frame

2. Syllabus

- PLANE STATICS **(09 Hours)**

  Introduction, Equilibrium of a particle, The triangle of forces, The polygon of forces, Lamy's theorem, equilibrium of system of particles, External and Internal forces, Necessary conditions for equilibrium (forces), Moment of a vector about a line, The theorem of Varignon, Necessary conditions for equilibrium (moments), Equipollent systems of forces, Couples, Moment of a couple, reduction of a general plane force system, Work and potential energy, The principle of virtual work.

- APPLICATIONS IN PLANE STATICS **(05 Hours)**

  Mass center, Theorems of Pappus, Gravitation, Friction, Laws of static and kinetic friction, Flexible cables, General formula for all flexible cables hanging freely, The suspension bridge, The common catenary.

- PLANE KINEMATICS **(05 Hours)**

  Kinematics of a particle, Tangential and Normal components of velocity and acceleration, Radial and transverse components, The hodograph.

- PLANE DYNAMICS **(08 Hours)**

  Equations of motion of a particle, Principle of angular momentum for a particle and system, Principle of energy for a particle and system, Principle of linear momentum for a system, d'Alembert's principle, Hamilton's principle, Some techniques of calculus of variation, Derivation of Lagrange's equation from Hamilton's principle.

- APPLICATIONS IN PLANE DYNAMICS **(09 Hours)**

  Motion in resisting medium, motion of particles of varying mass, Central orbits, Kepler's law of motion, Moment of inertia: theorem of parallel axes, Theorem of perpendicular axes, Kinetic energy and angular momentum, Konig's theorem, Rigid body rotating about a fixed axis, The compound pendulum, Cylinder rolling down an inclined plane.

- INTRODUCTION TO DYNAMICS IN SPACE **(06 Hours)**

  Euler's dynamical equations for the motion a rigid body, Motion of rigid body about fixed axis, Motion of rigid body about rotating axis, Coriolis acceleration.

Total Lecture Hours: 42

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3. Books Recommended

1. J. L. Synge and B. A Griffith, Principle of Mechanic, 2nd Edition, Tata McGraw Hill, New Delhi. 1949.
2. H. Goldstein, C. P. Poole and J. L. Safko, Classical Mechanics, 3rd Edition, Addison Wesley Publishing company, Inc., 1980.
3. N. C. Rana and P. C. Joag, Classical Mechanics, Tata McGraw-Hill. 1991.
4. R. G. Takwale and P. S. Puranik, Introduction to Classical Mechanics, Tata McGraw-Hill, 2000.
5. P. V. Pant, Classical Mechanics, Alpha Science International, 2004.

Kumar

MA 305: Ordinary Differential Equations

L	T	P	Credit
3	2	0	05

1. Course Outcomes (COs)

At the end of the course the students will be able to :

CO1: analyze the existence, uniqueness of first and higher order linear ODEs on a given interval.

CO2: develops skills for different types of methods for finding the solution of ODEs.

CO3: elaborate the properties of dynamical system

CO4: assess the asymptotic behavior of dynamical system

CO5: determine the solution of higher order BVP through eigen-functions and Green functions.

2. Syllabus

- **REVIEW OF SOLUTION METHODS FOR DIFFERENTIAL EQUATIONS** **(06 Hours)**

  Second order linear differential equations with variable coefficients and its solution properties, Series solution (Bessel functions and Legendre polynomials).

- **EXISTENCE AND UNIQUENESS OF INITIAL VALUE PROBLEMS** **(08 Hours)**

  Fixed Point theorem, Picard's and Peano's Theorems, Gronwall's inequality, Continuation of solutions and maximal interval of existence, Dependence on the initial conditions, Extensibility of solutions, Non-Local existence theorem.

- **HIGHER ORDER AND SYSTEM OF LINEAR DIFFERENTIAL EQUATION** **(06 Hours)**

  Fundamental solutions, Wronskian, Variation of constants, Matrix exponential solution, Behaviour of solutions.

- **DYNAMICAL SYSTEM AND PHASE SPACE ANALYSIS** **(08 Hours)**

  Dynamical system, The flow of an autonomous equation, Orbits and invariant sets, The Poincare map, Critical points, Proper and improper nodes, Spiral points and saddle points.

- **ASYMPTOTIC BEHAVIOUR** **(06 Hours)**

  Stability of fixed points, Stability via Liapunov's method.

- **BOUNDARY VALUE PROBLEMS FOR SECOND ORDER EQUATIONS** **(08 Hours)**

  Sturm comparison theorems, Oscillation theory, Regular and periodic Sturm-Liouville problems, Green's function.

Total Lecture Hours: 42

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3. Books Recommended

1. M. Brown, Differential Equations and Their Applications, Springer, 1992.

2. S. L. Ross, Introduction to Ordinary Differential Equations, Wiley, 1980.
3. M. W. Hirsch, S. Smale and R. L. Deveney, Differential Equations, Dynamical Systems and Introduction to Chaos, Academic Press, 2004.
4. S. G. Deo, V. Raghavendra, R. Kar and V. Lakshmikantham, Textbook of Ordinary Differential Equations, McGraw-Hill Education, 2015.
5. G. F. Simmons and S. G. Krantz, Differential Equations: Theory, Technique and Practice, McGraw Hill Education, 2006.

CS 303: Computer Networks

L	T	P	Credit
3	1	2	05

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1: understand computer network models and services offered at different layers of network protocol stack.

CO2: apply knowledge of data communication, data transmission techniques using various transmission media to deliver error free data and communicate with multiple nodes.

CO3: analyse various routing methods to identify effective routing protocols.

CO4: evaluate network performance by means of transport and flow control protocols, Congestion Control protocols and Quality of services.

CO5: create a computer network application using modern network tools and simulation softwares.

2. Syllabus

- **INTRODUCTION** **(06 Hours)**

  Overview of computer networks and data communication, Computer networking protocols and standards, Types of computer networks, Network topology, Protocol hierarchies and design issues, Interfaces and services, Networking devices, OSI and TCP/IP reference models.

- **PHYSICAL LAYER** **(06 Hours)**

  Physical layer design issues, Data transmission techniques, Multiplexing, Transmission media, Asynchronous communication, Wireless transmission, ISDN, ATM, Cellular radio, Switching techniques and issues.

- **LOGICAL LINK CONTROL LAYER** **(06 Hours)**

  LLC design issues, Framing, Error and flow control, Framing techniques, Error control methods, Flow control methods, PPP and HDLC.

- **MEDIUM ACCESS CONTROL LAYER** **(06 Hours)**

  MAC layer design issues, Channel allocation methods, Multiple access protocols - ALOHA, CSMA, CSMA/CD protocols, Collision free protocols, Limited contention Protocols, LAN Architectures, IEEE -802 standards, Ethernet(CSMA/CD), Token bus, Token ring, DQDB, FDDI, Bridges and recent developments.

- **NETWORK LAYER** **(06 Hours)**

  Network layer design issues, Routing algorithms and protocols, Congestion control algorithms and QoS, Internetworking, Addressing, N/W layer protocols and recent developments.

- **TRANSPORT LAYER** **(06 Hours)**

  Transport layer design issues, Transport services, Sockets, Addressing, Connection establishment, Connection release, Flow control and buffering, Multiplexing, Transport layer protocols, Real Time Transport Protocol (RTP), Stream Control Transmission Protocol (SCTP), Congestion control, QoS and Recent developments, Virtualization, Network Functions Virtualization(NFV), Software defined networks.

- **APPLICATION LAYER** **(06 Hours)**

  Client server model, Domain Name System (DNS), Hyper Text Transfer Protocol (HTTP), Email: SMTP, MIME, POP3, Webmail, FTP, TELNET, Dynamic Host Control Protocol (DHCP), Simple Network Management Protocol (SNMP) and recent developments.

Total Lecture Hours: 42

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3. Practicals

1. Study network configuration commands and computer network setup.
2. Implementation of different Data Link and MAC Layer protocols.
3. Implementation of different Network Layer protocols.
4. Implementation of different Transport and Application Layer protocols.
5. Design and configure a network systems using modern network simulator softwares.
6. Implementation of Secured Socket Layer protocol.
7. Implementation of ICMP based message transmission over network.
8. Implementation of SMTP protocol for mail transfer.

4. Tutorials

1. Problem solving on basics of data communication and networking.
2. Problem solving on framing, error control and flow control of Data link layer.
3. Problem solving on various LAN standards.
4. Problem solving on logical address, sub net masking and routing protocols of Network Layer.
5. Problem solving on congestion control, flow control and error control of transport layer.
6. Problem solving on various services provided by application layer.

5. Books Recommended

1. W. Stalling, Data and Computer Communication, 10th Edition, Pearson India, 2017.
2. B. Forouzan, Data Communication and Networking, 5th Edition, McGraw Hill, 2017.
3. D. E. Comer, Internet working with TCP/IP Volume – I, 6th Edition, Pearson India, 2015.
4. A. S. Tanenbaum, Computer Network, 5th Edition, Pearson India, 2013.
5. W. R. Stevens, TCP/IP Illustrated Volume - I, 2nd Edition, Addison Wesley, 2011.

MA 361: Advanced Mathematical Methods

L	T	P	Credit
3	0	0	03

1. Course Outcomes (COs)

At the end of the course the students will be able to :

CO1: demonstrate a common framework that distinguishes various multivariate analytic techniques

CO2: develop the solution of ODEs using asymptotic methods

CO3: apply perturbation theory to solve various problems related to engineering and sciences

CO4: solve non-linear ODEs related to engineering and sciences using homotopy analysis method

CO5: design and implement a techniques based on varied factors for ODEs

2. Syllabus

- INTRODUCTION **(06 Hours)**

  Review on Power Series Method, Taylor Series Method.

- ASYMPTOTIC METHOD **(09 Hours)**

  Introduction, Asymptotic Solutions at Irregular Singular Points at Infinity, Method of Finding Solutions at Irregular Points, Asymptotic Method for Constructing Solutions along with the validity for large values, Asymptotic Solutions of Perturbed Problems, Solutions to ODEs Containing a Large Parameter, Applications.

- PERTURBATION TECHNIQUES **(11 Hours)**

  Basic Idea behind the Perturbation Method, Regular Perturbation Theory, Singular Perturbation Theory, Boundary-Layer Method, Applications.

- METHOD OF MULTIPLE SCALES **(07 Hours)**

  Introduction, Method of Multiple Scales, Applications.

- HOMOTOPY ANALYSIS METHOD **(09 Hours)**

  Introduction, Background, A brief history of the HAM, Characteristic of homotopy analysis method, Some advances of the HAM, Generalized zeroth-order deformation equation, Basic ideas of the homotopy analysis method, Convergence of homotopy-series solution.

Total Lecture Hours: 42

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3. Books Recommended

1. C. M. Bender and S. A. Orszag, Advanced Mathematical Methods for Scientists and Engineers: Asymptotic Methods and Perturbation Theory, Springer Science & Business Media, 1999.
2. S. I. Hayek, Advanced Mathematical Methods in Science and Engineering, 2^{nd} Edition, Chapman and Hall/CRC, 2010.
3. J. B. Doshi, Analytical Methods in Engineering, Narosa Publishing House, 1998.

4. A. D. Polyanin and V. F. Zaitsev, Handbook of Ordinary Differential Equations: Exact Solutions, Methods, and Problems, 3^{rd} Edition, Chapman and Hall/CRC, 2017.
5. S. Liao, Homotopy Analysis Method in Nonlinear Differential Equations, Springer-Verlag Berlin Heidelberg, 2012.

MA 363: Stochastic Differential Equations

L	T	P	Credit
3	0	0	03

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1. Course Outcomes (COs)

At the end of the course the students will be able to :

CO1: explain the basics of stochastic differential equations

CO2: elaborate Ito integrals, and its application to stochastic differential equations

CO3: analyze existence and uniqueness of stochastic differential equations.

CO4: solve stochastic differential equations.

CO5: explain its application to different boundary value problems

2. Syllabus

- INTRODUCTION (06 Hours)

  Stochastic analogues of classical differential equations.

- MATHEMATICAL PRELIMINARIES (06 Hours)

  Probability space, Random variable, Stochastic process, Brownian motion.

- ITO INTEGRAL (06 Hours)

  Definition, Properties, Extensions.

- ITO FORMULA AND MARTINGALE REPRESENTATION THEOREM (08 Hours)

  One-dimensional Ito formula, Multi-dimensional Ito formula, Martingle representation theorem.

- STOCHASTIC DIFFERENTIAL EQUATIONS (08 Hours)

  Examples and some solution methods, Existence and Uniqueness result, Weak and strong solutions.

- APPLICATIONS (08 Hours)

  Boundary value problems, Filtering, Optimal stopping, Stochastic control. The Black-Scholes formula and its application to mathematical finance.

Total Lecture Hours: 42

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3. Books Recommended

1. B. K. Oksendal, Stochastic Differential Equations: An Introduction with Applications, 6th Edition, Springer, 2010.
2. I. Karatzas and S. E. Shreve, Brownian Motion and Stochastic Calculus, Springer, 1991.
3. P. Protter, Stochastic Integration and Differential Equations, Springer, 2nd Edition, 2010.
4. I. Karatzas and S. E. Shreve, Methods of Mathematical Finance, Springer, 2010.
5. S. Watanabe and N. Ikeda, Stochastic Differential Equations and Diffusion Processes, North-Holland, 1981.

MA 302: Complex Analysis

L	T	P	Credit
3	2	0	05

1. Course Outcomes (COs)

At the end of the course the students will be able to :

CO1: explain the fundamentals of function of complex variables

CO2: evaluate contour integrals

CO3: deduct the poles and singularities with applications

CO4: evaluate proper and improper integrals

CO5: explain the basic concept of conformal mappings in complex plane with applications

2. Syllabus

- FUNCTIONS OF COMPLEX VARIABLE **(12 Hours)**

  Limit, Continuity, Differentiability, Analytic function, Cauchy-Riemann equation, Construction of analytic function, Harmonic function.

- CONTOUR INTEGRATION **(10 Hours)**

  Cauchy's theorem, Cauchy's inequality, Morera's theorem, Liouville's theorem. Power Series, Taylor's series, Maximum/Minimum modulus principle, Schwarz lemma.

- SINGULARITIES AND RESIDUES **(12 Hours)**

  Classification of Singularities: Isolated, removable, pole and essential singularities, Properties of zeroes and poles, Residue at pole, Residue at infinity, Cauchy's residue theorem, Number of poles and zeroes of an analytic function, Cauchy's integral formula, Laurent's series, Open mapping theorem, Rouche's theorem, Evaluation of integrals of the type $\int\limits_0^{2\pi} f(\sin\theta, \cos\theta)\, \mathrm{d}\theta$ and $\int\limits_{-\infty}^{\infty} f(x)\, \mathrm{d}x$, Improper real integrals of the form $\int\limits_{-\infty}^{\infty} \cos ax\, f(x)\, \mathrm{d}x$ and $\int\limits_{-\infty}^{\infty} \sin ax\, f(x)\, \mathrm{d}x$, Improper integrals with singular points on the real axis.

- CONFORMAL MAPPINGS **(08 Hours)**

  Introduction, Conformality Theorem, Mobiüs transformation, translation, rotation, inversion, cross-ratio, critical value of a transformation.

Total Lecture Hours: 42

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3. Books Recommended

1. J. W. Brown and R. V. Churchill, Complex Variables and Applications, 8th Edition, McGraw-Hill Higher Education, 2009.
2. J. B. Conway, Functions of one Complex variable, Springer, International Student Edition, Narosa, 1980.
3. H. S. Kasana, Complex Variables: Theory and Applications, 2nd Edition, PHI Learning Private Limited, Delhi, 2013.

4. S. Ponnusamy, Foundations of Complex Analysis, Narosa, 1997.
5. A. R. Shastri, An Introduction to Complex Analysis, Macmillan India, New Delhi, 1999.

MA 304: Continuum Mechanics

L	T	P	Credit
3	1	0	04

1. Course Outcomes (COs)

At the end of the course the students will be able to :

CO1: demonstrate the usefulness of tensors in Continuum Mechanics

CO2: analyze the Cauchy's stress principle to develop the stress vector–stress tensor relationship

CO3: solve problems in continuum theory

CO4: illustrate the Material derivative concept in obtaining the basic equations of Continuum Mechanics

CO5: apply the concept of mechanics in modern engineering and technology

2. Syllabus

- REVIEW OF TENSORS **(05 Hours)**

  Cartesian tensors, Tensor rank, Indicial notations; Range and summation conventions, Transformation laws for Cartesian tensors, Kronecker delta, Orthogonality conditions, Addition of Cartesian tensors, Multiplication by a scalar, Tensor multiplication, Matrix representation of Cartesian tensors, Principal values Principal directions of symmetric second order tensors.

- ANALYSIS OF STRESS **(08 Hours)**

  The continuum concept, Homogeneity, Isotropy, Mass density, Body forces, surfaces forces, Cauchy stress principle; The stress vector, State of stress at a point, The stress tensor - stress vector relationship, Principal stresses, Stress invariants, Stress ellipsoid.

- DEFORMATION AND STRAIN **(06 Hours)**

  Lagrangian and Eulerian description, Finite strain tensor, Small deformation theory, Rotation tensor, Strain invariant, Principal strains, Cubical dilatation.

- MOTION AND FLOW **(08 Hours)**

  Material derivatives, Pathline and stream lines, Rate of deformation, Vorticity vector, Material derivative of Line, Surface and Volume integrals.

- FUNDAMENTAL LAWS OF CONTINUUM MECHANICS **(07 Hours)**

  Equation of continuity, Equations of motion, Principle of angular momentum, Conservation of energy, Clausius-Dirhem inequality, Dissipation Function

- LINEAR ELASTICITY **(03 Hours)**

  Generalized Hooke's law, Strain energy function, Isotropy, Anisotropy, Elastic symmetry, Isotropic media, Elastic constants, Elastostatic problems, Elastodynamic problems.

- CLASSICAL FLUIDS **(05 Hours)**

  Viscous Stress Tensor, Stokesian, and Newtonian Fluids, Relation between stresses and rate of strain for compressible Newtonian viscous fluids.

Total Lecture Hours: 42

3. Books Recommended

1. G. T. Mase and G. E. Mase, Continuum Mechanics for Engineers, CRC press, 1999.
2. G. E. Mase, Theory and Problems of Continuum Mechanics, Schaum's Outline Series, McGraw Hill Book company, 1970.
3. J. W. Rudnicki, Fundamentals of Continuum Mechanics, John Wiley & Sons Ltd., 2015.
4. J. N. Reddy, An Introduction to Continuum Mechanics with Applications, Cambridge University Press, 2008.
5. X. Oliver and C. A. de-Saracibar, Continuum Mechanics for Engineers: Theory & Problems, 2^{nd} Edition, 2017.

MA 306: Metric Spaces

L	T	P	Credit
3	1	0	04

1. Course Outcomes (COs)

At the end of the course the students will be able to :

CO1: explain the basic definition of metric spaces and corresponding topological concepts

CO2: discuss sequences in metric spaces and its convergences

CO3: elaborate the compactness and its characterization

CO4: illustrate the concept of connectedness and can apply different aspects related to metric continuity

CO5: discuss the continuity and its geometric properties along with fixed point concepts

2. Syllabus

- **BASIC DEFINITIONS AND NOTIONS** **(10 Hours)**

  Need for "metric", abstract definition and examples of metric spaces, Consequences: Open balls and open sets and their properties and characterizations, Closed Sets and their properties and characterizations. Meaning of "Topology", Subspace topology and product topology with characterizations, Interior, Exterior, Boundary Points, Interior, Exterior and Boundary of a set and their properties and characterizations in terms of open and closed sets, Limit Points and Cluster points, Closure of a set, Dense sets and their properties and characterizations, Bounded sets and their properties and characterizations, Distance between sets, Equivalent metrics.

- **SEQUENCES IN METRIC SPACE** **(06 Hours)**

  Sequences and their convergence in a metric space, Characterizations of closed sets, limit points, cluster points, dense sets in terms of sequences and their convergence, Cauchy sequences in a metric space, Complete metric space: Difference between Cauchyness and convergence in abstract metric spaces, Completion of a metric space, Baire category theorem with a few applications at the beginner level.

- **COMPACTNESS** **(06 Hours)**

  Compact Spaces: Motivation, definition and their properties, Characterization of compact spaces in terms of sequentially compact, Closed and totally bounded and open cover definition, Equivalence of these definitions.

- **CONNECTEDNESS** **(05 Hours)**

  Connected sets, Connected Components, Totally disconnected sets.

- **CONTINUITY** **(10 Hours)**

  Motivation behind continuity of functions in metric spaces, The three equivalent definitions of continuity: sequence definition, epsilon–delta definition and open sets definition, Other characterizations of continuity in terms of open sets, closed sets, closure and interior of images and pre-images of sets, Uniform continuity and Lipschitz continuity, its properties and characterizations, Continuous functions on compact spaces and the Arzela-Ascolli's theorem, Continuous functions on connected spaces and path connectedness, Open and closed maps and their properties, Homeomorphisms and their importance.

- **BANACH CONTRACTION PRINCIPLE AND ITS APPLICATIONS** **(05 Hours)**

Contraction mappings, Contractive mappings, Non-expansive mappings, Fixed points, Banach contraction principle, Applications of Banach contraction principle to root finding problems, System of linear equations, Implicit function theorem.

Total Lecture Hours: 42

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3. Books Recommended

1. P. K. Jain and K. Ahmed, Metric Spaces, 2^{nd} Edition, Narosa Publications, 2004.
2. S. Kumaresan, Topology of Metric Spaces, 2^{nd} Edition, Narosa Publications, 2011.
3. S. Shirali and H. L. Vasudeva, Metric Spaces, Springer, 2006.
4. G. F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill Education, 1963.
5. D. Gopal, P. Kumam and M. Abbas, Background and Recent Developments in Metric Fixed Point Theory, CRC Press, 2017.

CS 308: Artificial Intelligence

L	T	P	Credit
3	0	2	04

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1: understand the role of agents and how it is related to environment and the way of evaluating it and how agents can act by establishing goals

CO2: apply various knowledge representation technique, searching techniques, constraint satisfaction problem and example problems- game playing techniques.

CO3: analyse the current scope, potential, limitations, and implications of intelligent systems.

CO4: evaluate the AI techniques suitable for recent areas of applications like expert systems, neural networks, fuzzy logic, robotics, natural language processing, and computer vision.

CO5: design a real world problem for implementation and understand the dynamic behaviour of a system.

2. Syllabus

- INTRODUCTION TO AI **(03 Hours)**

  Intelligent agents, AI techniques, AI-problem formulation, AI applications, Production systems, Control strategies.

- KNOWLEDGE REPRESENTATION **(06 Hours)**

  Knowledge representation using predicate logic, Introduction to predicate calculus, Resolution, Use of predicate calculus, Knowledge representation using other logic-structured representation of knowledge.

- PRODUCTION SYSTEM **(06 Hours)**

  Defining the problems as a state space search, Production systems, Production characteristics, Production system Characteristics, Forward and backward, State-space search, Problem solving methods – Problem Graphs, Matching, Indexing.

- PROBLEM-SOLVING THROUGH SEARCH **(06 Hours)**

  Generate and test, BFS, DFS, Blind, Heuristic, Problem-reduction, A, A*, AO*, Minimax, Constraint propagation, Neural, Stochastic, and Evolutionary search algorithms, Sample applications, Measure of performance and analysis of search algorithms, Problem reduction, Constraint satisfaction, Means-ends analysis, Issues in the design of search programs.

- KNOWLEDGE INFERENCE **(06 Hours)**

  Knowledge representation -Production based system, Frame based system. Inference – backward chaining, Forward chaining, Rule value approach, Fuzzy reasoning – certainty factors, Bayesian theory-Bayesian network-Dempster – Shafer theory, Symbolic logic under uncertainty : Non-monotonic reasoning, logics for non-monotonic reasoning, Statistical reasoning : Probability and Bayes theorem, Certainty factors, Probabilistic graphical models, Bayesian networks, Markov networks, Fuzzy logic.

- **GAME PLAYING AND PLANNING** (06 Hours)

  Overview and example domain: Overview, Minimax, Alpha-Beta cut-off, Refinements, Iterative deepening, The blocks world, Components of a planning system, Goal stack planning, Nonlinear planning using constraint posting, Hierarchical planning, Reactive systems, Other planning techniques.

- **NATURAL LANGUAGE PROCESSING** (04 Hours)

  Introduction, Syntactic processing, Semantic analysis, Semantic analysis, Discourse and pragmatic processing, Spell checking.

- **EXPERT SYSTEMS** (05 Hours)

  Expert systems – Architecture of expert systems, Roles of expert systems – Knowledge acquisition – Meta Knowledge, Heuristics, Typical expert systems – MYCIN, DART, XOON, Expert systems shells.

Total Lecture Hours: 42

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3. Practicals

1. Practical assignment to understanding basic concepts of prolog.
2. Practical assignment to implement various search strategies.
3. Practical assignment to implement various algorithm based on game theory.
4. Implementation of heuristic based search techniques.
5. Implementation of neural network based application.
6. Implementation of fuzzy logic based application.
7. Implementation of fuzzy inference engine for an application.
8. Implementation of neuro-fuzzy based system.

4. Books Recommended

1. E. Rich and K. Knight, Artificial Intelligence, 2nd Edition, Tata McGraw-Hill, 2003.
2. S. Russell, P. Norvig, Artificial Intelligence: A Modern Approach, 3rd Edition, Prentice Hall, 2009.
3. N. Nilsson, Artificial Intelligence: A New Synthesis, Morgan Kaufmann, 1998,
4. W. Patterson, Introduction to Artificial Intelligence and Expert Systems, Prentice Hall of India, 2010.
5. I. Bratko, Prolog Programming for Artificial Intelligence, 3rd Edition, Addison-Wesley, 2001,

MA 362: Integral and Wavelet Transform

L	T	P	Credit
3	0	0	03

1. Course Outcomes (COs)

At the end of the course the students will be able to :

CO1: discuss Fourier integral theorem and condition of its validity

CO2: determine the Fourier, Fourier Sine and Cosine transform of a function

CO3: utilize integral transform techniques to solve 2nd order ODE and PDE arising in Mathematical Physics

CO4: evaluate the solution of difference equation using Z-transform

CO5: demonstrate basic idea of Wavelets and Wavelet transform.

2. Syllabus

- **INTRODUCTION TO FOURIER TRANSFORM (10 Hours)**

  Fourier Integral Theorem, Definition and basic properties of Fourier transform. Inversion theorem, Convolution theorem, Parseval's relation, Fourier Cosine and Sine transform, Fast Fourier Transform, Applications to Ordinary and Partial Differential Equations.

- **HANKEL TRANSFORM (07 Hours)**

  Hankel transform, Inversion formula of Hankel transform, Parseval relation, Finite Hankel transform, Application to Partial differential equations.

- **MELLIN'S TRANSFORM (07 Hours)**

  Properties of Mellin's transform. Inversion theorem, Convolution theorem, Application of Mellin' s transform.

- **Z-TRANSFORM (08 Hours)**

  Introduction, Linear Systems, Impulse response, Definition of Z-transform and examples, basic operational properties, Inverse Z-transform and examples, Applications of Z-transform to solve finite difference equations, Summation of infinite series.

- **WAVELETS AND WAVELET TRANSFORM (10 Hours)**

  Introduction to Wavelet, brief history, Continuous Wavelet Transform, Discrete Wavelet Transform, Basic Properties of Wavelet Transform, Applications of Wavelet Transforms. Triple integrals, evaluation techniques, Application of triple integrals for evaluation of volume.

Total Lecture Hours: 42

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3. Books Recommended

1. L. Debnath and D. Bhatta, Integral Transforms and Their Applications, 3^{rd} Edition, Chapman & Hall, New York, 2014.
2. I. N. Sneddon, The Use of Integral Transform, McGraw-Hill, New York, 1972.
3. L. C. Andrews and B. K. Shivamoggi, Integral Transforms for Engineers, SPIE Press, Bellingham, 1999.

4. L. Debnath and F. Shah, Wavelet Transforms and Their Applications, Springer, New York, 2015.
5. R. V. Churchill, Operational Mathematics, McGraw-Hill, New York, 1972.

MA 364: Mathematical Finance

L	T	P	Credit
3	0	0	03

1. Course Outcomes (COs)

At the end of the course the students will be able to :

CO1: demonstrate the basic concepts in Probability theory

CO2: demonstrate the concepts relating to functions and annuities

CO3: demonstrate the Arbitrage theorem and Black-Scholes formula.

CO4: employ methods related to these concepts in a variety of financial applications

CO5: apply logical thinking to problem related to call and put options and valuing of investment.

2. Syllabus

- **INTRODUCTION** **(06 Hours)**

  Probability Theory, Stochastic Processes, Poisson Process, Brownian Motion, Martingales Present Value Analysis.

- **INTERESTS RATES AND PRESENT VALUE ANALYSIS** **(06 Hours)**

  Interest rates, Present value analysis, Rate of return, Continuously varying Interest rates.

- **THE ARBITRAGE THEOREM** **(06 Hours)**

  Market Model Specification problems. Arbitrage Theorem, Multi-period binomial Model, Proof of the Arbitrage Theorem.

- **THE BLACK-SCHOLES FORMULA** **(08 Hours)**

  The Black-Scholes formula, Properties of the Black–Scholes Option Cost, The Delta Hedging Arbitrage Strategy.

- **ADDITIONAL RESULTS ON OPTION** **(06 Hours)**

  Call Options on Dividend-Paying Securities, Pricing American Put Options, Estimating the Volatility Parameter.

- **VALUING BY EXPECTED UTILITY** **(10 Hours)**

  Valuing investments by expected utility, Portfolio selection problem, Capital Assets Pricing model, Rates of return, Single period and geometric Brownian motion, Mean-variance analysis of risk - neutral priced call options, Autoregressive models and mean regression, Other pricing options and applications.

Total Lecture Hours: 42

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3. Books Recommended

1. S. M. Ross, An Introduction to Mathematical Finance, Cambridge University Press, 1999.
2. A. J. Prakash, R. M. Bear, K. Dandapani, G. L. Ghai, T. E. Pactwa and A. M. Parhizgari, The Return Generating Models in Global Finance, Pergamon Press, 1998.

3. M. S. Joshi, The Concepts and Practice of Mathematical Finance, 2^{nd} Edition, Cambridge University Press, 2008.
4. M. Capiński and T. Zastawniak, Mathematics for Finance: An Introduction to Financial Engineering, 2^{nd} Edition Springer, 2011.
5. P. Wilmott, Derivatives: The Theory and Practice of Financial Engineering (Frontiers in Finance Series), John Wiley & Sons, 1998.

MA 366: Fuzzy Set Theory

L	T	P	Credit
3	0	0	03

1. Course Outcomes (COs)

At the end of the course the students will be able to :

CO1: demonstrate the concepts of crisp sets and fuzzy sets

CO2: apply various operations on fuzzy sets

CO3: demonstrate the fuzzy arithmetic

CO4: solve the fuzzy equations

CO5: solve the Engineering problems using the theory of fuzzy sets and fuzzy mathematics

2. Syllabus

- INTRODUCTION **(05 Hours)**

  Definition of Fuzzy sets. Fuzzy sets verse crisp sets, Alpha-cuts. Theorems on Cuts, Normality Extension Principle.

- OPERATIONS ON FUZZY SETS **(05 Hours)**

  Types of operations, Completion, Union and intersection, Difference, t-norm, t-conorms.

- FUZZY ARITHMETIC **(06 Hours)**

  Fuzzy numbers. Addition, Subtraction, Multiplication and Division, Triangular and trapezoid fuzzy numbers.

