SARDAR VALLABHBHAI NATIONAL INSTITUTE OF TECHNOLOGY, SURAT
DEPARTMENT OF ELECTRICAL ENGINEERING
Course Structure and Scheme of Evaluation (Semester-wise)
***M.Tech. in Control and Automation**
(A revised nomenclature of Instrumentation and Control Programme)

SEMESTER I

Sr. No.	Course Code	Course	L	T	P	Credits	Examination Scheme			
			Hrs	Hrs	Hrs		Theory Marks	Tutorial Marks	Practical Marks	Total Marks
1	ELCA101	**Linear System Theory**	3	0	0	03	100	-		100
2	ELCA102	**Robust and Optimal Control**	4	0	0	04	100	-	-	100
3	ELCA103	**Industrial Automation**	3	0	2	04	100	-	50	150
4	ELCA104	**Process Dynamics and Control**	3	0	2	04	100		50	150
5	ELCA1XX	**Elective 1**	3	0	0	03	100	-	-	100
6	ELCA1XX	**Elective 2**	3	0	0	03	100	-	-	100
		TOTAL	**19**	**0**	**4**	**21**	**600**	**-**	**100**	**700**
	TOTAL		**23**			**21**				

SEMESTER II

Sr. No.	Course Code	Course	L	T	P	Credits	Examination Scheme			
			Hrs	Hrs	Hrs		Theory Marks	Tutorial Marks	Practical Marks	Total Marks
1	ELCA201	**Nonlinear Systems &Control**	3	0	0	03	100	-		100

2	ELCA202	**System Identification and Adaptive Control**	4	0	0	04	100	-		100
3	ELCA203	**Advanced Control &Instrumentation**	3	0	2	04	100	-	50	150
4	ELCA204	**Advanced Automation**	3	0	2	04	100		50	150
5	ELCA2XX	**Elective 3**	3	0	0	03	100	-		100
6	ELCA2XX	**Elective 4**	3	0	0	03	100	-	-	100
		TOTAL	**19**	**0**	4	**21**	**600**	**-**	100	**700**
	TOTAL			**23**		**21**				

SEMESTER III

Sr. No.	Course Code	Course	L	T	P	Credits	Examination scheme				
			Hrs	Hrs	Hrs		Theory Marks	Tutorial Marks	Term work Marks	Practical Marks	Total Marks
1	ELCA 301	**Seminar**	-	-	04	02	-	-	20	30	50
2	ELCA302	**Dissertation Preliminaries**	-	-	16	08	-	-	100	150	250
		TOTAL	**-**	**-**	**20**	**10**	**-**	**-**	**120**	**180**	**300**
	TOTAL			**20**		**10**					

SEMESTER IV

Institute Elective

Sr. No.	Course Code	Course	L	T	P	Credits	Examination scheme				
			Hrs	Hrs	Hrs		Theory Marks	Tutorial Marks	Term work Marks	Practical Marks	Total Marks
1	ELCA401	**Dissertation**	-	-	24	12	-	-	160	240	400
		TOTAL	**-**	**-**	**24**	**12**	**-**	**-**	**160**	**240**	**400**

Seminar descriptions includes research writing, product design report preparation and their dissemination.

Total: 64 credits (obeying the credit range as adopted in the Senate resolution7 of its 51st meeting)

Elective I (From amongst the following electives, one subject will be offered to each group of students)	
ELCA110	Digital Signal Processing
ELCA111	Embedded Control
ELCA112	Autonomous Vehicles
ELCA113	AI and ML
ELCA114	Mathematical methods in Control

Elective II (From amongst the following electives, one subject will be offered to each group of students)	
ELCA121	Power Electronic Converters
ELCA122	Guidance and Fight control
ELCA123	Control of Renewable Energy Systems
ELCA124	Robotics and Automation
ELCA125	Cyber Physical Systems
ELCA126	Image Processing
ELCA127	Wide Area Power System Control

Elective III (From amongst the following electives, one subject will be offered to each group of students)	
ELCA210	Estimation of Signals and Systems
ELCA211	IoT
ELCA212	Electric Vehicles
ELCA213	Networked Control Systems
ELCA214	Advanced Communications

ELCA230	Automotive Control Systems
ELCA231/EEPE231	Modern Industrial Drives and Automation
ELCA232	Optimization in Control and Automation
ELCA233	Smart Grids
ELCA234	Instrumentation-based System Design

Note: Throughout this scheme structure, the notations L, T, P, C denote lecture, tutorial, practical and credit respectively for the related subject.

