

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 Processor 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

L	T	P	Credit
3	1	2	05

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.

L	T	P	Credit
3	1	2	05

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.

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 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 appraisal 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, Interleaver, Turbo code, 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.

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 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.

L	T	P	Credit
3	0	0	03

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.

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 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.

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 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.

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 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, Musculo-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, Chemical 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.

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 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 NVIDIA 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

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 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, Stamatias 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.

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 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 Lynch, Seth Hutchinson, George Kantor, Wolfram Burgard, Lydia Kavraki, and Sebastian Thrun, “Principles of Robot Motion-Theory, Algorithms, and Implementation”, MIT Press, Cambridge, 2005.

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 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.

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 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 Envelopgram, 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 Envelopogram, 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.

L	T	P	Credit
3	0	0	03

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, Taylor 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.

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 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, Cordic 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. Madiseti, "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.

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 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

- **FUNDAMENTALS OF 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. Gupta, “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 Circuits”, 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.

L	T	P	Credit
3	0	0	03

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 TRELIS 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 Ghayeb, “Coding for MIMO Communication Systems”, 1st Ed., John Wiley & Sons Ltd., 2007

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 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.

L	T	P	Credit
3	0	0	3

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, Issues 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.

L	T	P	Credit
3	0	0	03

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)**
Fiber 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. Books Recommended:

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. Uyles 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.

L	T	P	Credit
3	0	0	03

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., Artech 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.

L	T	P	Credit
3	0	0	03

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, Summary 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.

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 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 Kernel, 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 CHARACTERIZATION (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 Verlag, 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 multi-coloured VLC – colour space and signal space.
- **PERFORMANCE ENHANCEMENT TECHNIQUES AND LIGHT POSITIONING (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 POSITIONING 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.