- FUZZY RELATIONS AND FUZZY EQUATIONS **(13 Hours)**

  Crisp verses fuzzy relations, Binary fuzzy relations, Fuzzy equivalence relations, Fuzzy ordering relations. Fuzzy relation equations, Sup-i composition, Inf-w composition, Solution methods.

- FUZZY LOGIC **(07 Hours)**

  Fuzzy proposition, Fuzzy Quantifiers, Multivalued Logic, Inference Systems.

- ENGINEERING APPLICATIONS **(06 Hours)**

  Fuzzy controlar, Applications in Civil engineering, Mechanical engineering and Computer engineering.

Total Lecture Hours: 42

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3. Books Recommended

1. H. J. Zimmerman, Fuzzy Set Theory and its Applications, 3^{rd} Edition, Kluwer Academic Publishers, Boston, MA, 1996
2. D. Dubois and H. Prade, Fuzzy Sets and Systems: Theory and Applications, Academic Press, Cambridge, MA, 1980
3. T. J. Ross, Fuzzy Logic with Engineering Applications, 3^{rd} Edition, Wiley Publication, 2011

4. G. J. Klir, U. St. Clair and B. Yuan, Fuzzy Set Theory Foundations and Applications, PHI Inc. USA, 1997
5. C. Mohan, An Introduction to Fuzzy Set Theory and Fuzzy Logic, Viva Books Private Limited, 2017

MA 308: Mini Project

L	T	P	Credit
0	0	4	02

1. Course Outcomes (COs)

At the end of the course the students will be able to :

CO1: discover various research fields
CO2: improve their mathematical knowledge in the field of interest
CO3: develop collaborative skills
CO4: take part in group activity
CO5: formulate the problem of engineering and sciences into mathematical form

2. Syllabus

Students will work on a research topic in a group under the guidance of faculty member(s).

Five years Integrated M. Sc. (Mathematics)
Teaching Scheme

SEMESTER – VII

Sr. No.	Subject	Code	Teaching Scheme Hours Per Week			Credits	Examination Scheme			Total Marks
			L	T	P		Theory	Tutorial	Practical	
1	Topology	MA 401	3	1	0	04	100	25	0	125
2	Abstract Algebra	MA 403	3	1	0	04	100	25	0	125
3	Fluid Dynamics	MA 405	3	2	0	05	100	50	0	150
4	Optimization Techniques	MA 407	3	2	0	05	100	50	0	150
5	*Core Electives*		3	0	0	03	100	0	0	100
	Sobolev Space	MA 421								
	Data Science	CS 491								
	Block Chain Technology	CS 423								
			15	6	0	21				

Total Contact Hours per Week = 21 **Total Credits = 21** **Total Marks = 650**

SEMESTER – VIII

Sr. No.	Subject	Code	Teaching Scheme Hours Per Week			Credits	Examination Scheme			Total Marks
			L	T	P		Theory	Tutorial	Practical	
1	Functional Analysis	MA 402	3	1	0	04	100	25	0	125
2	Higher Transcendental Functions	MA 404	3	1	0	04	100	25	0	125
3	Partial Differential Equations	MA 406	3	2	0	05	100	50	0	150
4	Calculus of Variations & Integral Equations	MA 408	3	2	0	05	100	50	0	150
5	*Core Electives*		3	0	0	03	100	00	0	100
	Multiobjective optimization	MA 422								
	Natural Language Processing	CS 492								
			15	6	0	21				

Total Contact Hours per Week = 21 **Total Credits = 21** **Total Marks = 650**

MA 401: Topology

L	T	P	Credit
3	1	0	04

1. Course Outcomes (COs)

At the end of the course the students will be able to :

CO1: explain the concept of topology and intrinsic properties of topological spaces

CO2: demonstrate homeomorphism and topological manifold.

CO3: discuss compactness, connectedness and related theorems

CO4: explain the concept of Countability Axioms, Seperability

CO5: discuss the Metrization Theorem and its applications in topology

2. Syllabus

- INTRODUCTION **(14 Hours)**

  Topological Spaces, Examples of topological spaces, Subspace topology, Product topology, Metric topology, Order topology, Quotient topology, Bases, Sub bases, Continuous function, Homeomorphism, Topological manifold.

- COMPACTNESS **(10 Hours)**

  Compact spaces, Heine-Borel theorem, Local compactness, One-point compactification, Tychnoff theorem. The Stone-Cech compactification.

- CONNECTEDNESS **(06 Hours)**

  Connected spaces, Components and local connectedness.

- COUNTABILITY & SEPARATION AXIOMS **(12 Hours)**

  Countability Axioms, Seperability i.e. T0, T1, T2 spaces, Regularity, Completed regularity, Normality, Urysohn lemma, Tychnoff embedding and Urysohn metrization theorem, Tietze extension theorem.

Total Lecture Hours: 42

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3. Books Recommended

1. M. A. Armstrong, Basic Topology, Springer(India), 2004.
2. K. D. Joshi, Introduction to General Topology, New Age International, New Delhi, 2000.
3. J. L. Kelley, General Topology, Van Nostrand, Princeton,1955.
4. J. R. Munkres, Topology, 2^{nd} Edition, Pearson Education (India), 2001.
5. G. F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill, New York, 1963.

MA 403: Abstract Algebra

L	T	P	Credit
3	1	0	04

1. Course Outcomes (COs)

At the end of the course the students will be able to :

CO1: demonstrate insight into abstract algebra with focus on axiomatic theories

CO2: develop capacity for mathematical reasoning through analyzing, proving and explaining concepts from advance group theory

CO3: explain the fundamental concepts of ring theory and their role in modern mathematics

CO4: prove fundamental results and solve algebraic problems using appropriate techniques

CO5: discuss about field extension and fundamental theorems of Galois theory

2. Syllabus

- **ADVANCED GROUP THEORY** **(14 Hours)**

  Solvable groups and theorem of them, Conjugacy, Conjugate classes, Theorems on finite groups, Class equations, Sylow's theorem, Normal and subnormal series, Composition series, Jordan-Holder theorem, Nilpotent groups.

- **RING THEORY** **(12 Hours)**

  Rings, Subrings and ideals, Sum of ideals, Product of ideals, Minimal ideal, Maximal ideal, Quotient rings, Homomorphisms. Polynomial rings, Division ring, Factorization in R[x], Divisibility, Integral domain, Euclidean domains, Prime and irreducible elements, Principal ideal domains and unique factorization domains.

- **FIELD THEORY** **(08 Hours)**

  Fields, Skew fields, Finite fields, Field of quotients and embedding theorems, Eisenstein's irreducibility criterion.

- **FIELD EXTENSIONS AND GALOIS THEORY** **(08 Hours)**

  Prime field, field extensions, Splitting fields and normal extensions, Separable and inseparable extensions. Automorphisms of field extensions, Galois extensions and Galois groups, Fundamental theorems of Galois theory.

Total Lecture Hours: 42

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3. Books Recommended

1. M. Artin, Algebra, 2^{nd} Edition, Pearson Education India, 2010.
2. J. A. Gallian, Contemporary Abstract Algebra, 9^{th} Edition, Cengage Learning India (P.) Ltd., 2019.
3. J. B. Fraleigh, First Course in Abstract Algebra, 3^{rd} Edition, Narosa Publishing House, New Delhi, 2003.
4. I. N. Herstein, Topics in Algebra, 2^{nd} Edition, Wiley India (P.) Ltd., New Delhi, 2009.
5. P. M. Chon, Algebra, Vols. I, II & III, John Wiley & Sons, 1989, 1991, 1992.

MA 405: Fluid Dynamics

L	T	P	Credit
3	2	0	05

1. Course Outcomes (COs)

At the end of the course the students will be able to :

CO1: explain the physical properties of fluid and their consequence on fluid flow

CO2: identify the fundamental kinematics of a fluid element

CO3: analyze practical applications of Bernoulli's equation

CO4: formulate conceptual and analytical models of flow system

CO5: solve problems in fluid dynamics using finite difference methods

2. Syllabus

- **GENERAL INTRODUCTION** **(04 Hours)**

  Introduction to fluid dynamics, Normal and shear stress, The concept of a fluid, Kinds of fluids, Characteristics of fluid, Density, Pressure, Viscosity, Surface tension and compressibility, Different types of flows, Visualization of flows.

- **EQUATIONS OF MOTION** **(06 Hours)**

  Pressure equation (Bernoulli's equation for steady and unsteady motion), Practical applications of Bernoulli's equation to Orifice meter, Pitot-tube, Venturimeter.

- **POTENTIAL FLOW** **(06 Hours)**

  Velocity potential and irrotational flow, Circulation and Kelvin's theorem, Theorem of Blasius, Stream function in two dimensions, Complex velocity potential.

- **GOVERNING EQUATION OF FLUID DYNAMICS** **(10 Hours)**

  Derivation of the Navier-stokes equation, Flow between parallel plates – Couette flow and plane Poiseuille flow. Hagen – Poiseuille flow through pipes, Steady flow through a cylindrical pipe, Steady flow between co-axial circular cylinders.

- **BOUNDARY LAYER FLOW** **(06 Hours)**

  Drag and lift, Prandtl's boundary layer theory, Boundary layer equation, Karman's integral (condition) equation, Flow parallel to a semi-infinite flat plate, Reynold's number, Prandtl number, Nusselt number, Froude number, Eckert number.

- **INTRODUCTION TO COMPUTATIONAL DYNAMICS** **(10 Hours)**

  General introduction and role of computational fluid dynamics in modern fluid dynamics, The method of finite differences, Derivation of elementary finite difference quotients, Basic aspects of finite-difference equations, Errors and an analysis of stability, Explicit finite difference methods; The Lax–Wendroff method, MacCormack's method, Stability criterion, Applications of the explicit time-dependent technique, Generalized Crank–Nicholson scheme.

Total Lecture Hours: 42

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3. Books Recommended

1. G. K. Bachelor, An Introduction to Fluid Dynamics, Cambridge University Press, 2000.
2. P. K. Kundu, and Ira M. Cohen, Fluid Mechanics, 3rd Edition, Burlington Elsevier, 2004.
3. M. E. O'Neill and F. Chorlton, Ideal and Incompressible Fluid Dynamics, John Wiley & Sons, 1986.
4. J. K. Goyal and K. P. Gupta, Fluid Dynamics and Advanced Hydrodynamics, Pragati Prakashan, 2016.
5. J. F. Wendt, Computational Fluid Dynamics: An Introduction, 3rd Edition, Springer, 2009.

MA 407: Optimization Techniques

L	T	P	Credit
3	2	0	05

1. Course Outcomes (COs)

At the end of the course the students will be able to :

CO1: demonstrate the importance of optimization in real life problems.

CO2: formulate the real world problems into optimization problems

CO3: analyze the sensitivity of different components of an LPP towards its solution.

CO4: estimate the solution of different real life problems using the concept of LPP

CO5: explain the basic concept of non-linear optimization

2. Syllabus

- LINEAR PROGRAMMING PROBLEMS (08 Hours)

  Introduction, Structure of L.P.P., Formulation of an L.P.P., Graphical Method of solution of L.P.P., Standard form of L.P.P., Simplex Algorithm, Simplex Tableau, Two Phase Method, Big-M Method, Types of Linear Programming solutions, Duality.

- REVISED SIMPLEX METHOD (05 Hours)

  Revised simplex method (with and without artificial variable), Bounded variable technique, Dual simplex method, Modified dual simplex method.

- SENSITIVITY ANALYSIS (06 Hours)

  Change in the objective function, Change in the requirement vector, Addition of a variable, Addition of a constraint, Parametric analysis of cost and requirement vector.

- INTEGER PROGRAMMING PROBLEMS (04 Hours)

  Gomory's cutting plane algorithm, Gomory's mixed integer problem algorithm, A branch and bound algorithm.

- TRANSPORTATION PROBLEMS (05 Hours)

  Mathematical Model for Transportation Problem, North-West Corner Method, Least Cost Method, Vogel's Approximation Method, Test for optimality, Degeneracy in Transportation Problem, Variations in Transportation Problem.

- ASSIGNMENT PROBLEMS (05 Hours)

  Mathematical Model for Assignment Problem, Solution Method for Assignment Problem, Variations in Assignment Problem, Traveling Salesman Problem.

- SEQUENCING PROBLEMS (04 Hours)

  Processing of Jobs through machines: Problems with n jobs two machines, n jobs three machines and n jobs m machines.

- INTRODUCTION TO NONLINEAR OPTIMIZATION (05 Hours)

  General NLPP, Formulation, unconstrained and constrained optimization, constrained optimization with equality constraints (Lagrange's theory), constrained optimization with inequality constraints (Kuhn-Tucker conditions).

Total Lecture Hours: 42

3. Books Recommended

1. E. M. L. Beale and L. Mackley, Introduction to Optimization, John Wiley, 1988.
2. K. Swarup, P. K. Gupta and M. Mohan, Operations Research, 19^{th} Edition, S. Chand & Sons, New Delhi, 2017.
3. S. S. Rao, Optimization Theory and Applications, 2^{nd} Edition, Willey Eastern Ltd., New Delhi, 1985.
4. H. A. Taha, Operations Research: An Introduction, 9^{th} Edition, Pearson, New Delhi, 2014.
5. J. K. Sharma, Operations Research: Theory and Applications, 6^{th} Edition, Trinity Press, New Delhi, 2017.

MA 421: Sobolev Space

L	T	P	Credit
3	0	0	03

1. Course Outcomes (COs)

At the end of the course the students will be able to :

CO1: explain the concept of distribution

CO2: demonstrate L^1, L^2 and L^p Fourier transform

CO3: discuss the $W_\infty^{1,p}(\Omega)$, $W^{1,p}(\Omega)$, $H^1(\Omega)$ spaces and their properties

CO4: explain the imbedding theorem and weighted space

CO5: discuss various inequalities in Sobolev space

2. Syllabus

- **DISTRIBUTION** **(04 Hours)**

  Test function spaces and distributions, Convergence distribution derivatives

- **FOURIER TRANSFORM** **(06 Hours)**

  L^1–Fourier transform, Fourier transform of a Gaussian, L^2–Fourier transform, Inversion formula, L^p–Fourier transform, Convolution

- **SOBOLEV SPACE** **(08 Hours)**

  The spaces $W_\infty^{1,p}(\Omega)$ and $W^{1,p}(\Omega)$, Their simple characteristic properties, Density result, Min and Max of $W^{1,p}$ functions, The space $H^1(\Omega)$

- **IMBEDDING THEOREM** **(06 Hours)**

  Continuous and compact imbedding of Sobolev spaces into Lebesgue spaces, Sobolev imbedding theorem, Rellich–Kondrasov theorem

- **WEIGHTED SPACE** **(08 Hours)**

  Definition, Motivation, Examples of practical importance, Special weights of power type, General weights, Weighted Lebesgue space $P(\Omega, \sigma)$, weighted Sobolev spaces $W^{k,p}(\Omega, \sigma)$, $W_o^{\Omega,\sigma}$ and their properties.

- **INEQUALITIES** **(10 Hours)**

  Methods of local co-ordinates, The classes C^o, $C^{0,k}$, Holder's condition, Partition of unity, The class $K(x_0)$ including cone property. Hardy inequality, Jensen's inequality, Young's inequality, Hardy–Littlewood–Sobolev inequality, Sobolev inequality and its various versions.

Total Lecture Hours: 42

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3. Books Recommended

1. R. A. Adams, Sobolev Spaces, Academic Press Inc. New York, 1975.
2. K. Kesavan, Topics in Functional Analysis and Applications, John Wiley & Sons Ltd , 1989.
3. A. Kufner, Weighted Sobolev Spaces, John Wiley & Sons Ltd. New York,1985.
4. G. Leoni, A First Course in Sobolev Spaces, Americal Mathematical Society, 2009
5. R. S. Pathak, A course in Distributioin Theory and Applications, Narosa Publication House, 2001.

CS 321: Data Science

L	T	P	Credit
3	0	0	03

1. Course Outcomes (COs)

At the end of the course the students will be able to :

CO1: understand types of data and various data science approaches

CO2: apply various data pre-processing and manipulation techniques including various distributed analysis paradigm using hadoop and other tools and perform advance statistical analysis to solve complex and large dataset problems.

CO3: analyse different large data like text data, stream data, graph data.

CO4: interpret and evaluate various large datasets by applying Data Mining techniques like clustering, filtering, factorization.

CO5: design the solution for the real life applications.

2. Syllabus

- INTRODUCTION **(02 Hours)**

  Examples, Applications and results obtained using data science techniques, Overview of the data science process.

- MANAGING LARGE SCALE DATA **(02 Hours)**

  Types of data and data representations, Acquire data (E.G., Crawling), Process and parse data, Data manipulation, Data wrangling and Data cleaning.

- PARADIGMS FOR DATA MANIPULATION, LARGE SCALE DATA SET **(08 Hours)**

  MapReduce (Hadoop), Query large data sets in near real time with Pig and Hive, Moving from traditional warehouses to map reduce. Distributed databases, Distributed Hash Tables.

- TEXT ANALYSIS **(10 Hours)**

  Data flattening, Filtering and chunking, Feature scaling, Dimensionality reduction, Nonlinear factorization, Shingling of Documents, Locality Sensitive Hashing for Documents, Distance Measures, LSH Families for Other Distance Measures, Collaborative filtering.

- MINING DATA STREAM **(08 Hours)**

  Sampling data in a stream, Filtering streams, Counting distinct elements in a stream, Moments, Windows, Clustering for streams.

- ADVANCED DATA ANALYSIS **(12 Hours)**

  Graph visualization, Data summaries, Hypothesis testing, ML model-checking and comparison, Link analysis, Mining of graph, Frequent item sets analysis, High dimensional clustering, Hierarchical clustering, Recommendation systems.

Total Lecture Hours: 42

3. Books Recommended

1. Tom White, Hadoop: The Definitive Guide, 4th Edition, O'Reilly Media. 2015, ISBN: 9781491901687.
2. Anand Rajaraman and Jeffrey David Ullman, Mining of Massive Datasets, 2nd Edition, Cambridge University Press, 2014, ISBN: 9781107077232.
3. Andrew Bruce and Peter Bruce, Practical Statistics for Data Scientists, 1st Edition, O'Reilly Publishing House, 2017.
4. J. Joel Grus, Data Science from Scratch, 1st Editiion, O'Reilly Media, 2015. ISBN: 9781491901410.
5. Montgomery, C. Douglas, and George C. Runger, Applied Statistics and Probability for Engineers, John Wiley & Sons, 7th Edition, 2018. ISBN: 9781119400363.

CS 423: Block Chain Technology

L	T	P	Credit
3	0	0	03

1. Course Outcomes (COs)

At the end of the course the students will be able to:

CO1: understand the need, functions and challenges of blockchain technology.

CO2: deploy smart contracts for given use cases.

CO3: analyse blockchain based system structure and security offered therein.

CO4: asses functions, benefits and limitations of various blockchain platforms.

CO5: design and develop solution using blockchain technology in various application domains.

2. Syllabus

- INTRODUCTION (04 Hours)

  Introduction to Blockchain Technology, Concept of Blocks, Transactions, Distributed Consensus, the Chain and the Longest Chain, Cryptocurrency, Blockchain 2.0, Permissioned Model of Blockchain, Permission less Blockchain.

- DECENTRALIZATION USING BLOCKCHAIN (06 Hours)

  Methods of Decentralization, Disintermediation, Contest-Driven Decentralization, Routes to Decentralization, the Decentralization Framework Example, Blockchain and Full Ecosystem Decentralization, Storage, Communication, Computing Power and Decentralization, Smart Contracts, Decentralized Autonomous Organizations, Decentralized Applications (DApps), Requirements and Operations of DApps, DApps Examples, Platforms for Decentralizations.

- CRYPTO PRIMITIVES FOR BLOCKCHAIN (04 Hours)

  Symmetric and Public Key Cryptography, Cryptographic Hard Problems, Key Generation, Secure Hash Algorithms, Hash Pointers, Digital Signatures, Merkle Trees, Patricia trees, Distributed Hash Tables.

- BITCOINS AND CRYPTOCURRENCY (06 Hours)

  Introduction, Digital Keys and Addresses, Private and Public Keys in Bitcoins, Base58Check Encoding, Vanity Addresses, Multi Signature Addresses, Transaction Lifecycle, Data Structure for Transaction, Types of Transactions, Transaction Verification, The Structure of Block in Blockchain, Mining, Proof of Work, Bitcoin Network and Payments, Bitcoin Clients and APIs, Wallets, Alternative Coins, Proof of Stake, Proof of Storage, Various Stake Types, Difficulty Adjustment and Retargeting Algorithms, Bitcoin Limitations.

- SMART CONTRACTS (02 Hours)

  Smart Contract Templates, Oracle, Smart Oracle, Deploying Smart Contract on Blockchain.

- PERMISSIONED BLOCKCHAIN (05 Hours)

  Models and Use-cases, Design Issues, Consensus, Paxos, RAFT Consensus, Byzantine General Problem, Practical Byzantine Fault Tolerance.

- DEVELOPMENT TOOLS AND FRAMEWORKS (05 Hours)

  Solidity Compilers, IDEs, Ganache, Metamask, Truffle, Contract Development and

Deployment, Solidity Language, Types, Value Types, Literals, Enums, Function Types, Reference Types, Global Variables, Control Structures, Layout of Solidity Source Code File.

- **HYPERLEDGER** **(05 Hours)**

  The Reference Architecture, Requirements and Design Goals of Hyperledger Fabric, The Modular Approach, Privacy and Confidentiality, Scalability, Deterministic Transactions, Identity, Auditability, Interoperability, Portability, Membership Services in Fabric, Blockchain Services, Consensus Services, Distributed Ledger, Sawtooth Lake, Corda.

- **BLCOKCHAIN USE-CASES AND CHALLENGES** **(05 Hours)**

  Finances, Government, Supply Chain, Security, Internet of Things, Scalability and Challenges, Network Plane, Consensus Plane, Storage Plane, View Plane, Block Size Increase, Block Interval Reduction, Invertible Bloom Lookup Tables, Private Chains, Sidechains, Privacy Issues, Indistinguishability Obfuscation, Homomorphic Encryption, Zero Knowledge Proofs, State Channels, Secure Multiparty Computation, Confidential Transactions.

Total Lecture Hours: 42

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3. Books Recommended

1. Imran Bashir, Mastering Blockchain, 2^{nd} Edition, Packt publishing, Mumbai, 2018.
2. Andreas Antonopoulos, Mastering Bitcoin: Unlocking Digital Cryptocurrencies, 2^{nd} Edition, O'Reilly, 2014.
3. Melanie Swan, "Blockchain Blueprint for a New Economy", 1^{st} Edition, O'Reilly Media, 2015.
4. Don and Alex Tapscott, "Blockchain Revolution", 1^{st} Edition, Penguin Books Ltd, 2018.
5. Alan T. Norman, "Blockchain Technology Explained", 1^{st} Edition, CreateSpace Independent Publishing Platform, 2017.

MA 402: Functional Analysis

L	T	P	Credit
3	1	0	04

1. Course Outcomes (COs)

At the end of the course the students will be able to :

CO1: demonstrate the concept of normed linear spaces

CO2: explain bounded linear map, their properties and applications

CO3: prove the theorems related to Hilbert space

CO4: discuss the concept of dual spaces and corresponding operator theory

CO5: prove spectral theorem for different operators

2. Syllabus

- **FUNDAMENTALS OF NORMED LINEAR SPACE** **(06 Hours)**

  Normed Linear Spaces, Finite dimensional spaces, Riesz lemma.

- **BOUNDED LINEAR MAPS ON NORMED LINEAR SPACES** **(10 Hours)**

  Definition and examples, linear maps on finite dimensional spaces, operator norm, Banach Spaces, HahnBanach theorems and its applications, Open mapping and Closed Graph theorems, Uniform Boundedness Principle.

- **HILBERT SPACES** **(07 Hours)**

  Inner product spaces, orthonormal sets, Gram-Schmidt orthogonalization, Bessel's inequality, orhtonormal basis, Separable Hilbert spaces, projection and Riesz representation theorem, Divergence of Fourier series.

- **DUAL SPACES AND ADJOINT OF AN OPERATOR** **(06 Hours)**

  Duals of classical spaces, weak and weak* convergence, BanachAlaoglu theorem, Adjoint of an operator.

- **BOUNDED OPERATORS ON HILBERT SPACE** **(07 Hours)**

  Adjoint operator, normal, unitary, self adjoint operator, compact operator, eigen value, eigen vectors, Banach algebras.

- **SPECTRAL THEOREM** **(06 Hours)**

  Spectral theorem for compact self adjoint operators, spectral theorem for bounded self adjoint operators, and unitary operators.

Total Lecture Hours: 42

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3. Books Recommended

1. J. B. Conway, A Course in Functional Analysis, 2^{nd} Edition, Springer-Verlag, New York, 1990.
2. E. Kreyszig, Introductory Functional Analysis with Applications, 1^{st} edition, John Wiley & Sons, New York, 1989.
3. B. V. Limaye, Functional Analysis, 3^{rd} Revised Edition, New Age International Private Limited, 2014.

4. G. F. Simmons,Introduction to Topology and Modern Analysis, 1st Edition McGraw-Hill Education, New York, 2017.
5. W. Rudin, Functional Analysis, 2nd Edition, McGraw-Hill, New York, 1991.

MA 404: Higher Transcendental Functions

L	T	P	Credit
3	1	0	04

1. Course Outcomes (COs)

At the end of the course the students will be able to :

CO1: explain the fundamentals of higher transcendental functions

CO2: demonstrate the infinite products and their convergence with applications

CO3: analyze with the solution of hypergeometric function and their properties

CO4: develop the generating relations of different functions and polynomials

CO5: explain the concept of q-series with applications

2. Syllabus

- INFINITE PRODUCT (08 Hours)

  Definition of infinite product, convergence conditions, The associated series of logarithm Absolute convergence, Uniform convergence, The Euler or Mascheroni constant, Gamma function, Psi function, Euler product of gamma function, , Euler integral for gamma function, Beta function, Legendre duplication formula, Gauss' multiplication theorem.

- HYPERGEOMETRIC FUNCTION (10 Hours)

  Introduction, Hypergeometric function and generalized hypergeometric function, Integral representation, Differential properties of hypergeometric function, Confluent hypergeometric function and its integral representation.

- THEORY OF GENERATING FUNCTION (08 Hours)

  Introduction to generating functions, Generating functions of the family of the form $G(2xt - t^2)$, $e^t\phi(t)$ etc., with suitable examples (Bessel function, Legendre Polynomial, Hermite polynomial and Laguerre Polynomial), Boas and Buck type, Pure recurrence relations, Appell, Sheffer and 0-type characterizations of polynomial sets.

- ORTHOGONAL POLYNOMIALS (08 Hours)

  Introduction, The moment functional, and orthogonality, Existence of OPS, The fundamental recurrence formula, Zeros, Gauss quadrature, Kernel polynomials, Symmetric moment functional, Certain related recurrence relations, Orthogonality of Lagguere, Legendre, Hermite and Bessel Functions.

- BASIC HYPERGEOMETRIC SERIES AND THEIR APPLICATIONS (08 Hours)

  Introduction to basic Hyper geometric series, q-analogue of orthogonal polynomials, q-Gamma and q-Beta functions.

Total Lecture Hours: 42

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3. Books Recommended

1. G. E. Andrews, R. Askey and R. Roy, Special Functions, Cambridge Univ. Press, 1990.

2. W. N. Bailey, Generalized Hypergeometric Series, Stechert-Hafner Service Agency, New York and London, 1964.
3. E. T. Copson, Introduction to the Theory of Functions of a Complex Variable, The English Language Book Society, London, 1978.
4. T. S. Chihara, Introduction to Orthogonal Polynomials, Gordon and Breach Science Publishers Inc., New York, 1978.
5. E. D. Rainville, Special Functions, The Macmillan Company, New York, 1960.

MA 406: Partial Differential Equations

L	T	P	Credit
3	2	0	05

1. Course Outcomes (COs)

At the end of the course the students will be able to :

CO1: formulate the physical problem into partial differential equations.

CO2: solve first order linear and nonlinear equations

CO3: analyze the existence and uniqueness of solutions

CO4: classify second order equations into three types of PDEs: parabolic, hyperbolic and elliptic

CO5: discuss the formulation and solution of Laplace, wave and heat equation

2. Syllabus

- INTRODUCTION TO PDE **(06 Hours)**

  Order and degree of PDE, Types of PDE, Solution of simple PDE, Formation of PDE, Initial and Boundary conditions, Types of solution.

- FIRST ORDER PDE **(12 Hours)**

  The method of characteristics, The existence and uniqueness theorem, Cauchy problem, Lagrange's method, Compatible system of first order PDEs , Charpit's method, Jacobi method, Geometrical interpretation and applications of first order PDE.

- SECOND AND HIGHER ORDER PDE **(12 Hours)**

  Homogeneous and non-homogeneous PDE of order two and higher with constant coefficient. PDEs reducible to equations with constant coefficients.
  PDEs of order two with variable coefficients. Classification of PDE, Reduction to canonical or Normal form, Riemann Method, Monges's method.

- LAPLACE EQUATION **(04 Hours)**

  Formulation and physical interpretation, Derivation of fundamental solution, Uniqueness of solution, Dirichlet's principle, Method of separation of variables.

- HEAT EQUATION **(04 Hours)**

  Formulation and physical interpretation, Derivation of fundamental solution, Uniqueness of solution, Method of separation of variables.

- WAVE EQUATIONS **(04 Hours)**

  Formulation and physical interpretation, D'Alembert's solution, Uniqueness of solution, Method of separation of variables.

Total Lecture Hours: 42

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3. Books Recommended

1. M. P. Coleman, An Introduction to Partial Differential Equations with MATLAB, 2^{nd} Edition, CRC Press, 2013.
2. P. Prasad and R. Ravindran, Partial Differential Equations, New Age International Publishers, 2009.

3. Ian N. Sneddon, Elements of Partial Differential Equations, McGraw-Hill, 1957.
4. L. C. Evans, Partial Differential Equations, 2nd Edition, American Mathematical Society, 2010.
5. T. Amarnath, An Elementary Course in Partial Differential Equations, 2nd Edition, Narosa Publications, 2003.

MA 408: Calculus of Variations & Integral Equations

L	T	P	Credit
3	2	0	05

1. Course Outcomes (COs)

At the end of the course the students will be able to :

CO1: formulate variational problems and analyse them to deduce key properties of system behaviour.

CO2: explain the extremals of the BVP's through variational approach.

CO3: interpret the difference between Volterra and Fredholm integral equations.

CO4: solve IVP's and BVP's through integral equation approach.

CO5: solve integral equations through different analytical and numerical approach.

2. Syllabus

- **INTRODUCTION TO CALCULUS OF VARIATIONS** **(08 Hours)**

  Maxima and minima, Natural boundary conditions and transition conditions, Variational notation, constraints and Lagrange multipliers, Hamilton's principle, Lagrange's equations, Constraints in dynamical systems.

- **VARIATIONAL PROBLEMS** **(08 Hours)**

  The Euler-Lagrange Equation, Minimum Surface of revolution, Geodesic, The Brachistochrone, Several dependent variables, Parametric representation, Undetermined end points,Brachistochrone from a given curve to a fixed point.

- **ISOPERIMETRIC PROBLEMS** **(08 Hours)**

  The simple isoperimetric problem, Direct Extension, Problem of the maximum enclosed area, Moving boundaries and transversality condition, Essential and Suppressible boundary conditions, Variational problems for deformable bodies, useful transformations, Rayleigh-Ritz method, Kantorovich method.

- **INTEGRAL EQUATIONS** **(10 Hours)**

  Linear Integral Equations, Eigen values and Eigen functions, The Green's function, Linear equations in cause and effect, The influence function, Fredholm equations with separable kernels,Hilbert Schmidt theory, Volterra Integral equation, Solution by Resolvent kernel, Method of successive approximations, The Neumann series, Fredholm theory, Singular Integral Equations.

- **APPROXIMATION OF INTEGRAL EQUATIONS** **(08 Hours)**

  Iterative approximations to characteristic functions, Approximations of Fredholm equations by sets of algebraic equations, Approximate method of undermined coefficients, the method of collocation, the method of weighting functions, the method of least squares, Approximation of the kernel.

Total Lecture Hours: 42

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3. Books Recommended

1. F. B. Hilderbrand, Methods of Applied Mathematics, 2^{nd} Edition, Prentice Hall Inc., 1992.

2. R. P. Kanwal, Generalized Functions: Theory and Technique, 2nd Edition, Academic Press, New York, 1998.
3. A. M. Wazwaz, A First Course in Integral Equations, 2nd Edition, World Scientific Publishing Company, 2015.
4. M. R. Seikh and P. K. Nayak, Integral Equations and Calculus of Variations, 1st Edition, Narosa Publishing House, 2019.
5. Ian N. Sneddon, Mixed Boundary Value Problems in Potential Theory, 1st Edition, North Holland, 1966.

MA 422: Multiobjective Optimization

L	T	P	Credit
3	0	0	03

1. Course Outcomes (COs)

At the end of the course the students will be able to :

CO1: classify simple (single) objective and multi-objective optimization problems

CO2: formulate real world problems in multiobjective optimization.

CO3: solve multiobjective optimization problems by classical approaches

CO4: solve multiobjective optimization problems by Evolutionary approaches

CO5: explain the importance of multiobjective optimization in real life

2. Syllabus

- **ELEMENTS OF MULTIOBJECTIVE DECISION MAKING PROBLEM** **(06 Hours)**

  Introduction, Multiobjective decisions making process, Judgment and the value system, Decision making unit and the decision makers, Objectives and attributes, Decision Situation, Symbolic representation of the multiobjective Decisions problem, Scale of measurement, Elementary decision analysis, types of decision problems, Choosing a decision rule, decision tree.

- **MULTIOBJECTIVE OPTIMIZATION** **(06 Hours)**

  Definition of Multiobjective optimization, Difference between Single and Multiobjective optimization, Formation of multiobjective optimization problem, Pareto-optimality, Efficiency and dominance, Compromise Solution.

- **METHODS TO SOLVE MULTIOBJECTIVE OPTIMIZATION PROBLEMS** **(14 Hours)**

  Graphical method, Multiobjective simplex method, Goal programming method, ε constraint method, weighted sum method, Fuzzy programming approach with linear, exponential and hyperbolic membership function.

- **EVOLUTIONARY APPROACHES** **(08 Hours)**

  Introduction to Evolutionary approaches. Difficulties with classical optimization algorithm, Genetic Algorithm for the solution of multiobjective optimization problem.

- **SELECTED MULTIOBJECTIVE OPTIMIZATION PROBLEMS** **(08 Hours)**

  Multiobjective transportation problems, Multiobjective solid transportation problems, Multiobjective assignment problems.

Total Lecture Hours: 42

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3. Books Recommended

1. C. Vira, Y. H. Yacov, Multiobjective Decision Making Theory and Methodology, North Holand, Elsevier Science Publishing Company Newyork, 2008.

2. K. Deb, Multiobjective Optimization using Evolutionary Algorithms, John Willey & Sons, 2003.
3. S. N. Sivanandam, S. N. Deepa, Introduction to Genetic Algorithms, Springer-Verlag Berlin Heidelberg, 2008.
4. D. T. Luc, Multiobjective Linear Programming an Introduction, Springer International Publishing Switzerland, 2016
5. J. Lu, G. Zhang, D. Ruan and F. Wu, Multiobjective Group Decision Making Methods, Software and Applications With Fuzzy Set Techniques, Imperial College Press London, 2007.

CS 324: Natural Language Processing

L	T	P	Credit
3	0	0	03

1. Course Outcomes (COs)

At the end of the course the students will be able to :

CO1: understand basics principles of natural language processing.

CO2: apply machine learning techniques for NLP based different tasks.

CO3: perform statically analysis and classification, recognition using NLP knowledge acquired.

CO4: evaluate the performance of machine translation solutions through statistical parameters.

CO5: design efficient solution for parser, translator and different applications based on NLP for day to day usage.

2. Syllabus

- INTRODUCTION (04 Hours)

  Human Languages, Language Models, Computational Linguistics , Ambiguity and Uncertainty in Language, Processing Paradigms; Phases in Natural Language Processing, Basic Terminology, Overview of Different Applications, Regular Expressions and Automata, Finite State Transducers and Morphology, Automata, Word Recognition. Lexicon, Morphology. Acquisition Models, Linguistics Resources, Introduction to Corpus, Elements in Balanced Corpus.

- SYNTAX AND SYMANTICS (08 Hours)

  Natural Language Grammars, Lexeme, Phonemes, Phrases and Idioms, Word Order, Tense, Probabilistic Models of Spelling, N-grams, Word Classes and Part of Speech Tagging using Maximum Entropy Models, Transformation Based Tagging (TBL), Context Free Grammars for English, Features and Unification, Lexicalized and Parsing, Treebanks, Language and Complexity, Representing Meaning, Semantic Analysis, Lexical Semantics, Word Sense Disambiguation.

- PROBABILISTIC LANGUAGE MODELLING (08 Hours)

  Statistical Inference, Hidden Markov Models, Probabilistic (weighted) Finite State Automata, Estimating the Probability of a Word, and Smoothing, Probabilistic Parsing, Generative Models of Language, Probabilistic Context Free Grammars, Probabilistic Parsing, Statistical Alignment and Machine Translation, Clustering, Text Categorization, Viterbi Algorithm for Finding Most Likely HMM Path.

- PRAGMATICS (06 Hours)

  Discourse, Dialogue and Conversational Agents, Natural Language Generation, Machine Translation. Dictionary Based Approaches. Reference Resolution, Algorithm for Pronoun Resolution, Text Coherence, Discourse Structure, Applications of NLP- Spell-Checking.

- MACHINE TRANSLATION (08 Hours)

  Probabilistic Models for Translating One to Another Language, Alignment, Translation, Language Generation, Expectation Maximization, Automatically Discovering Verb Subcategorization, Language Modelling Integrated into Social Network Analysis, Automatic Summarization, Question-Answering, Interactive Dialogue Systems.

- **ADVANCED TOPICS** **(08 Hours)**

Summarization, Information Retrieval, Vector Space Model, Term Weighting, Homonymy, Polysemy, Synonymy, Improving User Queries, Document Classification, Sentence Segmentation, and Other Language Tasks, Automatically-Trained Email Spam Filter, Automatically Determining the Language, Speech Recognition.

Total Lecture Hours: 42

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3. Books Recommended

1. Daniel Jurafsky and James H. Martin, "Speech and Language Processing", 2nd Edition, Pearson Education, 2009.
2. James Allen, "Natural Language Understanding", 2nd Edition, Addison-Wesley, 1994.
3. Christopher D. Manning and Hinrich Schutze, "Foundations of Statistical Natural Language Processing", MIT Press, 1999.
4. Steven Bird, "Natural Language Processing with Python", 1st Edition, O'Reilly Publication, 2009.
5. Jacob Perkins, "Python Text Processing with NLTK 2.0 Cookbook", Packt Publishing, 2010.

Further Reading

1. A. Bharati, R. Sangal and V. Chaitanya, "Natural Language Processing: A Paninian Perspective", PHI, 2000.
2. T. Siddiqui and U. S. Tiwary, "Natural Language Processing and Information Retrieval", Oxford University Press, 2008.

Five years Integrated M. Sc. (Mathematics)
Teaching Scheme

Semester – IX

Sr. No.	Subject	Code	Teaching Scheme Hours Per Week			Credits	Examination Scheme				Total Marks
			L	T	P		Theory	Tutorial	Practical		
									Cont. Eval.	End Sem	
1	Measure Theory & Integration	MA 501	3	1	0	04	100	25	0	0	125
2	Probability & Statistics II	MA 503	3	1	0	04	100	25	0	0	125
3	Mathematical Modelling & Simulation	MA 505	3	1	2	05	100	25	50	0	175
4	Academic Writing	HU 501	3	0	0	03	100	00	0	0	100
5	Dissertation Preliminaries	MA 507	0	0	8	04	0	0	80	120	200
6	*Core Elective*		3	1	0	04	100	25	0		125
	Advanced Operations Research	MA 521									
	Fluid Dynamics in Porous Media	MA 523									
	Advanced Numerical Analysis	MA 525									
	Linear Operators and Approximation Theory	MA 527									
			15	4	10	24					

Total Contact Hours per Week = 29 **Total Credits = 24** **Total Marks = 850**

Semester – X

Sr. No.	Subject	Code	Teaching Scheme Hours Per Week			Credits	Examination Scheme				Total Marks
			L	T	P		Theory	Tutorial	Practical		
									Cont. Eval.	End Sem.	
1	Dissertation	MA 502	0	0	24	12	0	0	160	240	400

Total Contact Hours per Week = 24 **Total Credits = 12** **Total Marks = 600**

MA 501: Measure Theory & Integration

L	T	P	Credit
3	1	0	04

1. Course Outcomes (COs)

At the end of the course the students will be able to :

CO1: explain the fundamentals of measure theory

CO2: explain the Lebesgue measure with their properties and characterisation

CO3: apply the concept of measure theory in integration

CO4: explain the theorems related to measure theory and integration

CO5: utilize the concept of integration in different spaces

2. Syllabus

- INTRODUCTION **(09 Hours)**

  Introduction, Extended real numbers, Algebra and sigma algebra of subsets of a set, Sigma algebra generated by a Class, Monotone Class, Set functions, The length function and its properties. Countably additive set functions on intervals, Uniqueness problem for measure. Extension of measure, Outer measure and its properties. A Measurable sets.

- LEBESGUE MEASURE **(11 Hours)**

  Lebesgue measure and its properties, Characterization of Lebesgue measurable sets, Measurable functions, Properties of measurable functions, Measurable functions on measure spaces, Integral of non-negative simple measurable functions, Properties of non-negative simple measurable functions, Monotone convergence theorem and Fatou's Lemma.

- INTEGRATION OF FUNCTION (REAL VARIABLE) **(09 Hours)**

  Properties of integrable functions and dominated convergence theorem, Dominated convergence, Theorem and applications, Lebesgue integral and its Properties.

- MEASURE AND INTEGRATION **(09 Hours)**

  An introduction to product measure. Construction of product measures, Computation of product measure, Integration on product spaces, Fubini's theorems, Lebesgue measure and integral in Euclidean space, Properties of Lebesgue measure in Euclidean space, Lebesgue integral in Euclidean space.

- THE RIEMANN-STEILTJES INTEGRAL **(04 Hours)**

  Definitions and existence of the integral, Conditions of integrability, The integral as a limit of sum, Some important theorems.

Total Lecture Hours: 42

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3. Books Recommended

1. I. K. Rana, An Introduction to Measure and Integration, Narosa Publishing House, New Delhi, 2007.
2. G. De Barra, Measure Theory and Integration, New Age International Publisher, New Delhi, 2017.

3. P. K. Jain, Measure Theory and Integration, New Age International Publisher, New Delhi, 2019.
4. J. L. Doob, Measure Theory, Springer, New York, 2010.
5. S. C. Malik and S. Arora, Mathematical Analysis, 2^{nd} Edition, New Age International (P) Limited, New Delhi, 1994.

MA 503: Probability & Statistics-II

L	T	P	Credit
3	1	0	04

1. Course Outcomes (COs)

At the end of the course the students will be able to :

CO1: analyze the differences among group variance in a sample using ANOVA

CO2: elaborate nonparametric statistics and analysis of categorical data

CO3: apply statistical techniques for quality control

CO4: discuss various stochastic processes and their applications

CO5: apply the knowledge of Markov Chain in industrial requirements

2. Syllabus

- DESIGN OF EXPERIMENTS **(09 Hours)**

  The Design of an Experiment, The Completely Randomized Design-A one –way classification, ANOVA for a completely Randomized design, random effects model, The Randomized Block Design- a Two-way classification, ANOVA for a Randomized Block Design. Factorial experiments, two factor factorial experiments, general factorial experiments, $2k$ factorial experiments.

- NON-PARAMETRIC STATISTICS **(05 Hours)**

  Wilcoxon Rank sum list: Independent random samples. The sign test for a paired experiment. A comparison of statistical tests, Wilcoxon signed- rank test for a paired experiment, The Kruskal-Wallis H-test for Completely Randomized Design.

- ANALYSIS OF CATEGORICAL DATA **(05 Hours)**

  Chi-square statistic, The goodness of fit test, The chi-square test of significance, Contingency tables: A two way classification, ways of comparing proportions, Measures of associations.

- STATISTICAL QUALITY CONTROL **(05 Hours)**

  Objectives of Quality Control, Causes of Variation in quality, Techniques of SQC, Control charts for Variables (X-charts & R-chart S-chart & σ -chart). 6σ concept, Control charts for Attributes (p-charts, np-chats, C-charts),Statistical process control, Terms used in sampling Inspection plans.

- STOCHASTIC PROCESS **(05 Hours)**

  Description & Specification of Stochastic Process, Stationary Processes, Martingales. Poisson Process, Inter-arrival & waiting time distributions, Non-homogeneous Poisson Process, Conditional Poisson process.

- MARKOV CHAINS AND RANDOM WALKS **(08 Hours)**

  Definitions, Chapman-Kolmogorov Equations & classification of states, Applications of Markov chains, Time reversible Markov chains . Continuous time Markov chains, Birth & Death Processes, Kolmogorov differential equations, Randomization.Duality in random walks. Use of Martingales to analyze random walks.

- MARKOV PROCESSES AND RENEWAL THEORY **(05 Hours)**

  Brownian motion, Wiener process, differential equations for a wiener process, Kolmogorov equations Renewal process, renewal processes in continuous time, Renewal equation, stopping time.

Total Lecture Hours: 42

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3. Books Recommended

1. W. Mendenhall, R. J. Beaver and B. M. Beaver, Introduction to Probability & Statistics, 15th Edition, Cengage Learning, 2020.
2. D. C. Montgomery, Design and Analysis of Experiments, 8th Edition, John Wiley & Sons, 2012.
3. S. Ross, A First Course in Probability, 9th Edition, Pearson Education India, 2013.
4. D. C. Montgomery and G. C. Runger, Applied Statistics and Probability for Engineers , 6th Edition, Wiley, 2013
5. J. Medhi, Stochastic Processes, New Age International Private Limited, 2019.

MA 505: Mathematical Modelling & Simulation

L	T	P	Credit
3	1	2	05

1. Course Outcomes (COs)

At the end of the course the students will be able to :

CO1: explain the concept of mathematical modelling & simulation

CO2: formulate the real world problem into Mathematical form

CO3: analyze the mathematical model

CO4: apply simulation in analysis of the real world problems

CO5: develop a computer code for the simulation of a system

2. Syllabus

- INTRODUCTION TO MATHEMATICAL MODELLING (10 Hours)

  Introduction to mathematical modelling, Real world problems, Identification of parameters, Significant parameters, Importance of parameters, Reduction of an open problem to a closed form, Conversion of a real problem into a mathematical problem, Quest for a mathematical technique for solution, Importance of numerical techniques, Physical interpretation of solution, Types of mathematical models, Characteristics of mathematical models, Framework of mathematical models, Validation of mathematical model, Advantage and disadvantage of mathematical model.

- MATHEMATICAL MODELS (12 Hours)

  Models based on system of algebraic equations, ODE based simple modelling, Population dynamics modelling, Multi-compartmental modelling, Detection of diabetic model, Technological innovation model, Heat and mass transport Models, Heat conduction and diffusion Problems.

- INTRODUCTION TO SIMULATION (10 Hours)

  Introduction to simulation, Types of simulation, Simulation methodology, Random number generation, Monte-Carlo simulation, Simulation of continuous system, Discrete event simulation, Design of experiments, Validation.

- SOME CASE STUDIES (10 Hours)

  Simulation of queuing system, Simulation of inventory control, Simulation of forecasting, Simulation of maintenance problem, Simulation of network problems, Simulation of regression analysis, Simulation of linear programming problems.

Total Lecture Hours: 42

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3. Practicals

1. Radioactive decay and Newton's law of Colling Model with their simulation
2. Population dynamics model and their simulation
3. Single Compartment modelling and their simulation
4. Multi compartment modelling and their simulation

5. Technological innovation model and their simulation
6. Detection of Diabetic model and their simulation
7. Analytical solution of PDE with MATLAB and their simulation (Heat Equation)
8. Analytical solution of PDE with MATLAB and their simulation (Wave Equation)
9. Simulation for Forecasting and PERT Network
10. Operation research based Simple simulation problems

4. Books Recommended

1. J. N. Kapoor, Mathematical Modeling, New Age International(p) Limited, 2018.
2. B. Barnes and G. R. Fulford, Mathematical Modelling with Case Studies, Using Maple and MATLAB, 3^{rd} Edition, CRC press, 2015.
3. J. Caldwell, K. S. Ng Douglas and J. Caldwell, Mathematical Modeling: Case Studies and Projects (Texts in the Mathematical Sciences), Springer Netherlands, 2004.
4. N. Deo, System Simulation with Digital Computer, PHI New Delhi, 2006.
5. F. L. Severvance, System Modeling and Simulation: An Introduction, John Wiley, 2001.

HU 501: Academic Writing

L	T	P	Credit
3	0	0	03

1. Course Outcomes (COs)

At the end of the course the students will be able to :

CO1: show expertise in writing skills in English

CO2: demonstrate the skill of editing and producing error free documents

CO3: effectively translate their ideas into written articles

CO4: learn the process of advance writing skills required for research

CO5: explain their work through presentations

2. Syllabus

- REVISING GRAMMAR (04 Hours)

  Sentences, Tenses, Modals, Determiners, Conditionals.

- THE WRITING PROCESS (08 Hours)

  Understanding the Word order, Breaking up Long Sentences, Structuring Paragraphs and Sentences, Paragraph Writing, Summarising and Paraphrasing, Using Linking Words.

- EDITING YOUR WORK (07 Hours)

  Common Errors, Right Vocabulary, Avoiding Ambiguity, Removing Redundancy, and Avoiding Plagiarism.

- WRITING FOR RESEARCH (05 Hours)

  Note Making, Drafting the abstract, Writing literature review, Parts of a scientific paper, Writing longer essays, Types of essays.

- PRESENTING YOUR RESEARCH (04 Hours)

  Types of Presentation, Steps of Making a Good Presentation, Use of Visual Aids in Presentation.

Total Lecture Hours: 28

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3. Books Recommended

1. G. Yule, Oxford Practice Grammar, Oxford University Press, 2008.
2. C. K. Cook, Line by Line How to Edit Your Own Writing, The Modern Language Association of America, 1985.
3. A. Wallwork, English for Writing Research Papers, Springer, 2011.
4. R. Murray and S. Moore, The Handbook of Academic Writing: A Fresh Approach, Open University Press, 2006.
5. S. Bailey, Academic Writing: A Practical Guide for International Students, 4^{th} Edition, Routledge, 2014.

MA 521: Advanced Operations Research

L	T	P	Credit
3	1	0	04

1. Course Outcomes (COs)

At the end of the course the students will be able to :

CO1: explain the importance of operations research in real life problems.

CO2: apply basic concepts of Mathematics to formulate and solve OR problems.

CO3: incorporate chance factor and calculate project completion time in PERT & CPM.

CO4: interpret multi-stage decision process through dynamic programming

CO5: solve NLPP using different methods.

2. Syllabus

- INTRODUCTION **(04 Hours)**

  Nature and scope of Operations Research, Convex sets and convex functions and their properties.

- INVENTORY MODELS **(07 Hours)**

  Inventory control -Deterministic including price breaks and Multi-item with constraints, Probabilistic (with and without lead time).

- QUEUING THEORY **(07 Hours)**

  Basic Structures of queuing models, Poisson queues –M/M/1, M/M/C for finite and infinite queue length, Non-Poisson queue -M/G/1, Machine Maintenance (steady state).

- PERT AND CPM **(07 Hours)**

  Introduction, Basic difference between PERT and CPM, Steps of PERT/CPM Techniques, PERT/CPM Network components and precedence relationships, Critical path analysis, Probability in PERT analysis, Project Time-Cost, Trade-off, Updating of the project, Resource allocation-resource smoothing and resource leveling.

- DYNAMIC PROGRAMMING **(06 Hours)**

  Introduction, Nature of dynamic programming, Deterministic processes, Non-Sequential discrete optimization, Allocation problems, Assortment problems, Sequential discrete optimization, Long-term planning problem, Multi-stage decision process, Application of Dynamic Programming in production scheduling and routing problems.

- NONLINEAR PROGRAMMING **(06 Hours)**

  Quadratic Programming, Duality theory, Search techniques - one variable (Fibonacci, Golden Section method) and several variables (Conjugate Gradient, Newton's method).

- GEOMETRIC PROGRAMMING **(05 Hours)**

  Introduction, Posynomial, Arithmatic-Geometric inequality, Geometric programming (both unconstrained and constrained).

Total Lecture Hours: 42

3. Books Recommended

1. F. S. Hiller and G. J. Lieberman, Introduction to Operations Research, 8th Edition, Tata McGraw-Hill, New Delhi, 2009.
2. K. Swarup, P. K. Gupta and M. Mohan, Operations Research, 19th Edition, S. Chand & Sons, New Delhi, 2017.
3. H. A. Taha, Operations Research: An Introduction, 9th Edition, Pearson, New Delhi, 2014.
4. J. K. Sharma, Operations Research: Theory and Applications, 6th Edition, Trinity Press, New Delhi, 2017.
5. M. S. Bazarra, H. D. Sherali and C. M. Shetty, Nonlinear Programming: Theory and Algorithms, 3rd Edition, John Wiley & Sons, New Jersy, 2016.

MA 523: Fluid Dynamics in Porous Media

L	T	P	Credit
3	1	0	04

1. Course Outcomes (COs)

At the end of the course the students will be able to :

CO1: explain the fundamental properties of porous media

CO2: elaborate filtration theory

CO3: elaborate the permeabilty and hydraulic conductivity

CO4: implement appropriate method in ground water problem.

CO5: use continuity equation for groudwater flow.

2. Syllabus

- **FUNDAMENTAL PROPERTIES OF POROUS MEDIA (11 Hours)**

  Porosity: general aspects and definition, Determination of porosity, Compressibility of porous media, Classification of porosity, Capillary properties, Saturation, Wettability, Classification of reservoir rocks based on wettability, Measurement of wettability, Contact angle measurement, Amott method, Capillary pressure, Definition, Measurement of capillary pressure in a porous medium, Method of centrifuge, Mercury injection (Purcell method), The Leverett function, Pore size distribution, Vertical equilibrium, Permeability, Darcy's law , Definition and units of permeability , Measurements of permeability, Klinkenberg effect , Analogies between the laws of Darcy, Ohm and Fourier, Filtration velocity , Quadratic equation of filtration, Relative permeabilities, Definition of relative permeability, Definitions of end-point saturations, Relative permeability measurements, The HASSLER method, PENN-STATE-method, Welge-method, Saturation distribution and relative permeability

- **INTRODUCTION TO GROUND WATER (06 Hours)**

  Introduction, Types of springs, Infiltration gallery, Karsez, distribution of water on earth, Groundwater resources of India, Geological formations, Properties of aquifers: void ratio, Specific retention, Specific yield, Methods of determining specific yield, Pumping method, The porosity, Specific yield and specific retention of different formations

- **PERMEABILITY AND HYDRAULIC CONDUCTIVITY IN SOIL FORMATION (09 Hours)**

  Permeability and hydraulic conductivity , Hydraulic conductivity or permeability coefficient, The effect of porosity, Pore space geometry, Submergence, Tortuosity of soil pores, Entrapped air, Measurement of hydraulic conductivity, Constant head method, Variable head method, Field methods, Below the water table field methods, Above the water field method, Intrinsic permeability, Apparent specific yield, Coefficient of storage, Specific storage, Hydraulic resistance, Leakage factor, Distribution of subsurface water, Zone of aeration, Soil water zone, Intermediate zone, Capillary fringe, Important features of the capillary fringe zone, Zone of saturation, Soil moisture, Groundwater flow potential, Measurement of groundwater, Conjunctive use of groundwater.

- **CONTINUITY EQUATIONS FOR GROUNDWATER FLOW (16 Hours)**

Introduction, Three dimensional continuity equation for groundwater flow, Continuity equation for homogeneous and isotropic formation(Medium), Confined and unconfined aquifer, General continuity equation in Cartesian coordinates, General continuity equation in polar coordinates, Continuity equation for confined aquifer with leakage from top and bottom, Dupuit-Forchheimer theory for unconfined aquifer with recharge. Flow through an unconfined aquifer.

Total Lecture Hours: 42

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3. Books Recommended

1. J. Bear, Dynamics of Fluids in Porous Media, Dover Pulication, New York, 1988.
2. V. C. Agarwal, Groundwater Hydrology. PHI Learning Private Limited, New Delhi, 2012.
3. F. Charlton, Textbook of Fluid Dynamics, CBS Publishers, 1985.
4. J. Bear, Hydraulics of Groundwater, Dover Publications, 2007.
5. G. K. Bachelor, An Introduction to Fluid dynamics, Cambridge University Press, 2000.

MA 525: Advanced Numerical Analysis

L	T	P	Credit
3	1	0	04

1. Course Outcomes (COs)

At the end of the course the students will be able to :

CO1: solve the initial value problems using multistep methods.

CO2: develop a finite difference scheme for ODEs and PDEs

CO3: analyze the stability and convergence of difference schemes

CO4: determine the solution for ODEs and PDEs using finite difference methods

CO5: assess suitability and effectiveness of finite difference schemes

2. Syllabus

- REVIEW ON THE SYSTEM OF LINEAR EQUATIONS (04 Hours)

  Condition number and ill conditioned systems. Matrix and vector norms. Error bounds, tridiagonal and pentagonal system of equations.

- INITIAL VALUE PROBLEMS IN ODES (08 Hours)

  Review single step methods, explicit multistep methods, implicit multistep methods, Predictor and corrector methods, Stability and convergence analysis.

- FINITE DIFFERENCE METHODS FOR BVPS IN ODES (08 Hours)

  Review on numerical approximation to derivatives, Approximation of boundary conditions of different kind, Solution of linear and non-linear boundary value problems, Convergence of difference schemes.

- FINITE DIFFERENCE METHODS FOR HYPERBOLIC PDES (08 Hours)

  Difference schemes in one space dimension with constant coefficient,Convergence and consistency, Stability, The Lax-Richtmyer theorem, The CFL condition, Analysis of difference schemes: Fourier and Von Neumann analysis, Stability condition, Order of accuracy of difference schemes.

- FINITE DIFFERENCE METHODS FOR PARABOLIC PDES (07 Hours)

  Explicit and implicit Difference schemes in one, two and three space dimensions. Two level and multilevel schemes, Solution of convection-diffusion equation. Consistency, stability and convergence of difference scheme.

- FINITE DIFFERENCE METHODS FOR ELLIPTIC PDES (07 Hours)

  Approximation to ∇^2 and ∇^4. Five point and nine point approximation for Laplace and Poisson equations, Dirichlet problem, ADI method, Neumann Problem, Mixed boundary value problems.

Total Lecture Hours: 42

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3. Books Recommended

1. G. D. Smith, Numerical Solutions of Partial Differential Equations, 3^{rd} Edition, Clarendon Press, Oxford, 1985.

2. M. K. Jain, Numerical Solution of Differential Equations, New Age Publication, New Delhi, 2008.
3. R. Mitchell and S. D. F. Griffiths, The Finite Difference Methods in Partial Differential Equations, Wiley and Sons, NY, 1980.
4. J. C. Strikwerda, Finite Difference Schemes for Partial Differential Equations, 2nd Edition, SIAM, 2004.
5. R. J. LeVeque, Finite Difference Methods for Ordinary and Partial Differential Equations: Steady State and Time Dependent Problems, SIAM, 2007

MA 527: Linear Operators and Approximation Theory

L	T	P	Credit
3	1	0	04

1. Course Outcomes (COs)

At the end of the course the students will be able to :

CO1: demonstrate the basics of approximation theory and basic problems

CO2: evaluate the order of approximation of functions by means of polynomials and polynomial operators

CO3: apply notions and theorems concerning trigonometric and polynomial approximation

CO4: demonstrate the concepts of linear continuous operators.

CO5: construct the Fourier series approximation of periodic function.

2. Syllabus

- **LINEAR FUNCTIONALS AND OPERATORS** **(10 Hours)**

  Linear positive functional, Linear positive operators, Approximation of functions by algebraic polynomials, Approximation of functions by trigonometric polynomials, Conditions for convergence of a sequence of linear positive operators.

- **ORDER OF APPROXIMATION OF FUNCTIONS BY POLYNOMIALS** **(10 Hours)**

  Polynomials which deviate the least from functions, Modulus of continuity, General methods of summation of Fourier series, Order of approximation of functions by means of trigonometric polynomials, Order of approximation of functions by means of algebraic polynomials. Order of growth of derivatives of polynomials and trigonometric polynomials.

- **ORDER OF APPROXIMATION OF FUNCTIONS BY MEANS OF LINEAR POSITIVE POLYNOMIAL OPERATORS** **(10 Hours)**

  Order of approximation of functions by means of linear positive functional, Order of approximation of functions by means of Fejer operators, Order of approximation of functions by means of Bernstein polynomials, Order of approximation of functions by means of linear positive polynomial operators.

- **LINEAR CONTINUOUS POLYNOMIAL OPERATORS** **(05 Hours)**

  Linear continuous operators, Auxiliary relations, Non-uniformly convergent sequence of linear continuous polynomial operators, Valle e-Poussin operators.

- **FOURIER SERIES** **(07 Hours)**

  The Fourier series, Uniform convergence of Fourier series, Mean convergence of Fourier series, Local convergence, Estimate of the deviation of partial sums of a Fourier series, Example of a continuous function not expandable in a Fourier series, Convergence of sequence of linear positive polynomial operators, General methods of summation of Fourier series

Total Lecture Hours: 42

3. Books Recommended

1. E. W. Cheney, Introduction to Approximation Theory, 2^{nd} Revised Edition, AMS Chelsea Publishing Co., 1999.
2. P. P. Korovkin, Linear Operators and Approximation Theory, Hindustan Publishing Corporation (India), 2017.
3. H. M. Mhaskar, and D. V. Pai, Fundamentals of Approximation Theory, Narosa Publishing House, 2000.
4. I. P. Natanson, Constructive Function Theory Volume-I, Fredrick Ungar Publishing Co., 1964
5. A. F. Timan, Theory of Approximation of Functions of a Real Variable, Dover Publication Inc., 1994.

Revised Syllabus for M.Sc. IInd to M.Sc. Vth year
Applied Physic Department

M.Sc. Year I (Semester-I)

Sr. No.	Course Code	Course	Teaching Scheme (Hours)			Credits	Examination Scheme			Total Marks
			L	T	P		Theory	Tutorial	Practical	
1	MA 101 S1	Mathematics – I	3	1	0	4	100	25	00	125
2	PH 102 S1/S2	Mechanics, Lasers and Fiber Optics	3	0	2	4	100	0	50	150
3	CY 104 S1/S2	Chemistry-I	3	0	2	4	100	00	50	150
4	CEME 105 S1	Engineering Drawing	2	0	4	4	00	00	100	100
5	CEME 105 S1/S2	Energy & Environmental Engineering	3	0	2	4	100	00	50	150
6	PHPH 101 S1	Branch Specific Course I	3	1	2	5	100	25	50	175
7	HU 107 S1/S2	Holistic Empowerment and Human Values	3	0	0	3	100	0	0	100
		Total	**20**	**2**	**12**	**28**	**600**	**50**	**300**	**950**
									Total Lecture Hours	**34**
									Total Credits	**28**

21/07/2020

M.Sc. Year I (Semester-II)										
Sr. No.	**Course Code**	**Course**	**Teaching Scheme**			**Credits**	**Examination Scheme**			**Total Marks**
			L	**T**	**P**		**Theory**	**Tutorial**	**Practical**	
1	MA 114 S2	Mathematics – II	3	1	0	4	100	25	0	125
2	PH 113 S2/S1	Physics of Materials and Nuclei	4	0	0	4	100	0	0	100
3	AM 108 S2/S1	Engineering Mechanics	3	0	2	4	100	0	50	150
4	CS 109 S2/S1	Fundamentals of Computers and Programming	3	0	2	4	100	0	50	150
5	HU 110 S2/S1	English & Professional Communication	3	0	0	3	100	0	0	100
6	PHPH 102 S2	Branch Specific Course II	3	1	2	5	100	25	50	175
7	ME 111 S2/S1	Workshop Practice	0	0	4	2	0	0	50	50
		Total	**19**	**2**	**10**	**26**	**600**	**50**	**200**	**850**
									Total Lecture Hours	**31**
									Total Credits	**26**

21/10/2020

First year of Five Years Integrated M.Sc. (Physics)
M.Sc. – I, Semester – I

Mechanics, Lasers and Fiber Optics

L	T	P	Credit
03	00	02	04

PH 102 S1

1. Course Outcomes (COs):

At the end of the semester students will be able to:

CO1	Infer the concept of D'Alembert, Lagrangian and Hamiltonian classical mechanics
CO2	Explain the origin of quantum mechanics to Schrodinger' equation for particles in box
CO3	Classify the Maxwell's electromagnetic equations and classify the polarized light
CO4	Interpret the concept of Lasers and understand the working of various types of lasers
CO5	Relate the concept of fiber optics and knowing the application of it

2. Syllabus

- **CLASSICAL MECHANICS** **(10 Hours)**
  Constraints,GeneralizedCoordinates,Velocitiesandmomenta,D'Alembert'sPrinciple,Lagrange'sequationofmotion,Planetorbits,Virialtheorem,Calculusofvariations,Variational technique form any independent variables, Hamilton principle, Hamilton's canonical equation of motion, Physical significance of H Advantage of Hamilton approach.

- **QUANTUM MECHANICS** **(10 Hours)**
  Inadequacy of classical mechanics (black body radiation, photoelectric effect), Wave and particle duality of radiation, de Broglie concept of matter waves, Electron diffraction, Heisenberg's uncertainty principle, Schrodinger's wave equation, Eigen values and Eigen functions, Superposition principle ,Interpretation of wave function, Particle confined in one dimensional infinite potential box.

- **ELECTRODYNAMICS** **(06 Hours)**
  Electromagnetic waves, Maxwell's equations in vacuum &medium, Types of polarization, Internal field and Claussius-Mosotti equation

- **LASERS** **(08 Hours)**
  Introduction to Laser, Characteristics of Lasers, Spontaneous and stimulated emissions, Einstein's coefficients, Population inversion and lasing action, Laser systems: Ruby laser, HeNeLaser, Semiconductor Laser, Advanced lasers, Holography.

- **FIBER OPTICS** **(08 Hours)**
  Fermat's principle and Snell's law-optical fiber, Principle and construction, Acceptance one, Numerical aperture, V Number, Types of fibers, Fabrication: Double Crucible Technique, Vapor phase Oxidation Process, Fiber optic communication principle, Fiber optic sensors, Other applications of optical fibers.

(Total Lecture Hours: 42 Hours)

3. BOOKS RECOMMENDED:

1. R.ResnickandD.Halliday Physics(PartI&II)Wiley, 2007
2. A.BeiserConceptoftheModernPhysicsMcGraw-Hill, 2008
3. Landauand Lipschitz MechanicsButterworth-Heinemann,1982
4. D.J.GriffithsIntroductiontoElectrodynamicsAddison-Wesley,2012
5. W.T. Silfvast,LaserFundamentals,Cambridge, 2004

21/07/2020

First year of Five Years Integrated M.Sc.(Physics)
M.Sc. – I, Semester – I

Introduction to Classical Mechanics

L	T	P	Credit
03	01	02	05

PHPH 101 S1

1.Course Outcomes (COs):

At the end of the semester students will be able to:

CO1	Infer the fundamentals of vectors and co-ordinate system
CO2	Define basic concept of various laws of motions and moment of inertia
CO3	Explain Euler's concept on rigid body motion
CO4	Interpret elastic properties of materials and Rephrase the concept of hydrodynamics
CO5	Analyze application of simple harmonic motions
CO6	Classify the different oscillations and summarize it in resonance

2.Syllabus

- **VECTORS FUNDAMENTALS AND DIFFERENT CO-ORDINATE SYSTEM(08 Hours)**
  Unit vectors, Vector operations, Tripple products, Vector algebra in component form, differential calculus, Cartesian coordinate system, Spherical coordinate system, Cylindrical coordinate system.

- **NEWTON'S LAWS OF MOTION,CONSERVATION LAWS,MOMENTS OF INERTIA (08 Hours)**
  Mechanics of the particle, Equation of motion, Different conservation laws, Moments of inertia, Motion in central force field.

- **RIGID BODY MOTION** **(06 Hours)**
  Euler's theorem, Angular momentum and kinetic energy, Euler's equation of motion, Euler's angles.

- **ELASTICITY &HYDRODYNAMICS** **(08 Hours)**
  Stress and Strain, Young's modulus, Shear modulus and Bulk Modulus, Buoyancy, Types of fluid flow, Bernoulli's equations, Viscocity, Terminal Velocity.

- **SIMPLE HARMONIC MOTION** **(04 Hours)**
  Restoring force, Elastic potential energy, Period and frequency, Energy, Pendulums, Applications of SHM.

- **OSCILLATIONS** **(08 Hours)**
  Damped oscillations, forced oscillations, coupled oscillations & resonance.

(Total Lecture Hours: 42 Hours)

3. BOOKS RECOMMENDED:

1. D. S.Mathur,Mechanics,S.Chand& Company, 2000.
2. R.G.Takwale&P.S.Puranik, Introductionto ClassicalMechanics,Tata McGraw-Hill Book Co, 1997.
3. R.P.Feymann,R.B. LightonandM.Sands,TheFeynmanLecturesinPhysicsVol.1,NarosaPublishers, 2008.
4. H. C.Verma,Concepts ofPhysics,Vol. 1 &2, BharatiBhavan, 2007.
5. L. D. Landau& E. M. Lifshitz,CourseonTheoreticalPhysics,Vol.1: Mechanics,Addison-Wesley,2002

21/07/2020

First year of Five Years Integrated M.Sc.(Physics)
M.Sc. – I, Semester – II

Physics of Materials and Nuclei

L	T	P	Credit
04	00	00	04

PH 113 S2/S1

1.Course Outcomes (COs):

At the end of the semester students will be able to:

CO1	Define the concept of basic crystallography
CO2	Interpret the importance of the semiconductors and find the parameters of it by Hall effects experiments
CO3	Explain the properties, synthesis types and application of nanomaterial
CO4	Give brief outline of magnetic materials and classify between conductor and superconductors
CO5	Understand the fundamental of statistical mechanics
CO6	Rephrase the nuclear properties and classify the elementary particles

2. Syllabus

- **CRYSTALLOGRAPHY (10 Hours)**
  Crystalline and amorphous solids, Lattice and unit cell, Seven crystal system and Bravais lattices, Symmetry operation, Miller indices, Atomic radius, Coordination number, Packing factor calculation for SC, BCC, FCC, Bragg's law of X-ray diffraction, Laue Method, Powder crystal method.

- **SEMICONDUCTOR PHYSICS (06 Hours)**
  Introduction, Direct and indirect bandgap semiconductors, Intrinsic and extrinsic semiconductors, Law of Massaction, Charge neutrality, Hall Effect.

- **NANOMATERIALS (10 Hours)**
  Introduction and properties, Synthesis: Chemical vapor deposition, Ball milling and relevant applications, Carbon nanotubes: structure and properties and Synthesis: Arc method and Pulsed laser deposition, Applications.

- **MAGNETIC MATERIALS,CONDUCTORS AND SUPERCONDUCTORS (10 Hours)**
  Magnetic materials: Definition of terms, Classification of magnetic materials and properties, Domain theory of ferromagnetism, Hard and soft magnetic materials, Conductors: Classical free electron theory (Lorentz–Drude theory), Electrical conductivity, Super conductors: Definition, Meissner effect, Type I &II superconductors.

- **STATISTICAL MECHANICS (10 Hours)**
  Macroscopic and microscopic states, Phase space, Condition for statistical equilibrium, Micro-canonical ensemble, canonical ensemble, Grand-canonical ensemble, Partition function, Bose-Einstein and Fermi-Dirac distribution.

- **NUCLEAR AND PARTICLE PHYSICS (10 Hours)**
  Nuclear properties and forces, Nuclear models, Shell model, Nuclear reaction, Radioactivity, Types and half-lives, Application in determining the age of rock and fossils, Stellar nucleo synthesis, Fundamental forces, Particle physics, Classification of matter, Quark model, Neutrino properties and their detection.

(Total Lecture Hours: 56 Hours)

21/10/2020

3. BOOKS RECOMMENDED:

1. R. Resnick and D. Halliday,Physics (Part I &II),Wiley,2007.
2. A. Beiser,Concept of the Modern Physics, McGraw-Hill, 2008.
3. K. Huang,Statistical mechanics,Willey,2008.
4. M. N. Avadhanulu and P. G. Kshirsagar, A text book of Engineering Physics, S Chand, 2009.
5. C. Kittel, Introduction to Solid State Physics, Wiley, 2016.

Additional Books:

1. K. K. Chattopadhyay and A. N. Banerjee,Nanoscience andNanotechnology,PHI, 2014.

21/07/2020

First year of Five Years Integrated M.Sc.(Physics)
M.Sc. – I, Semester – II

PHPH 102 S2:Kinetic Theory and Thermodynamics

L	T	P	C
03	01	02	05

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1. Course Outcomes (COs):

At the end of the semester students will be able to:

CO1	Interpret the fundamental concept of kinetic theory of gases
CO2	Compare properties of ideal gas and real Van der wall's gas state
CO3	Explain fundamental of thermodynamics laws and thermodynamic processes
CO4	Extend knowledge about Maxwell's thermodynamics relations and thermodynamic potentials
CO5	Classify the classical and quantum statistics distributions
CO6	Explain black body radiation in thermodynamics point of view

2. Syllabus

- **KINETICTHEORYOFGASES(04 Hours)**
  Postulates of kinetic theory of gases, velocity of gas molecules, Molecular energy, Kinetic-molecular model of an ideal-gas, kinetic interpretation of temperature, Degree of freedom of gas molecules, Maxwell's law of equi partition of energy.

- **INTERMOLECULAR FORCES&TRANSPORTPHENOMENA (04 Hours)**
  Viscosity of a gas, Thermal conductivity of gases, Vanderwall's equation of state, Brownian motion.

- **LAWSOFTHERMODYNAMICS(12 Hours)**
  Zeroth law of Thermodynamics, Iand IIlaws of Thermodynamics, Concepts of temperature, Internal energy and entropy, Calculations of change of internal energy and entropy in various thermodynamic processes.

- **THERMODYNAMICPOTENTIALS,HELMOLTZ&GIBBSFUNCTIONS,MAXWELLRELATIONS (10 Hours)**
  Gibbs and Helmholtz energy, Gibbs paradox, Enthalpy, Maxwell's thermodynamic relations.

- **ELEMENTS OFSTATISTICALPHYSICS (08 Hours)**
  Fermi Dirac, Maxwell Boltzmann and Bose Einstein distributions.

- **THERMODYNAMICS OFBLACKBODIES(04 Hours)**
  Black body and characteristics, Radiation principles like Rayleigh Jeans, Weinsand Planck's law of black body radiation.

(Total Lecture Hours: 42 Hours)

3.BOOKS RECOMMENDED:

1. F.W. Sears&Salingar,Thermodynamics,Kinetictheoryand StaticalThermodynamics, 3rdEdition. Addison-Wesley/Pearson, 1975
2. Young&Freedman, Searsand Zemansky'sUniversityPhysics, PearsonEducation, Singapore, 2004
3. R. P.Feymann. R.B.Leightonand M. Sands,The FeymannLecturesinPhysics,Vol.1Narosa Publishers, 2008
4. ZemanaskyM. W., HeatandThermodynamics,(McGrawHill),1957
5. CarterA.,ClassicalandStatisticalThermodynamics,PearsonEducation, 1999.

21/07/2020

M.Sc. Year II (Semester-III)										
Sr. No.	**Course Code**	**Course**	**Teaching Scheme (Hours)**			**Credits**	**Examination Scheme**			**Total Marks**
			L	**T**	**P**		**Theory**	**Tutorial**	**Practical**	
1	PH 201	Basic Electronics	3	1	0	4	100	25	00	125
2	PH 203	Classical Mechanics	3	1	0	4	100	25	00	125
3	MA211	(Interdisciplinary I): Mathematics-III	3	1	0	4	100	25	00	125
4	CY 209	(Interdisciplinary – II): Solid State Chemistry and Spectroscopy	3	1	0	4	100	25	00	125
5	HU 201	English & Professional Communication - II	3	0	0	3	100	00	00	100
6	PH 205	Experimental Techniques I	0	0	6	3	00	00	150	150
		Total	**14**	**5**	**6**	**22**	**500**	**100**	**150**	**750**
									Total Lecture Hours	**25**
									Total Credits	**22**

M.Sc. Year II (Semester-IV)										
Sr. No.	**Course Code**	**Course**	**Teaching Scheme (Hours)**			**Credits**	**Examination Scheme**			**Total Marks**
			L	**T**	**P**		**Theory**	**Tutorial**	**Practical**	
1	PH 202	Electromagnetics-I	3	1	0	4	100	25	00	125
2	PH 204	Quantum Mechanics-I	3	1	0	4	100	25	00	125
3	PH 206	Solid State Physics	3	1	0	4	100	25	00	125
4	MA 212/ CY 214	Interdisciplinary Elective – I*	3	1	2	5	100	25	50	175
5	CY 202	Introduction to Life Sciences	3	0	0	3	100	00	00	100
6	PH 208	Experimental Techniques II	0	0	6	3	00	00	150	150
		Total	**15**	**4**	**8**	**23**	**500**	**100**	**200**	**800**
									Total Lecture Hours	**27**
									Total Credits	**23**

***Interdisciplinary Elective – I**

- **MA 212: Computational Methods**
- **CY 214: ORGANIC CHEMISTRY – I**

21/08/2020

M.Sc. – II, Semester – III

Basic Electronics

L	T	P	Credit
03	01	00	04

PH 201

1. Course Outcomes (COs):

At the end of the semester students will be able to:

CO1	Understand the basis concept of circuit analysis theorem
CO2	Demonstrate familiarity with basic electronic components and use them to design simple electronic circuits
CO3	Describe the application of transistors for Current and voltage amplification. Also to describe the characteristics of different configurations of the transistor
CO4	Discuss the ideal of operational amplifier and their electrical parameters
CO5	Analyze and Design the different types of Oscillators, and their applications

2. Syllabus

- **BASIC CIRCUIT ANALYSIS** **(04Hours)**
  Kirchoff's current and voltage law, Network analysis, Superposition theorems.
- **SEMICONDUCTOR JUNCTION DIODES & APPLICATIONS** **(08 Hours)**
  The open circuit p-n junction, Energy bands in junction diode, I-V characteristics of p-n junction, diode as rectifier, Half-wave, full-wave, and bridge rectifier. Various applications of diode.
- **SEMICONDUCTOR TRANSISTOR & APPLICATIONS** **(08 Hours)** Junction transistor, transistor construction, CB, CE and CC configurations, cut-off and saturation regions, transistor load-line, Quiescent point, Transistor as an amplifier, Current gain and voltage gain.
- **FREQUENCY RESPONSE OF AMPLIFIERS** **(06 Hours)**
  The gain-bandwidth product, frequency response of CB, CE and CC amplifier, Classification of amplifiers, Feed-back in amplifiers and its classification, Study of different properties with feed-back Amplifier applications.
- **OPERATIONAL AMPLIFIERS** **(08 Hours)**
  The differential amplifier, The basic operational amplifier, The emitter-coupled differential amplifier, Transfer characteristics of a differential amplifier, Offset error voltage and currents, Parameters, Frequency response.
- **OSCILLATORS** **(08 Hours)**
  Criteria for oscillation, tank circuit, L-C oscillator, Hertley Oscillator, Colpitt oscillator, The phase shift oscillator, the Wien bridge oscillator, Crystal oscillator.

(Total Lecture Hours: 42Hours)

3. BOOKS RECOMMENDED:

1. J. D.Ryder, Electronics fundamentals and applications: Integrated and Discrete Systems, Prentice – Hall Of India, 1999
2. S. M. Sze, Physics of Semiconductor Devices, John Wiley & sons, 1981
3. T. L. Floyd, Electronic Devices (5th ed). Pearson education Asia (2001)
4. A.P. Malvino, Electronic Principles, Tata McGraw Hill, 1999
5. A.Mottershed, Electronic Devices and circuits, Prentice Hall India, 1989

21/07/2020

M.Sc. – II, Semester – III

Classical Mechanics

L	T	P	Credit
03	01	00	04

PH 203

1. Course Outcomes (COs):

At the end of the semester students will be able to:

CO1	Infer the principles of Lagrangianmechanics and the concepts of generalized quantities to derive the Euler-Lagrange equation
CO2	Identify the relevance of variational principle in classical mechanics and extend the concept to explain the Hamiltonian dynamics
CO3	Interpret the central forces and apply to understand the two-body problem
CO4	Understand the Canonical transformations by applying the generating functions and Poisson brackets
CO5	Analyze the rigid body dynamics

2. Syllabus

1. **LAGRANGIAN MECHANICS** **(08 Hours)**
   Principle of Virtual Work, d'Alembert's Principle, Degrees of Freedom, Constraints (scleronomic and rheonomic constraints), Generalized Coordinates and Velocity, Generalized Force, Kinetic Energy, Generalized Equation of Motion, Conservative Forces, Euler-Lagrange Equation.

2. **VARIATIONAL PRINCIPLE AND CLASSICAL MECHANICS** **(05 Hours)**
   Principle of Least Action, Euler's Equation, Hamilton's Principle, Method of Lagrange Multiplier, Euler equation with more than one independent variable, Non-holonomic constraints.

3. **CENTRAL FORCES AND TWO-BODY PROBLEM** **(08 Hours)**
   Central Force, Motion of Centre of Mass, Kepler's Planetary Motion, Equation of Orbit, Gravitational Force between two body, Elliptical Orbits, Rutherford's Scattering, Hyperbolic Orbits.

4. **HAMILTONIAN DYNAMICS** **(08 Hours)**
   Conservation Theorems, Generalized Momentum, Phase Space, Legendre Transformation, Hamilton's Equation of Motion, Definition of Hamiltonian, Accelerated Systems.

5. **CANONICAL TRANSFORMATIONS** **(05 Hours)**
   Point Transformations, Generating Functions, Poisson Brackets, Liouville's Theorem.

6. **RIGID BODY MOTION** **(08 Hours)**
   Damped oscillations, forced oscillations, coupled oscillations& resonance. Rotating Coordinate Systems and Reference Frames, Non-inertial system, Kinetic Energy of a Rigid Body, Inertia Tensor, Parallel and Perpendicular Axis Theorem, Angular Momentum of Rigid Body, Euler Equation for Rigid Body, Euler's Angle.

(Total Lecture Hours: 42 Hours)

21/08/2020

3.BOOKS RECOMMENDED:

1. P. Charles,Jr. Poole,L. John,Safko; Classical Mechanics, Pearson Publication; 3rd Edition. Herbert Goldstein 2013
2. N. Louis Hand and D. Janet Finch, Analytical Mechanics, Cambridge University Press 2008
3. Stephen T. Thornton and Jerry B. Marion, Classical Dynamics of Particle and Systems, Cengage Publications 2012
4. L. D. Landau, &E. M. Lifshitz, Course of theoretical physics. vol. 1: Mechanics. Oxford, 1960
5. David Morin, Introduction to Classical Mechanics with Problems and Solutions, Cambridge University Press, September 2009

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21/07/2020

M.Sc. – II, Semester – III

Mathematics-III

L	T	P	Credit
03	01	00	04

MA 211

1. Course Outcomes (COs):

At the end of the semester students will be able to:

CO1	Understand the concept of convergence and divergence of infinite series
CO2	Grasp the knowledge of metric space
CO3	Expand the periodic functions in the form of Fourier series along with different cases and Fourier Integral
CO4	Understand the concept of Integral transform with their applications
CO5	Deal with complex variables and its properties with their application

2. Syllabus

1. **INFINITE SERIES** **(07 Hours)**
Introduction, Positive term series, Comparison test, Cauchy's root test, D'Alembert's test, Raabe's test, Logarithmic test, Integral test, Gauss's test, Series with arbitrary terms, Rearrangement of terms.

2. **METRIC SPACE** **(07 Hours)**
Definition of metric space, example of metric space, open and closed balls, open and closed sets, theorems of open sets, limit points, sequences in a metric space, Cauchy sequences.

3. **LAPLACE TRANSFORMS** **(06 Hours)**
Introduction, Definition, Existence conditions, basic properties, Inverse Laplace transform and properties, Convolution Theorem and properties, Applications of Laplace transforms.

4. **FOURIER SERIES** **(07 Hours)**
Definition, Fourier series with arbitrary period, in particular periodic function with period 2π. Fourier series of even and odd function, Half range Fourier series.

5. **FOURIER INTEGRAL & FOURIER TRANSFORMS** **(07 Hours)**
Fourier Integral theorem, Fourier sine and cosine integral complex form of integral, Inversion formula for Fourier transforms, Fourier transforms of the derivative of a function.

6. **COMPLEX VARIABLES** **(08 Hours)**
Basic mathematical concept, Analytic function, C – R equations, Harmonic functions, its applications, Linear transformation of complex domain, some special transformation, bilinear transformations, conformal mapping and its application, complex integration including contour integration.

7. **Tutorials will be based on the coverage of the above topics separately (14 Hours)**

(Total Lecture Hours: 56Hours)

21/03/2020

3. BOOKS RECOMMENDED:

1. E. Kreyszing Advanced Engineering Mathematics, John Wiley, Int. Student Ed. 1995.
2. C. R.Wiley, Advanced Engineering Mathematics, McGraw Hill, Int. Student Ed. 1993
3. O'Neel Peter. Advanced Engg. Mathematics, Thompson, Singapore, Ind. Ed. 2002.
4. D. V. Ramana, Higher Engg. Mathematics, The McGraw-Hill Inc., New Delhi, 2007.
5. S. C.Malik, S.Arora, Mathematical Analysis, New age International publishers, Delhi, 2006.

21/07/2020

M.Sc. – II, Semester – II

Solid State Chemistry and Spectroscopy

L	T	P	C
03	01	00	04

CY 209

1. Course Outcomes (COs):

At the end of the semester students will be able to:

CO1	Acquire fundamental knowledge structure and bonding.
CO2	Learn basics of ionic structures and their bonding.
CO3	Acquire the knowledge of crystals and their diffraction techniques.
CO4	Discuss Electronic Transitions and apply Woodword Rule.
CO5	Calculate Vibrational Energy and study Selection Rules of Transitions in IR and Raman spectroscopy.

2. Syllabus

1. **STRUCTURE AND BONDING** **(08 Hours)**
   Spectral series, Quantum numbers, Aufbau and Pauli exclusion principles, Hund's multiplicity rule. Effective nuclear charge. Valence bond theory, Valence shell electron pair repulsion (VSEPR) theory and MO theory, multi centeric bonding in electron deficient molecules, bond strength and bond energy, percentage ionic character from dipole moment and electro negativity difference.

2. **IONIC SOLIDS** **(08 Hours)**
   Ionic structures (Zinc Blende and Wurtzite, Fluorite, anti-fluorite, spinel and inverse spinel), radius ratio calculation, limitation of radius ratio rule, lattice defects, solvation energy and solubility of ionic solids, polarizing power and polarisability of ions, Fajan's rule. Metallic bond, free electron, valence bond and band theories. Conductors, Semiconductors and Insulators. Superconductivity: Low Temperature superconductivity, High Temperature Super conductivity.

3. **THE CRYSTAL STRUCTURE** **(08 Hours)** Symmetry of crystals, Cubic crystal system, Density & Packing Fraction; Miller Indices, The diffraction phenomenon: Bragg equation, X-ray diffraction Methods: Single crystal and Powder Method, Indexing of powder diffraction patterns.

4. **ELECTRONIC (UV-VIS) SPECTROSCOPY** **(08 Hours)**
   Franck-Condon Principle, Beer-Lambert's law, Types of Electronic Transitions; Instrumentation; Applications; Wood word Rules.

5. **INFRARED AND RAMAN SPECTROSCOPY** **(10 Hours)**
   Molecular Symmetry and Fundamental Modes of Vibrations, Quantum Aspects of Molecular Vibrational Energy and Selection Rules of Vibrational Transitions; Vibrational Rotational Spectra; Instrumentation; Applications; Raman Effect; Quantum Mechanical Description; Rotational and Vibrational Raman Spectra; Mutual Exclusion and Complementarily.

(Total Lecture Hours: 42 Hours)

21/07/2020

3. BOOKS RECOMMENDED:

1. Puri, Sharma, Pathania, Principles of Physical Chemistry, 5th Ed. 2003, Vishal Publishing Co.
2. U.Wahid,G.D. Malik, R.D. Tuli, Madan, Selected Topics in Inorganic Chemistry, 17th Ed., S. Chand &Co. Ltd.2006
3. P.W. Atkins, The elements of Physical Chemistry, 4th Edition, Oxford.1998
4. C. N. Banwell and Elaine M. McCash,Fundamentals for Molecular Spectroscopy
5. Y. R. Sharma, Elementary OrganicSpectroscopy

21/08/2020

Second year of Five Years Integrated M.Sc. (Physics)
M.Sc. – II, Semester – III
ENGLISH & PROFESSIONALCOMMUNICATION -II

L	T	P	Credit
3	0	0	3

HU201

1 Course Outcomes (CO)

At the end of the semester the students will be able to:

CO1	express themselves using appropriate vocabulary and grammar
CO2	draft scientific reports and formal proposals
CO3	comprehend scientific and general content more skilfully and meaningfully
CO4	predict human transactions and behavioural modes
CO5	communicate effectively through various means and at varied levels

2 Syllabus

- **FUNCTIONAL ENGLISH GRAMMAR** **(8 Hours)**
  Language functions, Modals, Tenses, Active and Passive Voice, Conditional sentences, Concord errors.
- **TECHNICAL WRITING** **(6 Hours)** Formal and informal report- Information and recommendation reports, Progress and periodic report, Feasibility and trip report. Proposal writing- types, Logistics of proposals, The deliverables of proposals persuasion and proposal, The structure of the proposal.
- **LISTENING AND READING COMPREHENSION** **(10Hours)**
  Listening and note taking, Paraphrasing, Reading using SQ3R, Predicting, Understanding gist reading and listening general and scientific texts and developing vocabulary
- **LANGUAGE THROUGH LITERATURE** **(8Hours)**
  Short Stories:
  1. The Remarkable Rocket by Oscar Wild
  2. An Astrologer's Day by R. K. Narayan
  3. The Case of the Lower Case Letter by Jack Delany
- **GROUP COMMUNICATION & ACADEMIC WRITING** **(10Hours)**
  Transactional analysis; SOP; LOR; Research paper, Dissertation, Thesis; Types of group communication- Seminar, Conferences, Convention, Symposium, Panel discussion etc.

Total Contact Time - 42 Hours

3 Books Recommended:-

1. M. Markel, Practical Strategies for Technical Communication, 2nd Edition, Bedford/ St. Martin's, 2016.
2. R. V. Lesikar and M. E. Flatley,Basic Business Communication Skills for Empowering the Internet Generation, Tata McGraw Hill Publishing Company Limited, New Delhi, 2005.
3. L. J. Gurak and J. M. Lainon, Strategies for Technical Communication in the Workplace, Pearson, 2013.
4. C. L. Bovee, J. V. Thill, and M. Chaturvedi,Business CommunicationToday,9thEdition, Pearson, 2009.
5. W. S. Pfeiffer and T.V.S. Padmaja,Technical Communication: A Practical Approach,*6th*Edition, Pearson 2013.

21/08/2020

Second year of Five Years Integrated M.Sc.(Physics)
M.Sc. – II, Semester – III

Experimental Techniques I

L	T	P	Credit
00	00	06	03

PH 205

This course comprises the experiments related to the theory courses of electronics, classical mechanics andfundamental physics.

21/02/2020

Second year of Five Years Integrated M.Sc.(Physics)
M.Sc. – II, Semester – IV

Electromagnetics - I

L	T	P	Credit
03	01	00	04

PH 202

1. Course Outcomes (COs):

At the end of the semester students will be able to:

CO1	Explain the basics of vector algebra, coordinate transformations and differential operators
CO2	Interpret the Coulomb's and Gauss's law and their application in electrostatics
CO3	Classify the electric fields in conductors and dielectrics and extend it to understand the polarization effects and apply to boundary value problems
CO4	Interpret the Lorentz force, Biot-Savert's and Ampere's law and their applications in magnetostatics
CO5	Infer the Legendre polynomials and Bessel functions and relate their applications
CO6	Relate the magnetization in materials and explain the magnetic fields in matter

2. Syllabus

1. **VECTOR CALCULUS** **(06 Hours)**
   Vector Algebra, Coordinate Systems and Transformations, Differential Length, Differential Area and Differential Volume; Line, Surface and Volume Integrals, Gradient, Divergence, Curl and Laplacian (Cartesian & Polar Coordinates).

2. **ELECTROSTATICS** **(06 Hours)**
   Coulomb's Law, Intensity of Electric field, Gauss's Law and its Application, Divergence and curl of Electric Field, Electric Potential, Work and Energy in Electrostatics.

3. **ELECTRIC FIELDS IN MATTER** **(06 Hours)**
   Conductors, Dielectrics, Polarization, The Field of Polarized Object, The Electric Displacement, Boundary Conditions, Conduction and Convection Currents, Ohms Law.

4. **BOUNDARY VALUE PROBLEMS** **(08 Hours)**
   Laplace equation in one-, two- and three-dimensions, 1st and 2nd uniqueness theorem, Classic image problem, Induced surface charge, Force and energy, Other image problems, Separation of variables, Multipole expansion.

5. **MAGNETOSTATICS** **(08 Hours)**
   The Lorentz Force Law, Biot-Savert's law, The Divergence and Curl of Magnetic Field, Magnetic vector potential, Magnetic flux density, Ampere Circuital Law and its Application.

6. **MAGNETIC FIELDS IN MATTER** **(08 Hours)**
   Magnetization in Materials, The field of a Magnetized Object, The auxiliary field H, Linear and non-linear media, Magnetic Boundary Conditions.

(Total Lecture Hours: 42 Hours)

21/08/2020

3. BOOKS RECOMMENDED:

1. D. J. Griffiths, Introduction to Electrodynamics, 3rd Ed. Prentice – Hall of India Private Limited 1999.
2. J. A.Edminister, Schaum's Outline series, Theory and Problems of Electromagnetics, McGraw Hill, 1993.
3. M. N. O.Sadiku, Elements of Electromagnetics, 3rd Ed., Oxford University Press, 2003.
4. J. V. Stewart, Intermediate Electromagnetic Theory, Allied Publishers (with World Scientific), 2005.
5. J. D.Jackson, Classical Electrodynamics, Wiley Eastern, 2012

21/07/2020

Second year of Five Years Integrated M.Sc. (Physics)
M.Sc. – II, Semester – IV

Quantum Mechanics-I

L	T	P	Credit
03	01	00	04

PH 204

1. Course Outcomes (COs):

At the end of the semester students will be able to:

CO1	Explain the origin of quantum theory and interpret the wave function properties
CO2	Apply the Schrodinger's time-dependent and time-independent equations
CO3	Interpret the Fourier transform and delta functions
CO4	Examine the central potential theory and apply it to understand the energy spectrum of hydrogen atom
CO5	Identify various symmetries in quantum mechanics and interpret the angular momentum and spin in general
CO6	Inspect the Pauli's exclusion principle and perturbation theory

2. Syllabus

1. **ORIGINS OF QUANTUM THEORY & APPLICATIONS (06 Hours)**
The conceptual aspect, The state vectors, Bra and Ket notations, Eigen states and Eigen values, The postulates of quantum mechanics, Interpretation of the wave function, Operators, Commutation relations.

2. **SCHRÖDINGER EQUATION AND RELATED PROBLEMS (10 Hours)**
Equation of motion, Hamiltonian, Time dependent Schrodinger equation, Time independent Schrodinger equation, Schrodinger equation for particle in a potential well.

3. **FOURIER TRANSFORM, DELTA FUNCTIONS (06 Hours)**
Position representation of a state, momentum representation of a state, Plancherel's theorem, The Kronecker delta, Dirac delta function.

4. **CENTRAL POTENTIALS; HYDROGEN ATOM (05 Hours)**
Spherically symmetric potentials, The two body problem, Bound states, Scattering states, Energy spectrum of Hydrogen atom.

5. **SYMMETRIES IN QUANTUM MECHANICS, GENERAL TREATMENT OF ANGULAR MOMENTUM; SPIN (07 Hours)**
The invariance principles, Symmetry groups and their representation, Space-time symmetry, Rotation symmetry, Eigen values of angular momentum, Parity, Time reversal invariance.

6. **IDENTICAL PARTICLES; PAULI EXCLUSION PRINCIPLE. (04 Hours)**
The identity of particle, Quantum numbers, Spins and Statistics, Pauli's exclusion principle and the Slatter determinant.

7. **INTRODUCTION TO IST ORDER TIME-INDEPENDENT PERTURBATION THEORY (04 Hours)**
The WKB approximation, Variational methods, Non-degenerate Perturbation Theory, Degenerate Perturbation Theory, Two-fold Degeneracy.

(Total Lecture Hours: 42 Hours)

3. BOOKS RECOMMENDED:

1. Schiff L.I., Quantum Mechanics: McGraw Hill Education; 4 edition 1 July 2017
2. Ghatak A.K., &Loknathan S. Quantum Mechanics: Theory & Applications V Laxmi Publications, 1 January 2015
3. Shankar R., Principles of Quantum Mechanics: Springer; 2nd ed. 1994. edition 19October 2011,Corr. 14th printing 2014
4. Zettili N., Quantum Mechanics: Concepts and Applications;Wiley India Pvt. Ltd; 2nd edition, 12 October 2016
5. Mathews P.M., and VenkateshanK.,A Text book of Quantum Mechanics;McGraw Hill Education; 2 edition 1 July 2017

21/08/2020

Second year of Five Years Integrated M.Sc.(Physics)
M.Sc. – II, Semester – IV

Solid State Physics

L	T	P	Credit
03	01	00	04

PH 206

1. Course Outcomes (COs):

At the end of the semester students will be able to:

CO1	Explain the basics of crystallography and identify the crystal structures
CO2	Infer the concept of free electron theory and band theory of solids
CO3	Interpret the lattice vibrations and thermal properties of solids
CO4	Extend concept of energy band theory by various methods and apply to understand optical properties
CO5	Examine the properties of superconductors and understand the concept of liquid crystals

2.Syllabus

1. **Crystallography(08 Hours)**
   Symmetry elements in crystals, Single crystals and usage, Defects in crystals, techniques of growing, and studying different crystals, Determination of crystal structures by X-ray diffraction, formulations of Bragg and Von Laue, their equivalence, Laue condition and Ewald's construction, Laue, rotating crystal, power methods, geometrical structure factor, atomic form factors.

2. **Free Electron Theory(08 Hours)**
   Drude Theory of Metals, Somemerfeld Theory of Metals, Sommerfeld Theory of Conduction, Failure of The Free Electron Model, Band Theory of Solids, Distinction between Conductors, Insulators and Semiconductors, Electrical Resistance of Materials, Energy Bands, Equation of Motion of an Electron, Resistivity and Conductivity.

3. **Lattice Vibrations and thermal properties(08 Hours)**
   Vibrations of Monoatomic Lattice, normal mode frequencies, dispersion relation, Quantization of lattice vibrations, phonon momentum, Inelastic scattering of neutrons by phonons, Surface vibrations, Inelastic Neutron scattering. Anharmonic Crystal Interaction. Thermal conductivity, Lattice Thermal Resistivity.

4. **Energy band theory(08 Hours)**
   Periodic potentials and Schrodinger equation, Bloch theorem, Kronig-Penney model, Origin of band gap, Brillouin zones, electron motion in one dimension, effective mass, concept of a hole, mobility and temperature dependence, cyclotron resonance and hall effect, Tight binding method, Band structure of real semiconductors, High electric field and hot electrons, The Gunn effects, Optical properties: absorption processes, Photoconductivity, Luminescence.

5. **Superconductivity(10 Hours)**
   Superconductivity: type-I and type-II superconductors. Josephson junctions. Superfluidity. Defects and dislocations. Ordered phases of matter: translational and orientational order, kinds of liquid crystalline order. Quasi crystals.

21/07/2020 **(Total Lecture Hours: 42Hours)**

3.BOOKS RECOMMENDED:

1. C. Kittle, Introduction to Solid State Physics, John Willey, 1976.
2. M. A. Omar, Elementary Solid State physics, Addison-Wesley Pvt. Ltd, New Delhi, 2000.
3. A. J. Dekker, Solid State Physics, Macmillan India Ltd, 2000.
4. N. W. Ashcroft and N.D. Mermin, Solid State Physics, Holt-Saunders International Editing 1981.
5. W. A. Harrison, Solid State Theory, Tata McGraw Hill Education, 1970.

21/07/2020

Second year of Five Years Integrated M.Sc.(Physics)
M.Sc. – II, Semester – IV

Computational Methods

L	T	P	Credit
03	01	02	05

MA 202

1. Course Outcomes (COs):

At the end of the semester students will be able to:

CO1	Devise an algorithm to solve a mathematical problem numerically.
CO2	Analyze an algorithm's accuracy, efficiency and convergence properties.
CO3	Implement this algorithm and write computer code.
CO4	Describe classic techniques and recognize common pitfalls in numerical analysis.

2. Syllabus

1. PRELIMINARIES OF COMPUTING (02 Hours)

Errors, Types of errors, Propagation of Error, Floating point arithmetic. Approximation using Taylor's series.

2. SOLUTION OF NON-LINEAR EQUATIONS(08 Hours)

Bisection Method, Methods of false position, Newton's method, Modified Newton's method, Fixed point iterative method, Newton's and fixed point iterative method for system of nonlinear equations. Roots of polynomials, Error and convergence analysis of these methods.

3. SOLUTION OF SYSTEM OF LINEAR EQUATIONS (08 Hours)

Direct Methods: Gauss elimination with pivoting. LU decomposition method, Cholesky decomposition method, Error analysis for direct methods. Iterative methods: Jacobi, Gauss Seidel method, SOR method, Vector and matrix norm, Convergence of iterative methods. Eigen values problems: Jacobi's and Power method.

4. INTERPOLATION(12 Hours)

Finite difference operators, divided difference operators, Relation between difference operators, Application of difference operators. Polynomial Interpolation, Existence and uniqueness of interpolating polynomials, Lagrange and Newton's interpolation. Newton's forward and backward difference formula, Error in interpolation.

5. DIFFERENTIATION AND INTEGRATION (06 Hours)

Numerical differentiation: Methods based on interpolation, finite differences, Error in approximation, order of approximation. Numerical Integration: Quadrature formula, Newton Cotes Methods, Trapezoidal and Simpson's rules with error analysis. Gauss quadrature methods with error analysis.

6. INITIAL VALUE PROBLEMS (ODE) (06 Hours)

Picard's method, Taylor's series method, Euler and Runge-Kutta methods for initial value problems of order one and higher and system of first order ODEs with error analysis.

(Total Lecture Hours: 42 Hours)

21/08/2020

3. Practical:

Students can use MATLAB, PYTHON, Octave, SciLab, to write computer program

1. To solve the nonlinear equation.
2. To solve system of nonlinear equations
3. To solve the system of linear equations using direct methods
4. To solve the system of linear equations using indirect methods
5. To find the eigenvalue of a matrix
6. To make a difference table for interpolating arbitrary spaced and equally spaced data.
7. To approximate the derivative numerically
8. To integrate function numerically
9. To solve the initial value problems of order one and more and system of first orderODEs

4.BOOKS RECOMMENDED:

1.E. Kendall, Atkinson, An introduction to numerical analysis, 2nd Edition, 2008, John Wiley & sons, ISBN-13: 9788126518500

2.L. Richard, Burden and J. Douglas Faires, Numerical Analysis, 9th Edition, 2011, Cengage Learning, ISBN-13: 978813151654-6

3.Samuel D. konte and Cark de Boor, Elementary Numerical Analysis-An Algorithmic Approach, 3rd Edition, 1981, McGraw-Hill, ISBN: 0-07-012447-7

4.Mahendra K. Jain, Satteluri, R. K. Iyengar and Rajinder K. Jain, Numerical Methods : For Scientific And Engineering Computation, 6th Edition, 2014, New Age International Publishers, ISBN: 978-81-224-3323-4

5.John H. Mathews and Kurtis D. Fink, Numerical Methods using MATLAB, 4th Edition, 204, Pearson Education Inc., ISBN: 978-93-325-4935-7

21/08/2020

Second year of Five Years Integrated M.Sc.(Physics)
M.Sc. – II, Semester – IV

ORGANIC CHEMISTRY-I

L	T	P	Credit
03	01	02	05

CY 210

1. Course Outcomes (COs):

At the end of the semester students will be able to:

CO1	Impart knowledge in fundamental aspects of organic chemistry.
CO2	Acquire knowledge on chemical properties of heterofunctional groups.
CO3	Acquaint basic knowledge in the chemical properties of carbohydrates and heterocyclic compounds.
CO4	Understand basic knowledge in stability and chemical properties of cycloalkanes.
CO5	Interpret the structural confirmation of carbohydrates.

2. Syllabus

- **HETERO FUNCTIONAL GROUP – I** **(12 Hours)**
  Aliphatic and aromatic halides, hydroxy derivatives, aliphatic alcohols and phenols. Ethers – aliphatic, and aromatic carbonyl compounds. Acid and base-catalyzed ring opening of epoxides, orientation of epoxide ring opening, reactions of Grignard and organ lithium reagents with epoxides. Preparation and synthetic applications of ethyl aceto acetate and diethyl malonate, tautomerism.

- **HETERO FUNCTIONAL GROUP – II** **(08 Hours)**
  Aliphatic and aromatic carboxylic acids and their functional derivatives. Nitrogen containing compounds - preparations and reaction mechanisms.

- **CYCLOALKANES** **(06 Hours)**
  Nomenclature, methods of formation, chemical reactions, Baeyer's strain theory and its limitations, theory of strainless ring. Reactions and stereochemistry of substituted cyclo hexane.

- **HETEROCYCLIC COMPOUNDS(08 Hours)**
  Nomenclature, aromaticity, synthesis, properties, reactivity, uses and canonical structures of; pyrrole, furan, thiophene, pyridine, quinoline and isoquinoline.

- **CARBOHYDRATES** **(08 Hours)**
  Introduction, basic structural features and types of carbohydrates, reactions and conversions, role in biological systems. Introduction to disaccharides, glycosidic bond, structure determination of sucrose, lactose, maltose and cellobiose.

(Total Lecture Hours: 42 Hours)

21|08|2020

3. Practicals:

1. Purification of liquid organic compounds

a. Distillation
b. Fractional distillation
c. Steam distillation/Vaccum distillation
d. Determination of boiling point using distillation
d. Distillation at reduced pressure

2.Purification of solid organic compounds

a. Crystallization
b. Sublimation
c. Fractional recrystallization

4.BOOKS RECOMMENDED:

1. M. Anne Fox, James K. Whitesell, Organic Chemistry, 3rd Edition, Jones & Bartlett Learning, 2004.
2. P. Y. Bruice, "Organic Chemistry", 3rd Edition, Prentice-Hall, International Edition, 2009.
3. R. T. Morrison, R. N. Boyd, Organic Chemistry', 7th Edition, Prentice Hall, 2011.
4. A. Streitwieser, Jr., C. H. Heathcock,Introduction to Organic Chemistry 4th Edition, MacMillan, New York, 1998
5. R. R. Gupta, M. Kumar, V. Gupta, Heterocyclic Chemistry, Volume 2, 1st Edition, Springer India Pvt. Ltd – New Delhi, 2009.

Additional Books:

1. T. W. G. Solomons, C. B. Fryhle, Organic Chemistry, 9th Edition, Wiley India Pvt. Ltd., 2009.
2. B. S. Furniss, A. J. Hannaford, P. W. G. Smith, A. R. Tatchell, Vogel's Textbook of Practical Organic Chemistry, Pearson India, 5th Edition, 2005.

21/09/2020

Second year of Five Years Integrated M.Sc.(Physics)
M.Sc. – II, Semester – IV

Experimental TechniquesII

L	T	P	Credit
00	00	06	03

PH 208

This course comprises the experiments related to the theory courses of Electromagnetics-I, Quantum Mechanics-I, Solid State Physicsandfundamental physics.

21/08/2020

M.Sc. Year III (Semester-V)

			Teaching Scheme (Hours)				**Examination Scheme**			
Sr. No.	**Course Code**	**Course**	**L**	**T**	**P**	**Credits**	**Theory**	**Tutorial**	**Practical**	**Total Marks**
1	PH 301	Electromagnetics-II	3	1	0	4	100	25	0	125
2	PH 303	Semiconductor Devices	3	1	0	4	100	25	0	125
3	PH 305	Atomic & Molecular Physics	3	1	0	4	100	25	0	125
4	PH 307	Plasma Physics	3	1	0	4	100	25	0	125
5	PH 3XX	Institute Elective– I	3	0	0	3	100	0	0	100
6	PH 309	Experimental Techniques-III	0	0	8	4	0	0	200	200
7	PH 311	Mini Project-I	0	0	4	2	0	0	100	100
		Total	**15**	**4**	**12**	**25**	**500**	**100**	**300**	**900**
									Total Lecture Hours	**31**
									Total Credits	**25**

Institute Elective-I

			Teaching Scheme (Hours)				**Examination Scheme**			
Sr. No.	**Course Code**	**Course Name**	**L**	**T**	**P**	**Credits**	**Theory**	**Tutorial**	**Practical**	**Total Marks**
1	PH 361	Basics of Astronomy and Astrophysics	3	0	0	3	100	0	0	100
2	PH 363	Solar Cell Technologies	3	0	0	3	100	0	0	100

21/08/2020

M.Sc. Year III (Semester-VI)

			Teaching Scheme (Hours)				Examination Scheme			
Sr. No.	**Course Code**	**Course Name**	**L**	**T**	**P**	**Credits**	**Theory**	**Tutorial**	**Practical**	**Total Marks**
1	PH 302	Astrophysics and Space Science	3	1	0	4	100	25	0	125
2	PH 304	Mathematical Methods in Physics	3	1	0	4	100	25	0	125
3	PH 306	Digital Electronics	3	1	0	4	100	25	0	125
4	PH 308	Nuclear Physics	3	1	0	4	100	25	0	125
5	PH 3YY	Institute ElectiveII	3	0	0	3	100	0	0	100
6	PH 312	Experimental Techniques-IV	0	0	8	4	0	0	200	200
7	PH 314	Mini Project-II	0	0	4	2	0	0	100	100
		Total	**15**	**4**	**12**	**25**	**500**	**100**	**300**	**900**
									Total Lecture Hours	**31**
									Total Credits	**25**

Institute Elective-II

			Teaching Scheme (Hours)				Examination Scheme			
Sr. No.	**Course Code**	**Course Name**	**L**	**T**	**P**	**Credits**	**Theory**	**Tutorial**	**Practical**	**Total Marks**
1	PH 362	Basics Course on Relativity	3	0	0	3	100	0	0	100

21/07/2020

Third year of Five Years Integrated M.Sc. (Physics)
M.Sc. – III, Semester – V

Electromagnetics – II

L	T	P	Credit
03	01	00	04

PH301

1. Course Outcomes (COs):

At the end of the semester students will be able to:

CO1	Inferthe concept of Maxwell's equations and boundary conditions
CO2	Explain the conservation laws in electrodynamics
CO3	Examine the propagations of electromagnetic waves in vacuum and in matters
CO4	Interpret the different potentials and gauge in electrodynamics
CO5	Analyzethe mechanism of electric and magnetic radiations
CO6	Summarize the field of electrodynamics with relativity

2. Syllabus

- **ELECTRODYNAMICS(08 Hours)**
  Electromotive Force and motional emf, Faraday's law of Electromagnetic Induction and energy in the magnetic fields, Maxwell's Equations, How Maxwell Fixed Ampere's Law, Maxwell's Equations in Matter, Boundary Conditions.

- **CONSERVATION LAWS IN ELECTRODYNAMICS(06 Hours)**
  The Continuity Equation, Poynting's Theorem, Newton's Third Law in Electrodynamics, Maxwell's Stress Tensor, Conservation of Momentum, Angular Momentum.

- **ELECTROMAGNETIC WAVES (08 Hours)**
  Waves in One Dimension, Electromagnetic Waves in Vacuum and in Matter, Absorption and Dispersion in matter, Guided waves.

- **POTENTIALS AND FIELDS (07 Hours)**
  Scalar and Vector Potentials, Gauge Transformations, Coulomb Gauge and Lorentz Gauge, Retarded Potentials, Jefimenko's Equations, Lienard-Wiechert Potentials, The Fields of a Moving Point Charge.

- **RADIATION(06 Hours)**
  Electric and Magnetic Dipole Radiation, Radiation from an arbitrary source, Power radiated by a point charges, Radiation reaction.

- **ELECTRODYNAMICS AND RELATIVITY(07 Hours)**
  Special theory of relativity and relativistic mechanics, Relativistic Electrodynamics, Field tensor, Electrodynamics in tensor notation.

(Total Lecture Hours: 42 Hours)

21/03/2020

3. BOOKS RECOMMENDED:

1. David J. Griffiths,Introduction to Electrodynamics, 3rd Edition, Pearson Education 2008.
2. John David Jackson, Classical Electrodynamics, 3rd Edition, Wiley 2018
3. Matthew N. O. Sadiku, Elements of Electromagnetics, 6th Edition, Oxford University Press, 2014
4. L. D. Landau, E. M. Lifshitz, The Classical Theory of Fields, Course of Theoretical Physics: Vol. 2 by, 3rd Edition, Pergamon Press 1967
5. David K. Cheng, Field and Wave Electromagnetics by, 2nd Edition, Pearson Education 2001

21/10/2020

Third year of Five Years Integrated M.Sc. (Physics)
M.Sc. – III, Semester – V

Semiconductor Devices

L	T	P	Credit
03	01	00	04

PH 303

1.Course Outcomes (COs):

At the end of the semester students will be able to:

CO1	Understand the working of various FET devices and their applications
CO2	Understand the principle of operation of DIAC and TRIAC devices
CO3	Identify the principle of operation and structure of SCR devices
CO4	Interpret the concept of heterojunction devices and their applications
CO5	Classify the characteristics of various photonic devices
CO6	Examine the properties and applications of microwave devices

2.Syllabus

- **VARIOUS FET DEVICES: INTRODUCTION, CHARACTERISTICS AND APPLICATION** **(10 Hours)**

  Types of FET, JFET, MODFET, SIT, MOSFET, Structure and principle of operation of MOSFET, MOSFET as an amplifier, MOSFET analysis, Threshold voltage. Power MOSFET, HEMT.

- **DIAC, TRIAC: INTRODUCTION, CHARACTERISTICS AND APPLICATION** **(08 Hours)**

  Structure of DIAC, DIAC Principle of operation, Structure and principle of operation of TRIAC, Applications of TRIAC.

- **PNPN: INTRODUCTION, CHARACTERISTICS AND APPLICATION** **(06 Hours)**

  The silicon-controlled rectifier, Device structure, Principle of operation, Equivalent circuit. Applications.

- **INTRODUCTION TO THE HETERO JUNCTIONS AND APPLICATIONS** **(06 Hours)**

  Concept of Heterojunction, Multilayer Heterojunction, Energy band diagram for Heterojunction, Confinement of charge carrier, Application of Heterojunction.

- **PHOTONIC DEVICES: INTRODUCTION, CHARACTERISTICS AND APPLICATION** **(06 Hours)**

  Light Emitting Diode (LED), Characteristics of LED, Materials and wavelength of light, Laser diode, Structure, Characteristics of laser diode, Photodiode and solar cell.

- **MICROWAVE DEVICES: INTRODUCTION, CHARACTERISTICS AND APPLICATION** **(06 Hours)**

  MESFET, HEMT

(Total Lecture Hours: 42 Hours)

21|08|2020

3.BOOKS RECOMMENDED:

1. D.L. Schilling and C.Belove, Electronic Circuits : Discrete and Integrated, McGraw Hill, 1989
2. B. Streetman, &S. Banerjee, Solid State Electronic Devices, Prentice Hall, 2005
3. R.L. Boylestad and L. Nahselsky, Electronic Devices and Circuit Theory,Prentice Hall, 2005
4. S. Y. Liao, Microwave Devices and Circuits, Prentice Hall , 1996
5. S.M. Sze, Semiconductor Devices : Physics and Technology, John Wiley & Sons,1986

21/08/2020

Third year of Five Years Integrated M.Sc.(Physics)
M.Sc. – III, Semester – V

Atomic & Molecular Physics

L	T	P	Credit
03	01	00	04

PH 305

1. Course Outcomes (COs):

At the end of the semester students will be able to:

CO1	Classifyvarious atomic models and their importance
CO2	Interpret one-electron systems and associated relativistic corrections
CO3	Examine the effects of magnetic and electric fields on the spectral lines
CO4	Analyze the quantum mechanical aspects of hydrogen and helium atom structure
CO5	Explain the hartree theory and the idea of self-consistency
CO6	Analyze the molecular structure by inspecting the rotational, vibrational and electronic transitions

2.Syllabus

- **INTRODUCTION TO ATOMIC STRUCTURE AND MODELS** **(05 Hours)**
  The nuclear atom, Electron orbits, Atomic spectra, The Bohr atom, Energy levels and spectra, Correspondence principle, Nuclear motion, Atomic excitations.

- **ONE-ELECTRON ATOMIC SYSTEMS** **(12 Hours)**
  Relativistic corrections of energy terms: relativistic mass correction, Darwin term, and spin-orbit term. Fine structure. Lamb shift. Hyperfine structure. LS & JJ coupling, Zeeman, Paschen-Bach &Stark effect, Introduction to time-dependent perturbation theory.

- **HYDROGEN ATOM** **(08 Hours)**
  Limitations of classical mechanics, Schrodinger's time independent wave equation, Orbital angular momentum, parity of eigen functions.

- **HELIUM ATOM** **(06 Hours)**
  Spectrum of Helium, Quantum mechanical explanation of splitting of He terms, Ground state energy of He atom.

- **HARTREE THEORY AND IDEA OF SELF-CONSISTENCY** **(05 Hours)**
  Hartree's self-consistent field, Results of Hartree theory, Atomic orbitals and Hund's rule, the periodic table.

- **MOLECULAR STRUCTURE** **(06 Hours)**
  General nature of molecular structure, Born–Oppenheimer separation, rotation and vibration of diatomic molecules, electronic structure of diatomic molecules

(Total Lecture Hours: 42 Hours)

21/08/2020

3.BOOKS RECOMMENDED:

1. Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles, 2nd edition. R. Eisberg, R. Resnick. Wiley2006
2. Modern Quantum Mechanics,J. J. Sakurai, PearsonEducation,.2009
3. B. H. Bransden and C. J. Joachaim, Physics of Atoms and Molecules,Benjamin Cumming2003
4. Springer Handbook of Atomic, Molecular, and Optical physics Gordon Drake, Springer-Verlag New York2006
5. Molecular Physics: Theoretical Principles and Experimental Methods 1st edition. W Demtröder Wiley-VCH 2005

21/07/2020

Third year of Five Years Integrated M.Sc.(Physics)
M.Sc. – III, Semester – V

Plasma Physics

L	T	P	Credit
03	01	00	04

PH307

1. Course Outcomes (COs):

At the end of the semester students will be able to:

CO1	Interpretthe basic properties and criteria for plasma
CO2	Introspect the particle motions under the influence of external electric and magnetic field
CO3	Analyzethe electrodynamics and fluid equations for plasma
CO4	Examine the diffusion and transport properties of plasma
CO5	Classify the characteristics of plasma oscillations and plasma waves
CO6	Explainthe diagnostic method to study the plasma properties

2. Syllabus

- **INTRODUCTION** **(02 Hours)**
  General properties of plasma, Criteria for its existence, Occurrence in nature, Sources of plasma generation in laboratory, Applications, Concept of temperature in plasma.

- **MOTION OF CHARGED PARTICLES IN ELECTRIC AND MAGNETIC FIELD** **(08 Hours)**
  Uniform electric and magnetic field, Non-uniform magnetic field, Non-uniform electric field, Time-varying magnetic field, Time-varying electric field, Adiabatic invariant, Plasma confinement in laboratory, Summary of guiding centre drifts.

- **PLASMA AS FLUID** **(06 Hours)**
  Electrodynamics equations in plasma, Plasma dielectric constant, Fluid equations of motion, Fluid drifts in the presence of magnetic field.

- **DIFFUSION AND TRANSPORT** **(10 Hours)**
  Collision parameter, Diffusion parameter, Ambipolar diffusion, Recombination, Diffusion across a magnetic field, Collisions in fully ionized plasma, Plasma resistivity, and The single-fluid MHD equations.

- **PLASMA OSCILLATION AND WAVES** **(10 Hours)**
  Overview of wave, Phase velocity and Group velocity, Plasma oscillations, Electron plasma waves, Sound waves, Ion waves, Comparison of electron and ion waves, Upper hybrid frequency, Lower hybrid frequency, Electromagnetic plasma waves, Cut-off and resonances.

- **BASIC PLASMA DIAGNOSTICS USING ELECTRICAL METHOD** **(06 Hours)**
  Debye shielding problem, Plasma sheath - physical mechanism, wall potential and inner structure, Plasma probe.

(Total Lecture Hours: 42 Hours)

21/08/2020

3. BOOKS RECOMMENDED:

1. Plasma Physics and Controlled Fusion. F. F. Chen, 2nd Edition Volume 1: Plasma Physics, Springer 2006.
2. Principles of Plasma Discharges and Material Processing. M. A. Liebermann and A. J. Lichtenberg, 2nd Edition, Wiley-Interscience 2005.
3. Fundamentals of Plasma Physics. J. A. Bittencourt, 3rd Edition, Springer 2004.
4. Introduction to Plasma Physics. R. J. Goldston and P. H. Rutherford, 1st Edition, CRC Press 1995.
5. Fundamentals of Plasma Physics. P. M. Bellan, Cambridge University Press 2012.

21|07|2020

Third year of Five Years Integrated M.Sc.(Physics)
M.Sc. – III, Semester – V

Basics of Astronomy and Astrophysics

L	T	P	Credit
03	00	00	03

PH 361

1. Course Outcomes (COs):

At the end of the semester students will be able to:

CO1	Relatethe basic understanding of the Astronomy and Astrophysics
CO2	Interpretthe important concepts as applied to Astronomy and Astrophysics
CO3	Apply the concepts learned to find the properties of Celestial objects and phenomena
CO4	Analyze the results available in literature or those derived in the course
CO5	Evaluate the limitations and robustness of the concepts as applied to Astronomy and Astrophysics

2. Syllabus

- **UNIVERSE AND CELESTIAL BODIES(18 Hours)**
  Matter vs Radiation Dominated universe, The early universe, structure formation, Galaxies, Nebulae, Stars, Classification of celestial bodies, other celestial objects.

- **SOLAR SYSTEM(10 Hours)**
  Birth, Life and death of a star, H-R diagram, Solar system & its members.

- **EARTH AND ITS ATMOSPHERE (07 Hours)**
  Formation and structure of the Earth, different surface features of the earth, earth's Atmosphere and its different parts, radio window, ozone depletions.

- **SPACE EXPLORATIONS(07 Hours)**
  Radiation in the universe, its effect on human and other non-living mechanisms, types Space vehicles, manned space explorations.

(Total Lecture Hours: 42 Hours)

3. BOOKS RECOMMENDED:

1. S. S. Degaonkar,Space Science, Gujarat University Press, 1968
2. M. Patrick,Atlas of the Universe, Cambridge University Press, 2000
3. A. Beiser,Concept of the Modern Physics, TMH, 2008
4. M. Mukhanov, Physical Foundations of Cosmology, CUP, 2005.
5. J. N. Islam, An Introduction to Mathematical Cosmology, CUP, 2004.

21/08/2020

Third year of Five Years Integrated M.Sc.(Physics)
M.Sc. – III, Semester – V

Solar Cell Technologies

L	T	P	Credit
03	00	00	03

PH 363

1. Course Outcomes (COs):

In the end of semester the students will be able to:

CO1	Summarize the status of energy crisis and appreciate role of Solar PV
CO2	Interpret the physics of semiconductor materials and junctions
CO3	Identify the designing aspects of solar cells and modules
CO4	Examine the silicon based solar cell technologies
CO5	Inspect the thin-film solar cell, concentrator solar PV technologies

2. Syllabus

- **Energy Scenario and Solar Photovoltaics (PV) (4 Hours)**
  World energy requirement, review of renewable energy sources, economics and global energy market, role of solar PV, solar radiation as energy source, solar spectrum, Sun-Earth system, movements and radiation collection. sun-tracking. measurement of solar radiation.

- **Physics of Semiconductor Materials and Junctions(8 Hours)**
  Fundamentals of semiconductors, formation of energy bands, direct and indirect band gap, charge carriers in semiconductors, carrier concentration and distribution, density of energy states, carrier motion in semiconductors, electric field and energy band bending, generation & recombination of carriers, p-n junction: equilibrium condition, space charge region, p-n junction in non-equilibrium condition, p-n junction under illumination: solar cell, generation of photovoltage, light generated current. i-v equations of solar cells. solar cell characteristics.

- **Design of Solar Cells and Modules (8 Hours)**
  Solar cell parameters, losses in solar cell, models of solar cell, effect of series, shunt resistance, radiation and temperature on efficiency, solar cell design, solar simulator, quantum efficiency measurement, minority carrier lifetime and diffusion length measurement, Solar PV modules for solar cells, mismatch in series and parallel connections, design and structure of PV modules, PV module power output.

- **Silicon Based Solar Cell Technologies(8 Hours)**
  Growth of solar PV industry silicon, production of Si wafers, monocrystalline Si ingots: CZ and FZ processes, multicrystalline Si ingots, wafer dicing: ID and wire sawing, solar grade silicon, process flow of commercial Si cell technology, high efficiency Si solar cells.

- **Thin-Film Solar Cell Technologies(6Hours)**
  Advantages of thin films technologies, material for thin film technologies, use of TCO and light trapping, possible solar cell structure, substrate and superstrate configuration, thin film module manufacturing, amorphous Si solar cell technology, CdTe solar cell technology, CIGS solar cell technology, thin film Si based technologies.

- **Concentrator Solar PV and Other Emerging Solar Cell Technologies(8 Hours)**
  Concentrator PV Cells, concentration ratio, optics for concentrator PV, tracking requirement of CPV, cooling requirements, minority carrier injections under high concentration, high concentrator solar cells, organic solar cell, dye-sensitized solar cell, perovskties solar cells, Gas solar cells, thermo-photovoltaics,

21|02|2020

need to go beyond current cell technologies.

(Total Lecture Hours: 42 Hours)

3.BOOKS RECOMMENDED:

1. Chetan Singh Solanki,Solar Photovoltaics: Fundamentals, Technologies and Applications,PHI Learning Pvt. Ltd. Publication, 2015
2. Martin Green,Solar Cells: Operating Principles, Technology, and System Applications, Prentice Hall Publications, 1983
3. K. L. Chopra and S. R. Das,Thin Films Solar Cells,; Springer Publications, 1983
4. Stephen Fonash,Solar Cell Device Physics,Academic Press Publication,2010
5. P. Jayarama Reddy,Science and Technology of Photovoltaics, BS Publications,2009

21/08/2020

Third year of Five Years Integrated M.Sc.(Physics)
M.Sc. – III, Semester – V

Experimental Techniques III

L	T	P	Credit
00	00	08	04

PH 309

This course comprises the experiments related to the theory courses of Electromagnetics-II, Semiconductor Devices, Atomic & Molecular physics, Plasma Physics and fundamental physics.

21/08/2020

Third year of Five Years Integrated M.Sc.(Physics)
M.Sc. – III, Semester – V

Mini Project-I

L	T	P	Credit
00	00	04	02

PH 311

This course comprises the project work related to either theoretical and/or experimental topics of physics.

21/08/2020

Third year of Five Years Integrated M.Sc.(Physics)
M.Sc. – III, Semester – VI

Astrophysics and Space Science

L	T	P	Credit
03	01	00	04

PH302

1. Course Outcomes (COs):

At the end of the semester students will be able to:

CO1	Interpret the concepts of Astrophysics, and Space Science
CO2	Analyze how astrophysical processes are studied, understood and utilized for furthering our understanding of the universe
CO3	Apply the concepts of space science to different problems
CO4	Evaluate the applications to various problems related to Astrophysics and Space Sciences
CO5	Analyze the satellite system such as GPS, Galileo, IRNSS.

2. Syllabus

- **Introduction to the course(02 Hours)**

- **Large Scale objects(10 Hours)**
  Astrophysical objects of interests like Galaxies, stars, their Evolution, Clusters, techniques to study these objects.

- **Stellar objects(10 Hours)**
  Types of stars, their properties. Evolution of stellar objects. The Sun, the standard model. Quiescent Sun, Disturbed sun.

- **Solar Terrestrial Relationship(08 Hours)**
  The quiet and disturbed solar features and their impact on space weather. Magnetosphere, Ionosphere, atmosphere.

- **Radio Wave Propagation through Ionosphere(06 Hours)**
  Refraction, effect of the ionosphere on wave propagation. Quiet ionsophere, disturbed ionosphere. The effects on technological systems.

- **Advanced topics of relevance(06 Hours)**
  Global Navigational Satellite System like GPS, Galileo, IRNSS.

(Total Lecture Hours: 42 Hours)

3. BOOKS RECOMMENDED:

1.Ratcliff, J. A., Introduction to ionosphere & Magnetosphere, Cambridge University Press. 1975
2.Hargreaves, J. K., The Solar Terrestrial Environment, Cambridge University Press 1995
3.Kievelson, M. J., Introduction to Space Physics Cambridge University Press. 1995
4.Lang, K. R. Sun, Earth and Sky Springer 2006
5.BasuBaidyabath, T. Chattopadhyay and S. N. Biswas, An Introduction to Astrophysics, PHI Learning Pvt. Ltd., 2018

21|08|2020

Third year of Five Years Integrated M.Sc.(Physics)
M.Sc. – III, Semester – VI

Mathematical Methods in Physics

L	T	P	Credit
03	01	00	04

PH304

1. Course Outcomes (COs):

At the end of the semester students will be able to:

CO1	Explain the basis of vector spaces, determinants and matrices to apply it for linear transformation
CO2	Utilize the eigenvalues and eigenvectors
CO3	Analyze the vectors with indices and extend it to understand the tensors and interpret the types and properties of tensors
CO4	Solve the second order ODE including Bessel, Hermite, Legendre, Hypergeometric and Confluent Hypergeometric equations
CO5	Interpret the Legendre polynomials and Bessel functions and relate their applications

2. Syllabus

- **VECTOR SPACES (06 Hours)**
  Subspaces, Basis and dimension, co-ordinates, row space, column space, nullspace.

- **LINEAR TRANSFORMATION (10 Hours)**
  Representation of linear transformation by Matrices, rank-nullity theorem, duality and transpose, determinant, linear functional, dual space.

- **EIGEN VALUES & EIGEN VECTORS (04 Hours)**
  Minimal & characteristic polynomials, diagonalisations, Cayley Hamilton theorem.

- **TENSOR ANALYSIS (08 Hours)**
  Vectors and Indices: Transformation Properties of Vectors, Covariant and Contravariant Vectors; From Vectors to Tensors: Algebraic Properties of Tensors, Numerical Tensors; Metric Tensor: Index Raising and Lowering, Differentiation of Tensors: Covariant Derivative, Metric Connection.

- **SOLUTIONS TO BESSEL, HERMITE, LEGENDRE, HYPER GEOMETRIC AND CONFLUENT HYPER- GEOMETRIC EQUATIONS (04 Hours)**

- **BESSEL FUNCTIONS AND THEIR APPLICATIONS (04 Hours)**
  Bessel Function of the first kind, Orthogonality, Neumann functions, Modified Bessel's functions, Asymptotic Expansions, Spherical Bessel function.

- **LEGENDRE POLYNOMIALS AND SPHERICAL HARMONICS (06 Hours)**
  Generating Function, Recurrence relations, Orthogonality, Associate legendre functions, Spherical harmonics, Legendre functions of the second kind, Vector spherical harmonics.

(Total Lecture Hours: 42 Hours)

21/08/2020

3. BOOKS RECOMMENDED:

1.K. Hoffman, and R.Kunze, Linear Algebra, PHI, 1991

2. S. Lang, Introduction to Linear Algebra (Undergraduate text in Mathematics), Springer, 1986

3.Grinfeld, Pavel. Introduction to tensor analysis and the calculus of moving surfaces. New York: Springer, 2013

4.Riley, Kenneth Franklin, Michael Paul Hobson, and Stephen John Bence. Mathematical methods for physics and engineering: a comprehensive guide. Cambridge university press, 2006.

5.Hassani, Sadri. Mathematical methods: for students of physics and related fields. Vol. 720. Springer Science & Business Media, 2008.

21/07/2020

Third year of Five Years Integrated M.Sc.(Physics)
M.Sc. – III, Semester – VI

Digital Electronics

L	T	P	Credit
03	01	00	04

PH 306

1. Course Outcomes (COs):

At the end of the semester students will be able to:

CO1	Explain the basic concepts and terminology of number systems, binary codes and logic gates
CO2	Interpret the basic relations of logic gates conversations by using Boolean algebra and Karnaugh maps
CO3	Analyze various combination circuits, flip-flops and timing circuits
CO4	Identify the basic principles of A to D and D to A conversions
CO5	Design and implement application-oriented digital circuits

2. Syllabus:

- **INTRODUCTION, NUMBER SYSTEM (04 Hours)**
  Digital & Analog System, Logic Levels and Pulse Waveforms, Elements of Digital Logic, Functions of Digital Logic, Digital Integrated Circuits, The Decimal Number System, The Binary Number System, Representation of Signed Numbers and Binary Arithmetic in Computers, Different Number Systems.

- **BINARY CODES & LOGIC GATES (03 Hours)**
  Different Codes, and Gates, , Inhibit circuits, 7400 series ICs, ANSI/IEEE Standard Logic symbols, Pulsed operation of Logic Gates.

- **BOOLEAN ALGEBRA (03 Hours)**
  Logic Operations, Axioms and Laws of Boolean Algebra, Duality, Reducing Boolean Expressions, Boolean Expression and Logic Diagrams, Converting AND/OR/Invert Logic to NAND/NOR logic, Determination of Output lev0el from the diagram.

- **THE KARNAUGH AND QUINE-McCLUSKY METHODS(06 Hours)**
  Expansion of a Boolean Expression to SOP & POS form, Computation of total Gate inputs, All variables K-map, Don't care combinations, Hybrid logic, Minimization of Multiple output circuits, Variable mapping, Quine-McClusky Method, Function minimization of multiple output circuits.

- **COMBINATION CIRCUITS(06 Hours)**
  The Half- Full-adder -Subtractor, Parallel Binary Address, the look-ahead carry adder, IC parallel adders, Two's complement addition & subtraction using parallel Adders, serial Adders, BCD Adders, Binary multipliers, code converters, Parity generators/checkers, Comparators, IC Comparator, Decoders, BCD to seven segment decoders, Display devices, Encoders, Multiplexers, Demultiplexers and Applications.

- **FLIP-FLOPS AND TIMING CIRCUITS (04 Hours)**
  The S-R latch, Gated latches, Edge-trigged Flip-Flops, Asynchronous inputs, Flip-flop operating characteristics, Master Slave (Pulse-triggered) flip-flop, Conversion of Flip-flops, Applications of Flip-flops, ANSI/IEEE Symbols, Schmitt Trigger, Multivibrators , crystal controlled clock generators.

21|08|2020

- **SHIFT REGISTERS , COUNTERS(06 Hours)**
  Buffer register, Controlled Buffer register, Shift Registers & Data Transmission in shift register, Counters, Pulse Train Generators, Pulse Generators using shift registers, Cascading of Synchronous counters.

- **LOGIC FAMILIES AND ANALOG-TO-DIGITAL AND ANALOG–TO-ANALOG CONVERTERS(06 Hours)**
  Digital IC Specification Technology, Logic Families, Transistor Transistor Logic (TTL), Open – collector Gates, Digital-to-Analog(D/A) Conversion, The R-2R Ladder Type DAC, The Weighted – resistor Type DAC, The Switched Current-source Type DAC, Analog-to-Digital Conversion, The Counter-type A/D Converter, The Tracking-type A/D Converter, The Flash-type A/D Converter, The Dual-slop Type A/D Converter, The Successive-approximation Type ADC.

- **DESIGNING DIGITAL CIRCUITS(04 Hours)**
  Reactor design, Traffic signal, Stepper motor.

(Total Lecture Hours: 42 Hours)

3. BOOKS RECOMMENDED:

1. Floyd T. L, Jain R. P., Digital Fundamentals, Dorling Kindersley (India) Pvt Ltd 2008.
2. Morris Mano M.Digital Logic & Computer Design, Dorling Kindersley (India) Pvt. Ltd. 2008.
3. A. Anand Kumar, Fundamentals of Digital Circuits,Prentice-hall of India Pvt. Ltd. 2009.
4. Jain. R. P., Modern Digital Electronics, Tata McGraw Hill Publishing Company Ltd.2009.
5. Malvino A.P., Leach P. D., Digital Principals & Applications., Tata McGraw Hill Publishing Company Ltd.2008.

21/03/2020

Third year of Five Years Integrated M.Sc.(Physics)
M.Sc. – III, Semester – VI

Nuclear Physics

L	T	P	Credit
03	01	00	04

PH 308

1. Course Outcomes (COs):

At the end of the semester students will be able to:

CO1	Interpretthe concept of structure of nuclei, and simple nuclear models such as the liquid drop model and the shell model
CO2	Explain the deuteron behavior at ground and excited states
CO3	Classifythe techniques in scattering theory which are relevant in nuclear physics
CO4	Understand the differences between various decay modes, state selection rules, and determine whether a given decay can take place
CO5	Identify the key features of nuclear fission and fusion and their applications

2. Syllabus:

- **Properties of Nuclei(08 Hours)**
  Constituents of nucleus and their Intrinsic properties, quantitative facts about mass, radii, charge density, matter density and its experimental determination, binding energy, average binding energy, Packing fraction, BE/A vs. A plot, stability of nuclei (N Vs Z plot), angular momentum, parity, magnetic moment, electric moments.

- **Nuclear Models(08 Hours)**
  Liquid drop model approach, Weizsacker's semi-empirical mass formula and significance of its various terms, condition of nuclear stability, Mass parabolas -Prediction of stability against beta decay for members of an isobaric family, Stability limits against spontaneous fission. Fermi gas model (degenerate fermion gas, nuclear symmetry potential in Fermi gas), evidence for nuclear shell structure, nuclear magic numbers, basic assumption of shell model, Rotational spectra, concept of mean field, residual interaction, concept of nuclear force, Deuteron problem, Meson theory of nuclear forces.

- **RADIOACTIVITY DECAY(08 Hours)**
  Alpha decay: basics of α-decay processes, theory of α-emission, Gamow factor, Geiger Nuttall law, α-decay spectroscopy, decay Chains. Β-decay: energy kinematics for β-decay, β-spectrum, positron emission, electron capture, neutrino hypothesis. Gamma decay: Gamma rays emission from the excited state of the nucleus & kinematics, internal conversion.

- **INTERACTION OF NUCLEAR RADIATION WITH MATTER(06 Hours)**
  Energy loss due to ionization (Bethe-Block formula), energy loss of electrons, Cerenkov radiation. Gamma ray interaction through matter (photoelectric effect, Compton scattering, pair production), neutron interaction with matter.

- **NUCLEAR REACTIONS(06 Hours)**
  Types of Reactions, Coulomb scattering (Rutherford scattering) Coulomb barrier, Conservation Laws, kinematics of reactions, Q-value, reaction rate, reaction cross section, Concept of compound and direct Reaction, Optical model, resonance reaction.

21/03/2020

- **NUCLEAR ENERGY(FUSION AND FISSION** **(06 Hours)**
  Introduction,Asymmetric fission -Mass yield, Emission of delayed neutrons, Nuclear energy release in fission, Nature of fission fragments, Energy released in the fission of U235, Fission of lighter nuclei, Fission chain reaction, Neutron cycle in a thermal nuclear reactor (Four Factor Formula), Nuclear power and breeder reactors, Natural fusion Possibility of controlled fusion.

(Total Lecture Hours: 42 Hours)

3. Books Recommended:

1. Kenneth S. Krane,Introductory Nuclear Physics Wiley India Pvt. Ltd., 2008.
2. S. N. Ghoshal,Nuclear Physics, First edition, S. Chand Publication, 2010.
3. S.B. Patel, Nuclear Physics,New Age International (P) Ltd. 2012.
4. D. C. Tayal,Nuclear Physics, 5th ed., Himalayan Publishing House 2009.
5. K Heyde,Basic Ideas and concepts in Nuclear Physics: An introductory Approach, Third edition, IOP Publication, 1999.

Additional Books:

1. Bernard L Cohen Concepts of Nuclear Physics, Tata McGraw Hill Publication, 1974.
2. G.F. Knoll,Radiation detection and measurement, John Wiley & Sons, 2010.
3. William R Leo,Technique for Nuclear and Particle Physics experiments, Springer, 1994.

31/08/2020

Third year of Five Years Integrated M.Sc.(Physics)
M.Sc. – III, Semester – VI

Basic course on Relativity

L	T	P	Credit
03	00	00	03

PH 362

1. Course Outcomes (COs):

At the end of the semester students will be able to:

CO1	Interpret the concepts of special and general theory of relativity
CO2	Analyse how relativistic processes are studied, understood and utilised for furthering our understanding of the universe
CO3	Apply the concepts and theories to a range of problems related to relativity
CO4	Approach and solve new problems in the range of relativity
CO5	Evaluate and analyse the recent observations of objects/events

2. Syllabus:

- **INTRODUCTION TO THE COURSE(04 Hours)**
  Inertial Frames, Universality of Newton's second law in all inertial frames, Classical Relativity, Does universal rest (ether) exists? Michelson Morley Experiment.

- **SPECIAL THEORY OF RELATIVITY(08 Hours)**
  Postulates of Special Theory of Relativity, Concept of transformation, Galilean Transformation, Simultaneity of two events in different inertial frames of reference and its frame dependence. Lorentz Transformation. Length Contraction and Time dilation with examples. Velocity Transformation, Relative velocity with examples, Time like and Space Like intervals, Causality.

- **FOUR VECTORS (06 Hours)**
  Need to redefine Momentum, Vector and Four-Vectors. Proper time interval, Velocity and Momentum-Energy Four Vector. Mass-Energy Relationship, Relationship between new energy and momentum.

- **ELECTRODYNAMICS IN LIGHT OF RELATIVITY(06 Hours)**
  Four Dimensional forms of Maxwell's equations. Four dimensional Vector Potential.

- **GENERAL RELATIVITY(10 Hours)**
  Special and General Principle of Relativity, The Gravitational Field, The Equality of Inertial and Gravitational Mass as an Argument for the General Postulate of Relativity.

- **THE EXPERIMENTAL CONFIRMATIONS(08 Hours)**
  Motion of the Perihelion of Mercury, Deflection of Light by a Gravitational Field, Displacement of Spectral Lines towards the Red, Gravitational Waves.

(Total Lecture Hours: 42 Hours)

3. Books Recommended:

1. Einstein A., Relativity: The Special And General Theory, Henry Holt And Company, 1920
2. Ryder L., Introduction to General Relativity, Lewis Ryder, Cambridge University Press, 2009
3. Misner C. W., Kip Thorne, J. A. Wheeler, Gravitation, W. H. Freeman and Co, 1970.
4. Schutz B. F., A First Course in General Relativity , Cambridge University Press, 2009
5. Weinberg S., Gravitation and Cosmology, J. Wiley & sons, 1972.

21/10/2020

Third year of Five Years Integrated M.Sc.(Physics)
M.Sc. – III, Semester – VI

Experimental Techniques IV

L	T	P	Credit
00	00	08	04

PH 312

This course comprises the experiments related to the theory courses of Astrophysics and Space Science, Mathematical Methods in Physics, Digital Electronics, Nuclear Physics and fundamental physics.

9/03/2020

Third year of Five Years Integrated M.Sc.(Physics)
M.Sc. – III, Semester – VI

Mini Project-II

L	T	P	Credit
00	00	04	02

PH 314

This course comprises the project work related to either theoretical and/or experimental topics of physics.

21/08/2020

M.Sc. Year IV (Semester-VII)										
			Teaching Scheme (Hours)				Examination Scheme			
Sr. No.	**Course Code**	**Course Name**	**L**	**T**	**P**	**Credits**	**Theory**	**Tutorial**	**Practical**	**Total Marks**
1	PH 401	Computational Physics	3	1	0	4	100	25	0	125
2	PH 403	Particle Physics	3	1	0	4	100	25	0	125
3	PH 405	Quantum Mechanics-II	3	1	0	4	100	25	0	125
4	PH 4AA	Core Elective – I	3	0	0	3	100	0	0	100
5	PH 4BB	Core Elective – II	3	0	0	3	100	0	0	100
6	PH 407	Experimental Techniques-V	0	0	8	4	0	0	200	200
7	PH 409	Mini Project-III	0	0	4	2	0	0	100	100
		Total	**15**	**3**	**12**	**24**	**500**	**75**	**300**	**875**
									Total Lecture Hours	**30**
									Total Credits	**24**

Core Electives-I										
			Teaching Scheme (Hours)				Examination Scheme			
Sr. No.	**Course Code**	**Course Name**	**L**	**T**	**P**	**Credits**	**Theory**	**Tutorial**	**Practical**	**Total Marks**
1	PH 421	Green's Function and Partial Differential Equations	3	0	0	3	100	0	0	100
2	PH 423	Remote Sensing	3	0	0	3	100	0	0	100
3	PH 425	Nanoscience and Nanotechnology	3	0	0	3	100	0	0	100

Core Electives-II										
			Teaching Scheme (Hours				Examination Scheme			
Sr. No.	**Course Code**	**Course Name**	**L**	**T**	**P**	**Credits**	**Theory**	**Tutorial**	**Practical**	**Total Marks**
1	PH 427	Materials Science	3	0	0	3	100	0	0	100
2	PH 429	Density Functional Theory	3	0	0	3	100	0	0	100

21/08/2020

M.Sc. Year IV (Semester-VIII)

			Teaching Scheme (Hours)				**Examination Scheme**			
Sr. No.	**Course Code**	**Course Name**	**L**	**T**	**P**	**Credits**	**Theory**	**Tutorial**	**Practical**	**Total Marks**
1	PH 402	Statistical Mechanics	3	1	0	4	100	25	0	125
2	PH 404	Condensed Matter Physics	3	1	0	4	100	25	0	125
3	PH 406	Electronics and Optical Communication	3	1	0	4	100	25	0	125
4	PH 4CC	Core Elective – III	3	0	0	3	100	0	0	100
5	PH 4DD	Core Elective – IV	3	0	0	3	100	0	0	100
6	PH 408	Experimental Techniques-VI	0	0	8	4	0	0	200	200
7	PH 412	Dissertation Preliminaries	0	0	4	2	0	0	100	100
		Total	**15**	**3**	**12**	**24**	**500**	**75**	**300**	**875**
									Total Lecture Hours	**30**
									Total Credits	**24**

Core Electives-IV

			Teaching Scheme (Hours)				**Examination Scheme**			
Sr. No.	**Course Code**	**Course Name**	**L**	**T**	**P**	**Credits**	**Theory**	**Tutorial**	**Practical**	**Total Marks**
1	PH 428	Many-Body Physics and Relativistic Quantum Mechanics	3	0	0	3	100	0	0	100
2	PH 432	Microprocessor	3	0	0	3	100	0	0	100
3	PH 434	Advanced Crystallography	3	0	0	3	100	0	0	100

21/08/2020

Fourth year of Five Years Integrated M.Sc.(Physics)
M.Sc. – IV, Semester – VII

Computational Physics

L	T	P	Credit
3	1	0	4

PH 401

1. Course Outcomes (COs):

At the end of the semester students will be able to:

CO1	Apply the numerical methods
CO2	Solve the problems involving partial differential equations numerically
CO3	Interpret the concept of Fourier series, Fourier integral and extend it to conclude the Fourier transform and its applications
CO4	Explainthe strategy of Monte-Carlo methods by making use of random numbers
CO5	Apply the Monte-Carlo methods for quantum mechanical systems
CO6	Analyze various physics problems by applying numerical techniques

2. Syllabus:

- **REVIEW OF NUMERICAL METHODS(10 Hours)**
  Errors & approximation, Algebraic and transcendental equations, System of linear equations, Least square curve fitting, Finite differences and difference operators, Newton's & Lagrange's Interpolation, Numerical integration, Numerical solution of ordinary differential equations, Numerov's method, Shooting method.

- **NUMERICAL SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS (05 Hours)**
  Introduction, Wave equation, Laplace's and Poisson's equations, Heat diffusion equation.

- **FOURIER ANALYSIS AND FOURIER TRANSFORM (10 Hours)**
  Fourier series of a periodic function, Examples. Half-range expansions, Fourier cosine and sine integral, Fourier cosine and sine transform, The Fourier transform, FFT, DFT.

- **MONTE-CARLO METHODS(05 Hours)**
  Introduction, Random numbers, Multiplicative congruential algorithm, Applet of random number, Buffon's needle experiment, Monte-Carlo integrations, Particle in a box, Radio-active decay, Random walk, Examples.

- **QUANTUM MONTE-CARLO METHODS (04 Hours)**
  Introduction, Variational Monte-Carlo method (VMC), Metropolis algorithm, VMC for quantum mechanical systems – Harmonic oscillator.

- **NUMERICAL TECHNIQUES FOR PHYSICS PROBLEMS- EXAMPLES(08 Hours)**
  Power spectrum of a driven pendulum under damping, The Legendre polynomials generator, Random number generator, π value calculation, Random walk, Heat distribution problem, RMS current by numeric integration.

(Total Lecture Hours: 42 Hours)

21/08/2020

3. Books Recommended:

1. Kreyszig, E., Advanced Engineering Mathematics 10th edition Wiley 2018
2. Arfken, G. B. and Weber, H. J., Mathematical Methods for Physicists, Academic Press. 2005
3. Chapra, S. G. and Canale, R. P., Numerical methods for Engineers, McGraw Hill 2006
4. Giordano, N. J. and Nakanishi, H., Computational Physics, Pearson-Prentice-Hall 2005
5. Joel Franklin,Computational Methods for Physics,Cambridge India 2015

21/10/2020

Fourth year of Five Years Integrated M.Sc.(Physics)
M.Sc. – IV, Semester – VII

Particle Physics

L	T	P	Credit
03	01	00	04

PH 403

1. Course Outcomes (COs):

At the end of the semester students will be able to:

CO1	Classify the principle and operation of various accelerators and detectors
CO2	Explain the fundamentals of particle interactions and decay laws
CO3	Interpret the concepts of relativistic kinematics and Feynman calculations
CO4	Examine the symmetries associated with conservation laws and properties of quarks
CO5	Analyze the bound states of hydrogen atom structure and its association with particle physics and inspect the historical background of neutrino experiments, double beta decay and neutrino oscillations

2. Syllabus

- **PARTICLE ACCELERATORS AND DETECTORS(05 Hours)**
  Electrostatic accelerators, cyclotron, synchrotron, linear accelerators, colliding beam accelerators, gas-filled counters, scintillation detectors, semiconductor detectors.

- **REVIEW OF PARTICLE PHYSICS(06 Hours)**
  Historical Introduction, Classification and Natural Units, Feynman Diagrams for the fundamental interactions, decays and conservation laws.

- **RELATIVISTIC KINEMATICS(02 Hours)**
  Lorentz transformations, Four Vectors, Energy and momentum, Collisions.

- **SYMMETRIES AND QUARKS(04 Hours)**
  Symmetries, Groups, Conservation laws, Spin and Angular Momentum, Addition of angular momentum, Flavour symmetries, Parity, Charge conjugation, CP Violation, Time reversal and the CPT Theorem. Mesons, Baryons hadron masses and colour factor.

- **BOUND STATES(04 Hours)**
  The Schrodinger equation for the central potential, Hydrogen atom, Fine structure, Lamb shift, Hyperfine structure, Positronium, quarkonium, Light quark mesons, Baryon masses and magnetic moment.

- **FEYNMAN CALCULATION(05 Hours)**
  Life time and cross section, Golden Rule, The Feynman rules for toy theory, lifetime scattering, Higher order diagrams.

- **BIRTH OF NEUTRINO AND IMPORTANT HISTORICAL EXPERIMENTS(06 Hours)**
  The birth of neutrino, Neutrino Detection, Solar Neutrino Detection, Parity violation, helicity measurement, differentiation of $\nu\mu$ and νe, Discovery of Weak Neutral currents and Weak gauge bosons, Observation of neutrinos from SN 1987A, Number of neutrino flavors from width of Z boson.

21/10/2020

- **DOUBLE BETA DECAY AND NEUTRINO OSCILLATIONS(10 Hours)**
  Introduction to double beta decay, double electron capture, decay rates, possibility of neutrinoless double beta decay and measurement of neutrino mass, Nuclear structure effects on matrix elements, Two - neutrino mixing, General formalism of neutrino oscillations, CP and T violation in neutrino oscillations, Neutrino oscillations in matter.

(Total Lecture Hours: 42 Hours)

3. Books Recommended:

1.D. H. Perkins,Introduction to High Energy Physics, Addison Wesley, 1982
2.F. Halzen and A. D. Martin,Quarks and Leptons: An Introductory Course in Modern Particle Physics, John Wiley & Sons, 1983
3.G. D. Coughlan, J. E. Dodd and B. M. Gripaios, The ideas of Particle Physics: An introduction for Scientists, Cambridge University Press, 1984.
4.Griffiths, David. Introduction to elementary particles. John Wiley & Sons, 2008.
5.Kai Zuber, Neutrino Physics, Series in High Energy Physics, Cosmology and Gravitation, Taylor and Francis Group 2004.

21/07/2020

Fourth year of Five Years Integrated M.Sc.(Physics)
M.Sc. – IV, Semester – VII

Quantum Mechanics-II

L	T	P	Credit
03	01	00	04

PH 405

1. Course Outcomes (COs):

At the end of the semester students will be able to:

CO1	Interpret the fundamental phenomena associated with time-independent and time-dependent perturbation theories
CO2	Examine the principles of symmetry related to identical particles
CO3	Interpret the characteristics of scattering phenomena
CO4	Explainthe Feynman formalism and path integrals for propagators
CO5	Analyze the adiabatic approximations, berry phase, Aharonov–Bohm effect and Hartree-Fock approximation

2. Syllabus:

- **TIME-INDEPENDENT PERTURBATION THEORY(06 Hours)**
  Non-degenerate Case, The Degenerate Case, Hydrogen like Atoms: Fine Structure and the Zeeman Effect, Variational Methods, WKB approximations.

- **TIME-DEPENDENT PERTURBATION THEORY(06 Hours)**
  The Interaction Picture, Time-Dependent Perturbation Theory, Fermi's Golden rule, Applications to Interactions with the Classical Radiation Field, Energy Shift and Decay Width.

- **IDENTICAL PARTICLES(06 Hours)**
  Permutation Symmetry, Symmetrization Postulate, Two-Electron System, The Helium Atom, Permutation Symmetry and Young Tableaux, Spins and Statistics, Slatter determinant.

- **SCATTERING THEORY(14 Hours)**
  Green's Functions, The Lippmann-Schwinger Equation, The Born Approximation, Optical Theorem, Eikonal Approximation, Scattering matrix, Free-Particle States: Plane Waves Versus Spherical Waves, Method of Partial Waves, Low-Energy Scattering and the Bound States, Resonance Scattering, Identical Particles and Scattering, Symmetry Considerations in Scattering, Time-Dependent Formulation of Scattering, Inelastic Electron-Atom Scattering, Coulomb Scattering.

- **PATH INTEGRALS (06 Hours)**
  The Dirac picture, propagators, transition amplitude and propagators, sum over paths, Feynman formalism, equivalence to Schrodinger equation, solving for some potentials.

- **SPECIAL TOPICS(04 Hours)**
  Adiabatic approximations, Berry Phase, Aharonov–Bohm effect, Hartree-Fock approximation.

21/07/2020

(Total Lecture Hours: 42 Hours)

3. BOOKS RECOMMENDED:

1.Sakurai, Jun John, and Jim Napolitano. Modern quantum mechanics. Vol. 185. Harlow: Pearson, 2014.
2.Zettili, Nouredine. Quantum mechanics: concepts and applications. Wiley, 2003
3.Shankar, Ramamurti. Principles of quantum mechanics. Springer Science & Business Media, 2012.
4.Griffiths, David J., and Darrell F. Schroeter. Introduction to quantum mechanics. Cambridge University Press, 2018.
5.Mathews P.M., and VenkateshanK.,A Text book of Quantum Mechanics;McGraw Hill Education; 2 edition (2017)

2/02/2020

Fourth year of Five Years Integrated M.Sc.(Physics)
M.Sc. – IV, Semester – VII

Green's Function and Partial Differential Equations

L	T	P	Credit
3	0	0	03

PH 421

1. Course Outcomes (COs):

At the end of the semester students will be able to:

CO1	Identify the correlation between the Green's function and Ordinary differential equations
CO2	Apply the methods for solving Green's functions
CO3	Interpretthe mathematical modeling for partial differential equations
CO4	Examine the characteristics of diffusion equation
CO5	Analyze the equations of Laplace, Poisson, wave phenomena and linear transport theory

2. Syllabus:

- **GREEN'S FUNCTIONS AND ORDINARY DIFFERENTIAL EQUATIONS(04 Hours)**
  The Dirac-Delta functions and its properties, Definition of Green's function, initial value problem, superposition integral, the boundary value problem.

- **METHODS OF SOLVING FOR GREEN'S FUNCTIONS(05 Hours)**
  Eigenvalue expansions, Combining green's functions, Fourier transform method, retarded and advanced greens functions, applications to sample ODEs.

- **MODELING USING PARTIAL DIFFERENTIAL EQUATIONS(04 Hours)**
  Mathematical Modeling, Partial differential equations and their types, well-posed problem, linear and non-linear PDEs, order of PDEs.

- **DIFFUSION EQUATION(07 Hours)**
  Introduction, conduction of heat, well-posed problem, separation of variables solution, the Cauchy problem, Fourier Series solution, Green's function for the Diffusion equation, Applications to Finance.

- **LAPLACE AND POISSON'S EQUATION(07 Hours)**
  Introduction, Harmonic functions, well-posed problem and uniqueness, properties of the solutions, solution of the Poisson's equation for some mass distributions, green's function for Laplace equation.

- **LINEAR TRANSPORT EQUATION(05 Hours)**
  Introduction, formulation of the problem and modeling, well-posed problem, stability calculations, integral solution, Green's function for the transport equation, applications.

- **WAVE EQUATION(10 Hours)**
  Concepts related to waves, group velocity and dispersion relations, finite speed of information transfer, waves on a string, 1-D wave equation, initial and boundary value problems, separation of variables, d'Alembert equation, the linear and non-linear case, the Cauchy problem, Green's Function for the wave equation.

31|07|2020

(Total Lecture Hours: 42 Hours)

3. Books Recommended:

1. Salsa, S., 2016. Partial differential equations in action: from modeling to theory (Vol. 99). Springer.
2. Duffy, D.G., 2015. Green's functions with applications. Chapman and Hall/CRC.
3. Farlow, S.J., 1993. Partial differential equations for scientists and engineers. Courier Corporation.
4. Kreyszig, E., Stroud, K. and Stephenson, G., 2008. Advanced engineering mathematics. Integration.
5. G. F. Roach, Green's FunctionsCambridge University Press; 2 edition (27 May 1982)

21/08/2020

Fourth year of Five Years Integrated M.Sc.(Physics)
M.Sc. – IV, Semester – VII

Remote Sensing

L	**T**	**P**	**Credit**
03	**00**	**00**	**03**

PH 423

1. Course Outcomes (COs):

At the end of the semester students will be able to:

CO1	Interpret the concepts of remote sensing
CO2	Analyze how physical processes are studied, understood and utilized for furthering our understanding of the interaction of radiation with matter in connection with remote sensing
CO3	Apply the concepts of photogrammetry and remote sensing to different problems
CO4	Evaluate the applications to various problems related to remote sensing

2. Syllabus:

- **CONCEPTS AND FOUNDATIONS OF REMOTE SENSING** **(06Hours)**
  Energy sources and Radiation principles, Energy interactions in the atmosphere, energy interactions with earth surface features, Data acquisition and Interpretations, Reference data, The Global Positioning System An ideal remote sensing system, Characteristics of real remote sensing system.

- **ELEMENTS OF PHOTOGRAPHIC SYSTEMS** **(06Hours)**
  Early history of Aerial photography, Basic negative to positive photographic sequence, Film exposure, Film density and characteristic curves, structure & Spectral sensitivity of black and white, color and color infrared films, film resolution, Aerial cameras, filters, electronic imaging, multiband imaging.

- **REMOTE SENSING SYSTEMS AND SENSORS** **(06Hours)**

Satellite borne systems, direct remote sensing, indirect remote sensing.

- **IMAGE PROCESSING FUNDAMENTALS** **(06Hours)**
  Introduction, Image rectification and restoration, Image enhancement, contrast manipulation, spatial feature manipulation, image classification, different classification schemes, Classification accuracyassessment, Image transmission and compression

- **EVOLUTION OF INTERNATIONAL REMOTE SENSING** **(06Hours)**

Radars and other international satellite systems

- **INDIAN REMOTE SENSING PROGRAMME** **(06Hours)**

Development of IRS system and its components, role and importance of remote sensing.

- **APPLICATIONS OF REMOTE SENSING** **(06Hours)**

Applications in (i) agriculture, (ii) Forestry, (iii) vegetation, and (iv) oceanography

(Total Lecture Hours: 42 Hours)

3. BOOKS RECOMMENDED:

1. Campbell J. B., Introduction to Remote Sensing, Taylor and Francis 1996
2. Kumar M., Remote Sensing, NCERT 2001
3. Liles and T. M. &Keifer R. W., Remote Sensing and Image interpretation, John Wiley & Sons 2002
4. Joseph G., Fundamentals of Remote Sensing, University Press 2004

21/08/2020

5. Wolf P. R., Elements of Photography, McGraw Hill 1974

Fourth year of Five Years Integrated M.Sc. (Physics)
M.Sc. – IV, Semester – VII

Nanoscience and Nanotechnology

L	T	P	Credit
03	00	00	03

PH 425

1. Course Outcomes (COs):

At the end of the semester students will be able to:

CO1	Inferthe fundamentals of nanoscience and nanotechnology
CO2	Classify different synthesis method for nanomaterials
CO3	Explain different types of nanomaterials
CO4	Examine nanomaterials under different characterization techniques
CO5	Interpret the properties of different types of the nanomaterials
CO6	Discuss the application of the nanoscience and nanotechnology

2. Syllabus:

- **INTRODUCTION** **(04Hours)**

  Nanoscale Science and Technology-Implications for Physics, Chemistry, Biology and Engineering; Classifications of nanostructured materials, nanoparticles; 3 quantum dots, nanowires, ultra-thin films-multilayered materials. Length Scales involved and effect on properties: Mechanical, Electronic, Optical, Magnetic and Thermal properties. Introduction to properties and motivation for study (qualitative only).

- **SYNTHESIS METHODS** **(10Hours)**

  Bottom-up Synthesis-Top-down Approach: Precipitation, Mechanical Milling, Colloidal routes, Self-assembly, Vapour phase deposition, MOCVD, Sputtering, Evaporation, Molecular Beam Epitaxy, Atomic Layer Epitaxy, MOMBE.

- **NANOMATERIAL** **(10Hours)**

  The Science of Nano - What is Nanobiotechnology, Introduction to Nanostructures : Carbon Nanotubes (CNT), Graphenes, Fullerenes, Nano Peapods, Quantum Dots and Semiconductor Nanoparticles Metal-based Nanostructures (Iron Oxide Nanoparticles) Nanowires Polymer-based Nanostructures including dendrimers, Introduction to metal based nanostructures, Protein-based Nanostructures: Nanomotors: Bacterial (E. coli) and Mammalian (Myosin family) Nanobiosensors: Science of Self-assembly - From Natural to Artificial Structures Nanoparticles in Biological Labelling and Cellular Imaging

- **CHARACTERIZATION TECHNIQUES** **(08Hours)**

  X-ray diffraction technique, Scanning Electron Microscopy - environmental techniques, Transmission Electron Microscopy including high-resolution imaging, Surface Analysis techniques-AFM, SPM, STM, XPS, , Small-angle X-ray and neutron scattering, Optical and Vibration Spectroscopy, Particle size analyzer

- **PROPERTIES** **(04Hours)**

  Metal Nanoclustures, Semiconducting nanoparticles , Rare Gas and Molecular Clusters

- **APPLICATIONS** **(06Hours)**

  Microelectromechanical Systems (MEMSs), Nanoelectromechanical Systems (NEMSs), catalysis, biomedical applications

(Total Lecture Hours: 42 Hours)

21/07/2020

3. Books Recommended:

1.M.H. Fulekar,Nanotechnology: Importance and Application, IK International, 2010.
2.Challa Kumar,Nanosystem Characterization Tools In The Life Sciences, Wiley-VCH, 2006.
3.Gary Wiederrcht, Handbook of Nanofabrication, Elsevier, 2010.
4.Gabor L. Hornyak, Joydeep Dutta, Harry F. Tibbals, Anil K. Rao,Introduction to Nanoscience, CRC Press, 2008.
5.Guozhong Cao,Nanostructures & Nanomaterials: Synthesis, Properties, and Applications, Imperial College Press, London, 2004.

Additional books:

1. Carbon Nanotechnology by Liming Dai. Elsevier Science, 2006
2. Introduction To Nanotechnology, Charles P. Poole, Jr. Frank J. Owens,John Wiley & Sons, 2003

21/08/2020

Fourth year of Five Years Integrated M.Sc.(Physics)
M.Sc. – IV, Semester – VII

Materials Science

L	T	P	Credit
03	00	00	03

PH 427

1. Course Outcomes (COs):

At the end of the semester students will be able to:

CO1	Interpretthe phenomena associated with crystal growth
CO2	Identify the characteristics of phase equilibrium and nucleation with the help of diagram
CO3	Classify various growth methods for materials synthesis
CO4	Comparethe characterization techniques for assessing material properties
CO5	Analyze the fabrication methods for nanomaterials preparation and its applications for semiconductor devices

2. Syllabus:

- **INTRODUTION TO CRYSTAL GROWTH** **(06Hours)**
  Materials and civilization, structure properties performance, classification of materials, states of matter, theory of liquids, transition between states of matter, energetics of transitions, structure of solids, crystallization, three dimensional bonding, interatomic distances, generalization based on bonding, formation of amorphous solids, metallic glasses, colloidal state of matter, gels, emulsions, liquid crystals, plasma state of matter, advanced materials, composite materials, modern materials needs, Polymeric materials, Organic Semiconductors, Ceramics.

- **PHASE EQUILIBRIUM AND NUCLEATION** **(08Hours)**
  Phase diagrams, definition and basic concepts, Gibb's phase rule, one component and two component phase diagrams, properties of phases in materials, crystalline and non-crystalline phases, practical aspects of phase diagram, non-equilibrium in phase diagrams, iron carbon alloy, Phase deformation in materials, nucleation, growth of nuclei, solidification of alloys, common phase transformations in solid materials

- **GROWTH TECHNIQUES** **(08Hours)**
  Crystal Growth from Melt, Solution, Vapour, Hydrothermal synthesis etc., Epitaxial Techniques, Liquid Phase Epitaxy, Vapour Phase Epitaxy, Metal Organic Chemical Vapour Deposition (MOCVD), Molecular Beam Epitaxy (CBE), Atomic Layer Epitaxy (ALE)

- **MATERIAL PROPERTIES AND CHARACTERIZATION** **(08 Hours)**
  Points defects in solids, lattice vacancies, colourcentres produced by irradiation with x-rays, methods of characterizations, single crystal technique, Fourier computational methods, techniques and applications of neutron diffraction, comparison of neutron and X-ray diffraction, Elastic and plastic behaviour of materials, viscous and viscoelastic deformation, character of plastic flow, deformation of crystalline materials, plastic deformation, creep fracture, fatigue, hardness, Magnetic properties, types of magnetic materials, applications, Optical properties of metals and non-metals, optical materials, luminescence excitation and emersion, decay mechanisms, thallium activated alkali halides, electroluminescence.

- **NANOMATERIALS** **(06Hours)**
  Introduction to nanomaterials, Fabrication of nanomaterials, Properties of materials at nano-scale, The era of new nanostructures of Carbon, Carbon Nano Tubes, Characterization of nanostructures, SPM, STM, AFM, SEM, TEM.

21|10|2020

- **MATERIALS DESIGN FOR SEMICONDUCTOR DEVICES** **(06Hours)**
  Semiconductor optoelectronic properties, III-V materials selection, semiconductor device structure for laser diodes, light emitting diodes (LED's), Photo cathodes, Microwave field-effect transistor.

  (Total Lecture Hours: 42 Hours)

3. Books Recommended:

1.Materials Science and Engineering, Callister W. D., 6th edition Wiley 2006
2. Raghavan, Materials Science and Engineering: A First Course, PHI; 6th edition 2015
3.W. F. Smith, J. Hashemi, R. Prakash, Materials Science and Engineering (In Si Units), McGraw HillEducation; 5th edition (1 July 2017).
4.Crystal Growth for Beginners:Fundamentals of Nucleation, Crystal Growth and Epitaxy 3rd Edition, Ivan V Markov World Scientific 2016
5.Springer Handbook of Crystal Growth (Springer Handbooks) 1st Edition, G. Dhanaraj, K. Byrappa, V. Prasad, M. Dudley Springer 2010

21/08/2020

Fourth year of Five Years Integrated M.Sc.(Physics)
M.Sc. – IV, Semester – VII

Density Functional Theory

L	T	P	Credit
03	00	00	03

PH 429

1. Course Outcomes (COs):

At the end of the semester students will be able to:

CO1	Infer the Thomas-Fermi energy and minimum energy principle
CO2	Identify the exchange and correlation energy by using Hartree-Fock Method
CO3	Interpret the Hohenberg-Kohn theorem and Kohn-Sham equations using variational principle
CO4	Analyze the approximations for exchange correlation energies and their applications
CO5	Apply time dependent density functional theory to excited states problems

2. Syllabus:

- **BACKGROUND** **(10Hours)**
  Thomas-Fermi Theory, Electron Density, Potential Relation, Minimum Energy Principle and Chemical Potential, Exchange energy from Fermi hole
- **EXCHANGE AND CORRELATION ENERGY** **(05Hours)**
  Hartree-Fock Method, Exchange energy in atoms, Correlations in Thomas Fermi Framework
- **HOHENBERG-KOHN THEOREM** **(05Hours)**
  Hohenberg-Kohn Theorem, V-Representability, derivative discontinuity, Spin Polarized systems, Density Matrix Functional.
- **KOHN-SHAM EQUATIONS AND VARIATIONAL PRINCIPLE** **(10Hours)**
  Basic Kohn-Sham equations, Variational principle and self-consistent equations, Extension to magnetic and multi-component systems
- **EXCHANGE CORRELATION ENERGIES** **(05Hours)**
  Approximations for exchange correlation energies and their application to atoms, molecules and solids.
- **TIME DEPENDENT DENSITY FUNCTIONAL THEORY** **(07Hours)**
  Relativistic and time dependent density functional theory and its application to excited states problems.

(Total Lecture Hours: 42 Hours)

3. BOOKS RECOMMENDED:

1. Parr, R. G. & Yang, W. Density-Functional Theory of Atoms and Molecules. (Oxford University Press, USA, 1994).
2. Koch, W. &Holthausen, M. C. A Chemist's Guide to Density Functional Theory. (John Wiley & Sons, 2015).
3. R. E. Nalewajski, Density Functional Theory (Relativistic & Time Dependent), Springer Verlag, 1996.
4. R. M. Martin, Electronic Structure: Basic Theory and Practical Methods, Cambridge University Press, 2004.
5. C. Fiolhais, F. Nogueira, M. Marques (eds.), A Primer in Density Functional Theory, Springer Verlag,2003 3

9/10/2020

Fourth year of Five Years Integrated M.Sc.(Physics)
M.Sc. – IV, Semester – VII

Experimental TechniquesV

L	T	P	Credit
00	00	08	04

PH 407

This course comprises the experiments related to the theory courses of Computational Physics, Particle Physics, Quantum Mechanics-II and fundamental physics.

21/07/2020

Fourth year of Five Years Integrated M.Sc.(Physics)
M.Sc. – III, Semester – VI

Mini Project-III

L	T	P	Credit
00	00	04	02

PH 409

This course comprises the project work related to either theoretical and/or experimental topics of physics.

21/07/2020

Fourth year of Five Years Integrated M.Sc.(Physics)
M.Sc. – IV, Semester – VII
Statistical Mechanics

L	T	P	Credit
03	01	0	04

PH 402

1. Course Outcomes (COs):

At the end of the semester students will be able to:

CO1	Identify the relevance between statistics and thermodynamics
CO2	Interpret the properties of microcanonical, canonical and grand canonical ensembles
CO3	Examine the quantum statistics and density matrix for various systems
CO4	Classify the consequences associated with Bose-Einstein and Fermi-Dirac statistics
CO5	Analyze the Ising model and its solution
CO6	Inferthe Einstein-Smoluchowski theory and Fokker-Planck and master equations

2. Syllabus:

- **THE STATISTICAL BASIS OF THERMODYNAMICS** **(09Hours)**
  The connection between statistics and thermodynamics; Concept of microstates phase space and its connection to Entropy; Classical Ideal Gas and the Maxwell Boltzmann Distribution, Entropy of mixing and Gibbs Paradox

- **ELEMENTS OF ENSEMBLE THEORY** **(08Hours)**
  Liouville's Theorem, Microcanonical Ensemble, Canonical Ensemble and Partition Function calculation for various systems; Energy fluctuations in the Canonical Ensemble; Grand Canonical Ensemble; Number Density and Energy Fluctuations in the Grand Canonical ensemble

- **FORMULATION OF QUANTUM STATISTICS** **(12Hours)**
  Quantum Statistics and calculation of the Density matrix for various systems; Indistinguishability of Particles, Symmetric and Anti - Symmetric wave functions and calculation of the Bose-Einstein and Fermi-Dirac Distribution for a quantum Ideal Gas; Thermodynamic behaviour of an Ideal Bose Gas, Black-Body radiation and other applications of Bose-Einstein statistics; Thermodynamic behaviour of an ideal Fermi gas and various applications of Fermi-Dirac statistics such as Pauli paramagnetism and calculation of Chandrasekhar limit in White Dwarf stars; Cluster expansion techniques for interacting systems.

- **THE ISING MODEL** **(05Hours)**
  Introduction to basic ideas of phase transitions via the Ising model and Van der Waals gas, the exact solution of the Ising model in 1D.

- **NONEQUILIBRIUM STATISTICAL PHYSICS** **(08Hours)**
  Boltzmann's Equation, H-Theorem, Description of Einstein-Smoluchowski theory of Brownian motion as a stochastic process; Basic ideas behind the Fokker-Planck and Master equations with simple examples.

(Total Lecture Hours: 42 Hours)

21/07/2020

3. Books Recommended:

1. Reif, Frederick. Fundamentals of statistical and thermal physics. Waveland Press, 2009.
2. Kardar, Mehran. Statistical physics of particles. Cambridge University Press, 2007.
3. Pathria, R. K., Statistical Mechanics. [SI]. (1996).
4. Huang, Kerson., Statistical Mechanics, John Wiley & Sons. New York (1963).
5. B. B. Laud, Fundamentals of Statistical MechanicsNew Age International Private Limited, January 2012.

9/08/2020

Fourth year of Five Years Integrated M.Sc.(Physics)
M.Sc. – IV, Semester – VIII

Condensed Matter Physics

L	T	P	Credit
03	01	00	04

PH 404

1. Course Outcomes (COs):

At the end of the semester students will be able to:

CO1	Interpret the basic concepts of lattice vibrations and properties of crystal structure
CO2	Explain the phase transitions during the growth process
CO3	Classify the liquid crystals and its applications
CO4	Compare different types of colloids and their formations
CO5	Inferthe magnetism phenomena and its applications
CO6	Summarize the origin of nanoscience and overview of current industrial applications

2. Syllabus:

- **OVERVIEW** **(05 Hours)**
  Crystal physics, Lattice vibration and thermal properties, Electronic properties, Dielectrics, Magnetism.

- **PHASE TRANSITIONS** **(08 Hours)**
  Review of critical phenomena through percolation. Phase transition in softmatter. Equilibrium phase diagrams, Kinetics of phase separation, Growth processes, Liquid-Solid transition, freezing and melting

- **LIQUID CRYSTALS** **(08 Hours)**
  Types of liquid crystals, Characterization and identification of liquid crystal phases, Orientational order, elastic properties, Phase transition in liquid crystals, Applications. Granular Materials through sandpile model and self-organized criticality.

- **COLLOIDS** **(08 Hours)**
  Types of Colloids, Characterization of Colloids, Charge and steric Stabilization, Kinetic properties, Forms of colloids: Sols, Gels, Clays, Foams, Emulsions, Electrorheological and Magneto-rheological fluids.

- **MAGNETISM** **(07Hours)**
  Review of magnetism, Circular and helical order. Consequences of broken symmetry, phase transition, Landau's theory, rigidity, excitation, magnons, domains and domain walls, magnetic hysteresis, pinning effects. Magneto resistance, giant magneto resistance, NMR, technological aspects of magnetic materials

- **INTRODUCTION TO NANOSCIENCE** **(06Hours)**
  The nanoscale dimension and paradigm, Definitions, history and current Practice, Overview of current industry applications, Nanoscale science and engineering principles.

(Total Lecture Hours: 42 Hours)

3. Books Recommended:

1. Introduction To Solid State Physics,C. KittelsWiley India editions, 2018
2. Soft Matter Physics, Masao Doi , Oxford University Press; 1 Edition 2013
3. Magnetism and Magnetic Materials, J. M. D. Coey, Cambridge University Press; 1 edition 2010
4. Introduction to Superconductivity, Michael Tinkham, Medtech 2017
5. Basic Notions Of Condensed Matter Physics, Philip W Anderson, CRC Press; 1 edition 2018

21/08/2020

Fourth year of Five Years Integrated M.Sc.(Physics)

M.Sc. – IV, Semester – VIII

Electronic and Optical Communication

L	T	P	Credit
03	01	00	04

PH 406

1. Course Outcomes (COs):

At the end of the semester students will be able to:

CO1	Apply the Fourier analysis to waveform spectra
CO2	Classify various types of noises in communication
CO3	Examine the properties of amplitude and frequency modulation
CO4	Interpret the characteristics of digital communication
CO5	Infer the phenomena of light transmission in optical fiber and associated attenuation losses
CO6	Analyze the components of optical communication system

2. Syllabus

- **WAVEFORM SPECTRA** **(06 Hours)**
  Various waveforms, Fourier series for periodic waveform, Fourier coefficients, Spectrum for the trigonometric Fourier series, Exponential Fourier series, Energy Signals and Fourier transform, FFT, Inverse FFT, Power Signal, Band-width.

- **NOISE** **(04 Hours)**
  Thermal noise, Shot noise, Partition noise, Flicker noise, Burst noise, Avalanche noise, Transistor noise, Signal to noise ratio, Noise factor, Noise temperature.

- **MODULATION** **(10Hours)**
  Review of amplitude modulation, Introduction to frequency modulation, Sinusoidal FM, Non-sinusoidal modulation, Deviation ratio, Modulation index for sinusoidal FM, Phase modulation, Equivalence between PM and FM, Digital phase modulation, Angle modulation circuits, Pulse amplitude modulation, Pulse code modulation, Pulse frequency modulation, Pulse time modulation, Pulse position modulation, Pulse width modulation.

- **DIGITAL COMMUNICATION** **(10 Hours)**
  Synchronisation, Asynchronous transmission, Bit error in baseband transmission, Matched filter, Bit-timing recovery, Digital carrier systems.

- **LIGHT TRANSMISSION IN OPTICAL FIBER** **(06 Hours)**
  Principle of light transmission in optical fiber, Numerical aperture, Losses in optical fiber, Dispersion, Types of optical fiber, fiber modes, attenuation, Signal distortion.

- **OPTICAL COMMUNICATION SYSTEMS** **(06 Hours)**
  Optical sources, Optical Power launching and coupling, Fiber splicing, Connectors, Optical amplifiers, Optical detectors.

(Total Lecture Hours: 42 Hours)

21/08/2020

3. **Books Recommended:**

1.Lathi B. P., Communication systems, Wiley Eastern Ltd 1992
2.Roddy D. and Coolen J., Electronic communications, Prentice Hall 2002
3.Keiser G., Optical fiber communications, McGraw-Hill 2000
4.Haykin S., Communication systems, Wiley India 2006
5.Selvarajan A., Kar S., and Srinivas T., Optical fiber communications : Principles and systems, Tata McGraw Hill 2006

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21/08/2020

Fourth year of Five Years Integrated M.Sc.(Physics)
M.Sc. – IV, Semester – VIII

Global Navigation Satellite System

L	T	P	Credit
3	0	0	3

PH 422

1. Course Outcomes (COs):

At the end of the semester students will be able to:

CO1	Interpretthe fundamentals of navigation systems
CO2	Identify the segments of GNSS
CO3	Analyze the characteristics of satellite signals
CO4	Identify the components of receiving systems
CO5	Apply the GNSS in surveying, location based services and aircraft landing

2. Syllabus

- **INTRODUCTION AND OVERVIEW** **(02 Hours)**
- **FUNDAMENTALS OF NAVIGATION SYSTEM** **(10 Hours)**
  Concept of Ranging using Time of Arrival, Reference coordinate system, fundamentals of satellite orbits, positioning
- **DIFFERENT SATELLITE NAVIGATIONAL SYSTEMS** **(06 Hours)**
  GPS, Galileo, IRNSS, Beidou etc.
- **GNSS SEGMENTS** **(06 Hours)**
  Control Segment, Space segment, User segment
- **SATELLITE SIGNAL CHARACTERISTICS** **(06 Hours)**
  Frequency and modulation, tracking loops, filters, formation of pseudorange, signal acquisition, processing
- **RECEIVING SYSTEMS** **(06 Hours)**
  Single frequency receivers, Dual frequency receivers, position accuracy, dilution of precision, New frequencies added
- **APPLICATIONS OF GNSS** **(06 Hours)**
  Surveying, location based services, aircraft landing, others

(Total Lecture Hours: 42 Hours)

3. Books Recommended:

1. Kaplan E.D. (ed) Understanding GPS: Principles and applications Artech House
2. Rabbany Ahmed Introduction to GPS: The Global Positioning System Artech House 2006
3. Guochang Xu GPS: Theory, Algorithms and Applications Springer 2007
4. Bradford W. Parkiwson (Ed.), James J. Jr. Spilker (ed.) James J. Spilker per enge (contributor) Global positioning system : Theory and applications (American Inst. Of Aeronautics &Astronaulid 1996
5. James Bao Yen TsuiFundamentals of Global Positioning system Receivers John Wiley & Sons 2005

21/08/2020

Fourth year of Five Years Integrated M.Sc.(Physics)
M.Sc. – IV, Semester – VIII

Thin Films and Vacuum Technology

L	T	P	Credit
03	00	00	03

PH 424

1. Course Outcomes (COs):

At the end of the semester students will be able to:

CO1	Evaluate and use models for nucleating and growth of thin films.
CO2	Interpret the general principles and techniques of thin film deposition.
CO3	Apply important laws of physics which govern how a vacuum system works
CO4	Account for which components are used in a vacuum system, their construction, function and use.
CO5	Discuss typical thin film applications.

2. Syllabus:

- **INTRODUCTION TO SURFACE PHYSICS** **(06 Hours)**
  Thermodynamic Potentials and the Dividing Surface, Surface Tension and Surface Energy, Surface Stress and Surface Energy, Surface Diffusion and the Boltzmann Distribution. Chemical Potential and Driving Force, Thermodynamics of Vapor Pressure.

- **GROWTH OF THIN FILMS** **(08 Hours)**
  Vacuum and Kinetic Theory of Gasses, Pressure and Molecular Velocity, The Molecular Density, Collision Frequency, The Mean Free Path, Gas Flow Regimes: viscous, turbulent and molecular flow, Collisions with Surfaces, Kinetics of Crystal Growth, Diffusion, Nucleation Barriers in Classical and Atomistic Models, Growth Modes: Island Growth, Clustering, Coalescence and Ripening, Monolayer Formation Times.

- **THIN FILM DEPOSITION TECHNIQUES** **(08 Hours)**
  Physical vapor deposition, thermal deposition, Electron beam deposition, Sputtering, Spin-coating, Sol-Gel technique, Epitaxy, Molecular beam epitaxy, Chemical vapor deposition

- **INTRODUCTION TO VACUUM TECHNOLOGY** **(06 Hours)**
  Fundamental Vacuum Concepts, System Volumes, Leak Rates and Pumping Speeds, Cryopump, The Idea of Conductance, Measurement of System Pressure, Surface Preparation and Cleaning Procedures for Vacuum Systems.

- **VACUUM SYSTEM OPERATION** **(06 Hours)**
  Types of Vacuum Pumps, Rotary pump, Diffusion pump, TMP, Oil free pumps, Chambers, Tube and Flange Sizes, Valves, Choice of Materials, Pressure Measurement and Gas Composition, Pressure Measurement Gauges, Ultra high vacuum.

- **THIN FILM CHARACTERIZATION AND APPLICATIONS** **(08 Hours)**
  Properties of thin films, optical properties, electrical properties, magnetic properties, mechanical properties, Introduction to Thin film characterization techniques: Imaging Techniques, Structural Techniques, Optical Techniques, Electrical / Magnetic Techniques, Mechanical Techniques, Applications of thin films.

(Total Lecture Hours: 42 Hours)

3. Books Recommended:

1.Smith D. L., Thin-Film deposition : Principle and practice, McGraw Hill 1995
2.Milton Ohring, Materials Science of Thin Films, 2nd Edition, Academic Press, 2001
3.Goswami A., Thin film fundamentals, New Age International 2007
4.Smith D. L., Thin-film deposition: principles and practice, McGraw Hill 1995
5.Seshan K., Handbook of thin-film deposition processes and techniques: principles, methods, equipment and applications, William Andrew, 2002

Additional Books:
1.Weissler G. L., Vacuum physics and technology, Academic Press, 1979

21/07/2020

Fourth year of Five Years Integrated M.Sc.(Physics)
M.Sc. – IV, Semester – VIII

Quantum Field Theory

L	T	P	Credit
3	0	0	3

PH 426

1. Course Outcomes (COs):

At the end of the semester students will be able to:

CO1	Infer the elements of classical field theories
CO2	Identify the second quantization using many-body systems
CO3	Analyze the quantum field theory with the help of scalar fields, fermionic fields and gauge fields
CO4	Interpret the Parity, Charge and Time symmetry for various fields
CO5	Analyze the interfacing peripherals and applications
CO6	Examine the divergence in Feyman diagrams and renormalization

2. Syllabus

- **ELEMENTS OF CLASSICAL FIELD THEORIES** **(03 Hours)**
  Lagrangian formulation; Lorentz invariance; symmetries, Noether's theorem and conserved currents

- **THE METHOD OF SECOND QUANTIZATION** **(03 Hours)**
  Discussing the basic framework for the formulation of many-body quantum systems.

- **QUANTUM FIELD THEORY WITH SCALAR FIELDS** **(07 Hours)**
  Free scalar fields, Klein-Gordon equation, canonical quantization, propagators, Interacting scalar fields Wick's theorem, Feynman rules.

- **QUANTUM FIELD THEORY WITH FERMIONIC FIELDS** **(08 Hours)**
  Gauge symmetries, quantum electrodynamics (QED), canonical quantization, working with Feynman diagrams, studying QED processes

- **QUANTUM FIELD THEORY WITH GAUGE FIELDS** **(08 Hours)**
  Gauge symmetries, quantum electrodynamics (QED), canonical quantization, working with Feynman diagrams, studying QED processes.

- **P, T AND C SYMMETRIES** **(05 Hours)**
  Parity, Charge and Time symmetry for various fields, CP symmetry, CPT symmetry.

- **ADVANCED TOPICS** **(08 Hours)**
  Introduction to path integral quantization, divergences in Feynman diagrams, renormalization.

(Total Lecture Hours: 42 Hours)

3. Books Recommended:

1.Peskin, M.E., 2018. An introduction to quantum field theory. CRC press.
2.Zee, A., 2010. Quantum field theory in a nutshell (Vol. 7). Princeton university press.
3.Srednicki, M., 2007. Quantum field theory. Cambridge University Press.
4.Lancaster, T. and Blundell, S.J., 2014. Quantum field theory for the gifted amateur. OUP Oxford.
5.Lahiri, A. and Pal, P.B., 2005. A first book of quantum field theory. CRC Press

21/08/2020

Fourth year of Five Years Integrated M.Sc.(Physics)
M.Sc. – IV, Semester – VIII

Many-Body Physics and Relativistic Quantum Mechanics

L	T	P	Credit
3	0	0	3

PH 428

1. Course Outcomes (COs):

At the end of the semester students will be able to:

CO1	Inferthe second quantization theories for the system of identical particles
CO2	Identify the characteristics of spin half Fermions and Bosons
CO3	Interpret the relativistic wave equations
CO4	Analyze the Lorentz transformation and covariance of the Dirac equation
CO5	Classify the solutions to the relativistic equations
CO6	Inspect the symmetries of the Dirac equation and conservation laws

2. Syllabus:

- **SECOND QUANTIZATION** **(05Hours)**
  System of identical particles, permutation symmetry, completely symmetric and antisymmetric states, bosons, fermions, field operators, momentum representation.

- **SPIN-½ FERMIONS AND BOSONS** **(10 Hours)**
  Non-interacting fermions, ground state energy and theory of electron gas, Hartree-Fock equation of atoms, Free Bosons, Weakly interacting dilute Bose gas.

- **RELATIVISTIC WAVE EQUATIONS** **(05 Hours)**
  The Klein-Gordon equation, continuity equation, Free solutions of the KG equation, Dirac equation, continuity equation, Dirac matrices, Dirac equation in covariant form, non-relativistic limit.

- **LORENTZ TRANSFORMATIONS AND COVARIANCE OF THE DIRAC EQUATION** **(09 Hours)**
  Transformation of Spinors, Representation of S, properties of S, properties of Gamma matrices, solution of Dirac equation for a free particle, Spinors with momentum, orthogonality relations and density, projection operators, The Foldy–Wouthuysen Transformation, Transformation for Free Particles.

- **SOLUTIONS TO THE RELATIVISTIC EQUATIONS** **(07 Hours)**
  Coupling of the equations to electromagnetic potential, solution to KG equation, solution to Dirac equation, Wave Packets and Zitterbewegung, Superposition of Positive Energy States, the General Wave Packet, General Solution of the Free Dirac Equation in the Heisenberg Representation, Potential Steps and the Klein Paradox, The Hole Theory.

- **SYMMETRIES OF THE DIRAC EQUATION** **(06 Hours)**
  Invariance and Conservation Laws, The General Transformation, Rotations, Translations, Spatial Reflection, Charge Conjugation, Time Reversal Invariance of the Dirac Equation.

21/08/2020

(Total Lecture Hours: 42 Hours)

3. **Books Recommended:**

1. Schwabl, F. Advanced Quantum Mechanics. Beijing: World Publishing Corporation.2012
2. Bjorken, J.D. and Drell, S.D. Relativistic Quantum Mechanics. McGraw-Hill. 1965
3. Negele, J.W. Quantum Many-Particle Systems. CRC Press. 2018
4. Greiner, W.Relativistic Quantum Mechanics (Vol. 3). Berlin: Springer. 1990
5. Sakurai, J.J. Advanced Quantum Mechanics. Pearson Education India. 1967

31/08/2020

Fourth year of Five Years Integrated M.Sc.(Physics)
M.Sc. – IV, Semester – VIII

Microprocessor

L	T	P	Credit
3	0	0	3

PH 432

1. Course Outcomes (COs):

At the end of the semester students will be able to:

CO1	Explainthe architecture of microprocessor 8085
CO2	Identify the programming techniques and set of instructions
CO3	Classify the timing for the execution of input and output instructions
CO4	Inferthe interrupt structure of 8085
CO5	Analyze the interfacing peripherals and applications
CO6	Compare the 8085 and 8086 microprocessors

2. Syllabus

- **INTRODUCTION TO MICROPROCESSOR-8085** **(06 Hours)**
  Basic 8085 microprocessor architecture and its functional blocks, 8085 microprocessor IC pin outs, Memory and Address, data and control buses, Clock signals, Instruction cycles, Machine cycles, Timing states, Instruction timing diagrams.

- **PROGRAMMING 8085 MICROPROCESSOR** **(06 Hours)**
  Basic 8085 instruction set, Programming Techniques with Additional Instructions, Counters and Time delays, Stack and Subroutines, Code Conversion, BCD Arithmetic, and 16-Bit Data Operations.

- **8085 INTERFACING** **(06 Hours)**
  Bus interfacing concepts, Timing for the execution of input and output (I/O) instructions, I/O address decoding, Memory and I/O interfacing, Serial I/O lines of 8085.

- **INTERRUPTS** **(08 Hours)**
  Interrupt structure of 8085, RST (restart) instructions, vectored interrupt, interrupt process and timing diagram of interrupt instruction execution.

- **INTERFACING PERIPHERALS (I/OS) AND APPLICATIONS** **(08 Hours)**
  Interfacing Data Converters, Programmable Interface Devices, General- Purpose Programmable Peripheral Devices, Serial I/O and Data Communication, Microprocessor Applications.

- **ADVANCE MICROPROCESSORS** **(08 Hours)**
  Introduction to Microprocessor-8086, Comparison between 8085 and 8086, and Development of x86 series of microprocessors and microcontrollers.

(Total Lecture Hours: 42 Hours)

21/07/2020

3. **Books Recommended:**

1.Gaonkar R. S., Microprocessor architecture, programming and applications: With the 8085/8080A Wiley Eastern 1995
2.Srinath N. K., 8085 Microprocessor programming and interfacing Prentice Hall 2005
3.Uffenbeck J., Microcomputers and microprocessors : The 8080, 8085 and Z-80 programming inferfacing and troubleshooting Prentice Hall 2005
4.Ghosh P. K. and Sridhar P. R., 0000 to 8085: Introduction to Microprocessors for engineers and scientists Prentice Hall 2006
5.Rafiquzzaman M. Microprocessors and Microcomputer-Based System Design CRC Press1995

21/08/2020

Fourth year of Five Years Integrated M.Sc.(Physics)
M.Sc. – IV, Semester – VIII

Advanced Crystallography

L	T	P	Credit
03	00	00	03

PH 434

1. Course Outcomes (COs):

At the end of the semester students will be able to:

CO1	Analyze the nucleation process and choose proper growth rate condition for crystal growth
CO2	Classify the different experimental crystal growth methods
CO3	Examine defects in crystalline materials after growth
CO4	Explain in detail experimental method for crystal structure
CO5	Determine the crystal structure
CO6	Develop the application of crystals in protein crystallizations

2. Syllabus:

- **NUCLEATION AND GROWTH RATE** **(04 Hours)**
  Nucleation, homogeneous nucleation and heterogeneous nucleation, driving force for crystallization, growth on rough faces, growth on perfect singular faces, growth on imperfect singular faces, transport at growth interface, transport in bulk solids, growth rate of a crystal

- **CRYSTAL GROWTH METHODS** **(10 Hours)**
  Bridgman and related methods-basic processes, Czochralski and related methods: Kyropoulos growth, Dendrite method, Stepanov method, edge define film fed growth, high pressure methods, hydrothermal growth. Chemical vapour transport technique: introduction, some theoretical aspects- concepts of epitaxy, reaction, transport processes, stability condition, closed systems, open systems for bulk crystals, open systems for thin layers.

- **DEFECTS IN CRYSTALLINE MATERIALS** **(08 Hours)**
  Defects in crystalline materials – an introduction, concept of slip, dislocations and slip, cross slip, velocity of dislocations, climb, and experimental observations of climb. Stress field of a dislocation-edge and screw, strain energy of a dislocation, forces on dislocations, forces between dislocations, unit dislocation, partial dislocations- the Shockley partial, Frank partial or Sessile dislocation, Lomer-Cottrell sessile dislocation, Intersections of dislocations, movement of dislocation containing elementary jogs, composite jogs.

- **EXPERIMENTAL METHOD FOR CRYSTAL STRUCTURE** **(08 Hours)**
  Laue Photographs, Powder Photographs, Diffractometer and Spectrometer Measurements

- **APPLICATIONS** **(06 Hours)**
  Orientation and Quality of Single Crystals, Structure of Polycrystalline Aggregates, Determination of Crystal Structure

- **Protein Crystals** **(06 Hours)**
  Protein sources, Protein Purification, Principles of Protein Crystallization, Protein crystallization Techniques, Phase Calculations using isomorphism and anomalous dispersion methods, multiple wave length methods, Ramchandran plot, Protein folding, Application of Synchrotron radiation.

(Total Lecture Hours: 42 Hours)

2|10|20[illegible]

3. **Books Recommended:**

1. Crystal growth processes by J.C. Brice (Blackie and sons Ltd.)
2. Crystal growth by Santaraghvan and P. Ramasamy (Kru Publishers)
3. Introduction to dislocation by D. Hull (Pergamon press)
4. Elements of X-ray diffraction by B.D. Cullity, S.R.Stock, Prentice Hall, New Jersey
5. Physics of Crystal Growth (Collection Alea-Saclay: Monographs and Texts in Statistical Physics)Alberto Pimpinelli, Jacques Villain, Cambridge University Press (10 December 1998)

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21/07/2020

Fourth year of Five Years Integrated M.Sc.(Physics)
M.Sc. – IV, Semester – VIII

Experimental TechniquesVI

L	T	P	Credit
00	00	08	04

PH 408

This course comprises the experiments related to the theory courses of Statistical Mechanics, Condensed Matter Physics, Electronics and Optical Communication and fundamental physics.

21/08/2020

Fourth year of Five Years Integrated M.Sc.(Physics)
M.Sc. – IV, Semester – VIII

Dissertation Preliminaries

L	T	P	Credit
00	00	04	02

PH 412

In this course students will make a literature survey on the chosen area and identify the problem for dissertation. Depending on the problem identified, a dissertation supervisor will be assigned. This course comprises of two seminars related to his/her research problem which will be evaluated by the committee.

21/10/2020

Option-A

M.Sc. Year V (Semester-IX)

			Teaching Scheme (Hours)				Examination Scheme			
Sr. No.	**Course Code**	**Course Name**	**L**	**T**	**P**	**Credits**	**Theory**	**Tutorial**	**Practical**	**Total Marks**
1	PH 501	Dissertation – I Dissertation Part A	0	0	20	10	0	0	400	400
		Total	**0**	**0**	**20**	**10**	**0**	**0**	**400**	**400**
									Total Lecture Hours	**20**
									Total Credits	**10**

OR

Option-B

M.Sc. Year V (Semester-IX)

			Teaching Scheme (Hours)				Examination Scheme			
Sr. No.	**Course Code**	**Course Name**	**L**	**T**	**P**	**Credits**	**Theory**	**Tutorial**	**Practical**	**Total Marks**
1	PH 503	Elementary Excitations in Solids	3	0	0	3	100	0	0	100
2	PH 5AA	Core Elective – V	3	0	0	3	100	0	0	100
3	PH 505	Dissertation – I Dissertation Part A	0	0	8	4	0	0	200	200
		Total	**6**	**0**	**8**	**10**	**200**	**0**	**200**	**400**
									Total Lecture Hours	**14**
									Total Credits	**10**

Core Electives-V

			Teaching Scheme (Hours)				Examination Scheme			
Sr. No.	**Course Code**	**Course Name**	**L**	**T**	**P**	**Credits**	**Theory**	**Tutorial**	**Practical**	**Total Marks**
1	PH 521	Microcontrollers	3	0	0	3	100	0	0	100
2	PH 523	Research Methodology and Data Analysis	3	0	0	3	100	0	0	100
3	PH 525	Non Destructive Testing	3	0	0	3	100	0	0	100
3	PH 527	Electromagnetic Communication	3	0	0	3	100	0	0	100

M.Sc. Year V (Semester-X)

			Teaching Scheme (Hours)				Examination Scheme			
Sr. No.	**Course Code**	**Course Name**	**L**	**T**	**P**	**Credits**	**Theory**	**Tutorial**	**Practical**	**Total Marks**
1	PH 502	Dissertation – II Dissertation Part B	0	0	24	12	0	0	500	500
		Total	**0**	**0**	**24**	**12**	**0**	**0**	**500**	**500**
									Total Lecture Hours	**24**
									Total Credits	**12**

21/08/2020

Fifth year of Five Years Integrated M.Sc.(Physics)
M.Sc. – V, Semester – IX

Dissertation – I Dissertation Part A

L	T	P	Credit
00	00	20	10

PH 501

In this course the students will work on the research problem identified in the earlier semester under the supervision of the supervising teacher and will write a dissertation part A which will be examined by a committee.

21/08/2020

Fifth year of Five Years Integrated M.Sc. (Physics)
M.Sc. – V, Semester – IX

Elementary Excitations in Solids

L	T	P	Credit
3	0	0	3

PH 503

1. Course Outcomes (COs):

At the end of the semester students will be able to:

CO1	Interpretthe concepts and the principles of elementary excitations in solids
CO2	Identify the relevance of approximation methods in elementary excitations in solids and extend the concept to explain the dynamics of complex systems
CO3	Infer the properties of electrons and phonons in electron gas
CO4	Classify the behavior of electrons, plasmons and photons s in solids
CO5	Examine the electron-phonon interactions in metals
CO5	Inspect the concept of second quantization in free fields

2. Syllabus

- **INTRODUCTORY SURVEY** **(06Hours)**
  General considerations, Basic Hamiltonian, Elementary excitations, The measurement of the elementary excitation spectrum.

- **PHONONS** **(06Hours)**
  Lattice dynamics in one dimension, lattice dynamics in three dimension, lattice specific heat, melting criterion, neutron scattering in solids, Phonon-phonon interactions.

- **ELECTRONS AND PLASMONS** **(06 Hours)**
  Sommerfeld non-interacting electron gas, Hartree and Hartree-Fock approximations, correlation and correlation energy, dielectric response of an electron system, Properties of the electron gas in the RPA, Properties of the electron gas at metallic densities.

- **ELECTRONS, PLASMONS, AND PHOTONS IN SOLIDS** **(04Hours)**
  Introductory considerations, Experimental observation of Plasmons in solids, optical properties of solids, optical studies of solids.

- **ELECTRON-PHONON INTERACTION IN METALS** **(10 Hours)**
  Basic Hamiltonian, New features associated with the electron-phonon interaction, General physical picture, High temperature conductivity, Low temperature conductivity, Quasi-particle properties.

- **SECOND QUANTIZATION** **(10 Hours)**
  Quantization of free fields, elastic and electromagnetic fields, quantization of free fields, boson and fermion fields, illustration from problems in scattering

(Total Lecture Hours: 42 Hours)

21/10/2020

3. **Books Recommended:**

1. Elementary Excitations In Solids (Advanced Book Classics) 1st Edition Davide Pines CRC Press 2010
2. Basic Aspects of the Quantum Theory of Solids: Order and Elementary Excitations 1st Edition.D. I. Khomskii Cambridge University Press 2010
3. Elementary Excitations in Solids, Molecules, and Atoms: J. T. Devreese Springer 2012
4. Isotope Low-Dimensional Structures: Elementary Excitations and Applications V. G. Plekhanov. Springer 2012
5. Steven M. G. and Kun Yang. Modern Condensed Matter Physics, Westview Press, 1999.

Fifth year of Five Years Integrated M.Sc.(Physics)
M.Sc. – V, Semester – IX

Microcontrollers

L	T	P	Credit
3	0	0	3

PH 521

1. Course Outcomes (COs):

At the end of the semester students will be able to:

CO1	Compare the microprocessors and microcontrollers
CO2	Interpretthe architecture of 8051 microcontroller
CO3	Outline the fundamentals of timers and counters
CO4	Analyze the assembly language programming of 8051 microcontroller
CO5	Identify the interfacing and data transmission characteristics of 8051 microcontrollers

2. Syllabus:

- **MICROCONTROLLERS** **(06 Hours)**
  Introduction to Microcontrollers, Microprocessors and Microcontrollers, Microcontroller survey, 4, 8, 16, and 32 bit Microcontrollers.
- **MICROCONTROLLER-8051 ARCHITECTURE** **(08 Hours)**
  8051 architecture, Functional blocks, Internal memory, Input- output pins, I/O Ports, External memory, Addressing modes.
- **TIMERS AND COUNTERS** **(08 Hours)**
  Logical separation of program and data memory, timers/counters and programming of counters and timers, register in serial data input/output, serial data Transmission modes.
- **PROGRAMMING 8051** **(10 Hours)**
  Assembly language Programming, Programming tool and techniques. Assembly Language programming for 8051 microcontroller, Data transfer Instruction, Arithmetic instruction, Branch Instructions, Bit manipulation instruction, rotate Instruction, Instructions stack operation, calls and subroutines, Interrupts and returns.
- **INTERFACING 8051 AND DATA TRANSMISSION** **(10 Hours)**
  External Memory and Memory space decoding, Memory Mapped i/o, Memory decoding, Timing subroutines, Time delay using software and timer, Look up tables, Serial data transmission, Character Transmission by polling, Interrupt Driven Character Transmission and reception.

(Total Lecture Hours: 42 Hours)

3. Books Recommended:

1. Ayala K. J., 8051 Microcontroller : Architecture, programming and applications, Penram International 1997
2. Mazidi M. A. and Mazidi J. G.8051 microcontroller and embedded systems, Pearson Education 2003
3. Calcutt D. M., Cowan F. J., Parchizadeh G. H., 8051 microcontrollers: hardware, software, and applications Elsevier 1998
4. Predko M. Programming and customizing the 8051 microcontroller Tata McGraw-Hill 2007
5. MacKenzie I. S., The 8051 microcontroller Prentice Hall 1995

21/08/2020

Fifth year of Five Years Integrated M.Sc.(Physics)
M.Sc. – V, Semester – IX

Research Methodology and Data Analysis

L	T	P	Credit
3	0	0	3

PH 523

1. Course Outcomes (COs):

At the end of the semester students will be able to:

CO1	Analyze uncertainties in measurements, probability distributions and error analysis
CO2	Identify the appropriate methodologyfor a given research problem
CO3	Classify various data collection techniques
CO4	Examine data by statistical approach
CO5	Justify the hypothesis and conclude the limitation of it
CO6	Design the report based on interpretation of the data

2. Syllabus:

- **UNCERTAINTIES IN MEASUREMENTS, PROBABILITY DISTRIBUTIONS, ERROR ANALYSIS** **(08 Hours)**

  Uncertainties in Measurements: Measuring Errors, accuracy and Precision, systematic errors, Random errors, Significant figures and Round off, Uncertainties, Parent and Sample Distributions, Mean, median and mode, Standard Deviation of Distributions. Probability Distributions: Binomial Distributions, Poisson distribution, Gaussian or Normal Error Distribution, Lorentzian Distribution. Selected problems and examples. Error Analysis: Instrumental and Statistical Uncertainties, Propagation of Errors, Specific Error Formulas withy examples, Application of Error Equations. Numerical Errors, Conditioning and Stability, Convergence of Iterative Processes

- **RESEARCH THEORY** **(08 Hours)**

  Research theory and practice: Research basics, Research theory, Structuring the research project, Research ethics, Finding and reviewing the literature. Defining the Research Problem: Selection of a research Problem, Necessity of Defining the Problem, Technique Involved in Defining a Problem: An Illustration. Research Design: Meaning of Research Design, Need for Research Design, Features of a Good Design, Important Concepts Relating to Research Design, Different Research Designs

- **DATA COLLECTIONS** **(08 Hours)**

  Measurement in Research: Measurement Scales, Sources of Error in Measurement, Tests of Sound Measurement, Technique of Developing Measurement Tools. Scaling: Meaning of Scaling, Scale Classification Bases, Important Scaling Techniques, Scale Construction Techniques. Methods of Data Collection: Collection of Primary Data, Observation Method, Collection of Data through Schedules, Some Other Methods of Data Collection

- **DATA ANALYSIS** **(08 Hours)**

21/07/2020

Processing and Analysis of Data: Processing Operations, Some Problems in Processing. Elements/Types of Analysis: Statistics in Research, Measures of Central Tendency, Measures of Dispersion, Measures of Asymmetry (Skewness), Measures of Relationship, Simple Regression Analysis, Multiple Correlation and Regression, Partial Correlation, Association in Case of Attributes.

- **HYPOTHESES** **(06Hours)**
  Testing of Hypotheses-I (Parametric or Standard Tests of Hypotheses): Basic Concepts Concerning Hypothesis and Testing of Hypotheses, Procedure for Hypothesis Testing, Flow Diagram for Hypothesis Testing, Measuring the Power of a Hypothesis Test, Tests of Hypotheses. Important Parametric Tests, Hypothesis Testing of Means, Hypothesis Testing for Differences between Means, Hypothesis Testing for Comparing Two Related Samples. Hypothesis Testing of Correlation Coefficients, Limitations of the Tests of Hypotheses.

- **WRITING** **(04 Hours)**
  Interpretation and Report Writing: Technique of Interpretation, Precaution in Interpretation. Significance of Report Writing, Different Steps in Writing Report, Layout of the Research Report Types of Reports ,Mechanics of Writing a Research Report, Precautions for Writing Research Reports

(Total Lecture Hours: 42 Hours)

3. Books Recommended:

1. Research Methods the Basics by Nicholas Walliaman, Taylor and Francis London& New York 2011.
2. Research Methodology- Methods and Techniques 4th edition. By C R Kothari, New Age Int. Publ. 2019.
3. Data Reduction and Error Analysis for the Physical Sciences 3rd Ed. Philip R Bevington & D Keith Robinson, McGraw – Hill (2003)
4. Numerical Methods by Balagurusamy, Tata McGraw – Hill. 2000
5. Numerical Analysis, 2nd Ed. by Francis Scheid, McGraw-Hill. 2009

Additional books:

1. Numerical mathematical Analysis 6th edition, James B Scarboroughs. Oxford and IBH Publishing. 2005
2. Numerical Methods for Scientists and Engineers, K Sankara Rao, 4th Ed. PHI Learning Pvt Ltd. 2017

21/08/2020

Fifth year of Five Years Integrated M.Sc.(Physics)
M.Sc. – V, Semester – IX

Non Destructive Testing

L	T	P	Credit
03	00	00	03

PH 525

1. Course Outcomes (COs):

At the end of the semester students will be able to:

CO1	Interpretthe stress strain relationships and the application of these to mechanical behavior of a broad range of materials
CO2	Evaluate mechanical behavior, measurements of mechanical properties and test methods.
CO3	Calculate and interprets mechanical properties using Griffith equation
CO4	Identify the importance of non-destructive testing in quality assurance
CO5	Analyze basic of non-destructive testing to detect internal material defects
CO6	Apply the dye penetrant test and magnetic particle test to detect surface defects

2. Syllabus:

- **INTRODUCTION TO NON DESTRUCTIVE TESTING (02 Hours)**

- **MECHANICAL BEHAVIOR OF MATERIALS (10 Hours)**

  Engineering Stress, Engineering Strain, True Stress, True Strain, Shear Stress, Shear Strain, Tensile Test (Tension Test), Elastic and Plastic deformation, Ductility, Toughness, Resilience, Hardness, Hardness testing method, Fatigue, Creep.

  Dislocations & Plastic deformation and Mechanisms of Plastic deformation in metals (Slip System and Twinning), Critical Resolved Shear Stress (Schmid's law), Strengthening Mechanisms in Metals, Recovery, Recrystallization and Grain growth.

- **FRACTURE MECANICS AND MODES OF FAILURES (08 Hours)**

  Types of fractures – Ductile and brittle fractures, Types of Fracture in materials Intergranular Fracture and Transgranular (Intragranular)Fracture, Features of fracture surface for Ductile and Brittle fractography. Stresses around cracks - linear elastic fracture mechanics, Griffith's criterion for brittle crack propagation, Fracture Toughness, Impact testing, Ductile to Brittle Transition Temperature

- **VISUAL TESTING (04 Hours)**

  Fundamentals of Visual Testing, Basic principle, The Eye (defect which can be detected by Unaided visual inspection), Optical aids used for visual inspection, Microscope, Borescope, Endscope, Fibroscope, Holography, Application and Limitation of Visual Testing, Standards and Specifications (ASME, ASTM, AWS, BIS etc.)

- **LIQUID PENETRANT TESTING (04 Hours)**

  Introduction to Penetrant testing, Penetrants and their application, penetrant removal, Drying, developing, inspection, equipment's and control checks, Limitations

- **MAGNETIC PARTICLE TESTING (08 Hours)**

  Theory of magnetism - ferromagnetic, Paramagnetic materials - magnetization by means of direct and alternating current - surface strength characteristics - Depth of penetration factors, Direct pulsating current typical fields, advantages - Circular magnetization techniques, field around a strength conductors, right hand rule field - Prods technique, current calculation - Longitudinal magnetization.

21/08/2020

- **ULTRA SONIC TESTING** **(06Hours)**

  Nature of sound waves, wave propagation - modes of sound wave generation Various methods of ultrasonic wave generation - Principle of pulse echo method, through transmission method, Resonance Method - Advantages, limitations - contact testing, Immersion Testing.

(Total Lecture Hours: 42 Hours)

3. Books Recommended:

6. V. Raghavan, Materials Science and Engineering: A First Course, PHI; 5th edition (30 July 2011).
7. W. F. Smith, J. Hashemi, R. Prakash, Materials Science and Engineering (In Si Units), McGraw Hill Education; 5th edition (1 July 2017).
8. George E. Dieter, Mechanical Metallurgy, 3th edition, McGraw Hill Education 2017.
9. Krautkramer J. and Krautkramer H., Ultrasonic Testing of Materials, Springer-Verlag 1983.
10. Shull P.J., Nondestructive Evaluation: Theory, Techniques, and Applications, Marcel Dekker Inc 2002.

Additional books:

1. Hellier, C., Handbook of Nondestructive Evaluation, McGraw-Hill Professional, 2001.
2. Bray, D.E. and R.K. Stanley, Nondestructive Evaluation: A Tool for Design Manufacturing and Service, CRC Press,1996.
3. Non-destructive Evaluation and Quality Control, Volume 17, 9th edition, ASM Handbook (1992).

21/07/2020

Fifth year of Five Years Integrated M.Sc.(Physics)
M.Sc. – V, Semester – IX

Electromagnetic Communication

L	T	P	Credit
3	0	0	3

PH 527

1. Course Outcomes (COs):

At the end of the semester students will be able to:

CO1	Interpret the characteristics of transmission lines and cables
CO2	Classify the categories of microwave systems and elements of waveguides
CO3	Summarize the propagation properties of radio waves
CO4	Inferthe fundamentals of antenna design and its applications
CO5	Examine the key factors associated with the satellite communications

2. Syllabus:

- **TRANSMISSION LINES AND CABLES** **(10 Hours)**
  Primary Line Constants, Phase Velocity and Line Wavelength, Characteristic Impedance, Propagation Coefficient, Phase and Group Velocities, Standing Waves, Lossless Lines at Radio Frequencies, Voltage Standing-wave Ratio, Slotted-line Measurements at Radio Frequencies, Transmission Lines as Circuit Elements, Smith Chart, Time-domain Reflectometry, Telephone Lines and Cables, Radio-frequency Lines, Microstrip Transmission Lines, Use of Mathcad in Transmission Line Calculations

- **INTRODUCTION TO MICROWAVE THEORY AND WAVEGUIDES** **(08 Hours)**
  Electromagnetic wave equation, Microwave, microwave frequency bands, Categories of microwave systems, Applications, Introduction to Waveguides, Rectangular Waveguides, Other Modes

- **RADIO-WAVE PROPAGATION** **(08 Hours)**
  Propagation in Free Space, Tropospheric Propagation, Ionosphere Propagation, Surface Wave, Low Frequency Propagation and Very Low Frequency Propagation, Extremely Low-frequency Propagation, Summary of Radio-wave Propagation

- **ANTENNAS** **(06 Hours)**
  Antenna Equivalent Circuits, Coordinate System, Radiation Fields, Polarization, Isotropic Radiator, Power Gain of an Antenna, Effective Area of an Antenna, Effective Length of an Antenna, Hertzian Dipole, Half-wave Dipole, Vertical Antennas, Folded Elements, Loop and Ferrite-rod Receiving Antennas, Nonresonant Antennas, Driven Arrays, Parasitic Arrays, VHF-UHF Antennas, Microwave Antennas

- **SATELLITE COMMUNICATIONS** **(10 Hours)**
  Telephone Systems, Wire Telephony, Public Telephone Network, Problems Facsimile And Television, Facsimile Transmission, Television, Television Signal, Problems, Introduction, Kepler's First Law, Kepler's Second Law, Kepler's Third Law, Orbits, Geostationary Orbit, Power Systems, Attitude Control, Satellite Station Keeping, Antenna Look Angles, Limits of Visibility, Frequency Plans and Polarization, Transponders, Uplink Power Budget Calculations, Downlink Power Budget Calculations, Overall Link Budget Calculations, Digital Carrier

21/9/2020

(Total Lecture Hours: 42 Hours)

3. Books Recommended:

1. Roddy D., Coolen J., Electronic Communications, Prentice-hall of India Pvt Ltd. 2007
2. Blake R., Electronic Communication Systems, Thomson Asia 2008
3. George K., Electronic Communication Systems, McGraw-Hill 1992
4. Simon H., Communication Systems, Wiley Eastern 2007
5. Taub and Schilling, Principles of Communication Systems, McGraw-Hill 1991

21/10/2020

Fifth year of Five Years Integrated M.Sc.(Physics)
M.Sc. – V, Semester – IX

Dissertation – I Dissertation Part A

L	T	P	Credit
00	00	08	04

PH 505

In this course the students will work on the research problem identified in the earlier semester under the supervision of the supervising teacher and will write a dissertation part A which will be examined by a committee.

21/08/2011

Fifth year of Five Years Integrated M.Sc.(Physics)
M.Sc. – V, Semester – X

Dissertation – II Dissertation Part B

L	T	P	Credit
00	00	24	12

PH 502

In this course the students will work on the research problem identified in the earlier semester under the supervision of the supervising teacher and will write a dissertation part B which will be examined by a committee.

21/08/2020

[redacted]	[redacted]	[redacted]	[redacted]
1	I	20-02-12=34	28
2	II	19-02-10=31	26
3	III	15-04-06=25	22
4	IV	15-04-08=27	23
5	V	15-04-12=31	25
6	VI	15-04-12=31	25
7	VII	15-03-12=30	24
8	VIII	15-03-12=30	24
9	IX	(A) 0-0-20=30 OR (B) 6-0-8=14	10
10	X	0-0-24=24	12
Total			219

21/08/2020