M. Tech. (Electrical)(C&A), Ist year, Semester I

L	T	P	Credit
3	0	0	03

LINEAR SYSTEM THEORY

ELCA101

1. Course Outcomes (COs):

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

CO1	Understand the concepts of vector spaces and subspaces
CO2	Explain the concepts of Linear algebra and its application to control theory
CO3	Analyze discrete time systems with Z-transforms
CO4	Evaluate the stability of discrete time systems and obtain the state space representation of discrete time systems
CO5	Design controllers and observers for discrete time systems

2. Syllabus

- **LINEAR ALGEBRA** **(20 Hours)**
  Vector spaces, basis, operator, range of the linear operator, null space, rank, nullity, rank-nullity theorem, matrix representation of the linear operator in the bases, orthogonal bases, Inner product spaces, Holder inequality, Cauchy-Schwartz inequality, triangular inequality, Minkowski inequality, best approximation theorem , orthogonal projection lemma, Gram- Schmidt orthogonalization, Characteristics polynomial, minimal polynomial, eigen value and eigen vector, Diagonal form, Triangular form, Caley- Hamilton Theorem.
- **DYNAMICAL SYSTEM THEORY** **(22 Hours)**
  Axiomatic definition of a dynamical system, Lagrange equation of motion, state plane analysis, numerical technique, Solving Discrete LTI system using Z transformation, pulse transfer function, phase space analysis of the discrete LTI system, Jury Stability criterion, Schur-Cohn test, bilinear transformation applied with Routh's stability criterion. Conservative system, controllability, observability, observer Design, Diophantine equation, Full order, reduced order, minimum order observer.

Total Hours: 42

3. Books Recommended:

1. Kenneth Hoffmann and Ray Kunze**,** Linear Algebra**,** PHI India limited, 1971.
2. Gilbert Strang, Introduction to Linear Algebra, Wellesley Cambridge, 2003.
3. Stanislaw H. Zak, Systems & Control, Oxford University Press, New York, 2003.
4. Wilson J. Rugh, Nonlinear System Theory, The Johns Hopkins University Press, 2002.
5. Krzysztof Kowalski, Willi-Hans Steeb, Nonlinear dynamical systems and Carleman linearization, World Scientific, 1991.

M. Tech. (Electrical)(C&A), Ist year, Semester I

L	T	P	Credit
4	0	0	04

ROBUST AND OPTIMAL CONTROL

ELCA102

1. Course Outcomes (COs):

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

CO1	Formulate optimal control problem
CO2	Solve optimal control problems using calculus of variation approach
CO3	Apply Linear Quadratic Regulator for the state space control
CO4	Formulate robust control problem
CO5	Solve H_2 and H_∞ control problems

2. Syllabus

- **INTRODUCTION TO OPTIMAL CONTROL** **(03 Hours)**
  Introduction, Optimization, Optimal control, Plant model, Performance index, Constraints, Formulating an optimal control problem with examples.
- **CALCULUS OF VARIATIONS** **(12Hours)**
  Concept of functional, Optimum of a functional, The basic variational problem Fixed end point problem, Free end point problem, Extrema of functionals with constraints, Variation approach to optimal control systems, Hamiltonian approach.
- **LINEAR QUADRATIC OPTIMAL CONTROL SYSTEMS** **(10 Hours)**
  Finite time linear quadratic regulator problem formulation, Analytical solution of Matrix Differential Riccati Equation (Similarity transformation approach), Infinite horizon regulator problem, Analytical solution of the Algebraic Riccati equation, Frequency domain interpretation of LQR, LQR with a specified degree of stability, Time optimal control systems, Problem formulation, Solution of the time optimal control system.
- **ROBUST CONTROL** **(17 Hours)**
  Systematic formulation of robust control problem, Uncertainty and robustness, Effect on system stability and performance, Performance limitations, Review of measures of signals and systems, H_2 and H_∞ norm computations, Concepts of sensitivity and complementary sensitivity, Classification of perturbations, Linear fractional transformations, Small gain theorem, Parameterization of stabilizing controllers, Solutions to general H_2 and H_∞ control problems, H_∞ loop shaping, and Variable structure control.

Total Hours: 42

3. Books Recommended:

1. Donald E. Kirk, Optimal Control: an introduction, Dover Publications, 2006.
2. Desineni Subbaram Naidu, Optimal Control Systems, CRC Press, 2003.
3. Geir E. Dullerud, Fernando Paganini, A Course in Robust Control Theory, Springer, 2010.
4. K. Zhou, J.C. Doyle and K. Glover, Robust & Optimal Control, Prentice Hall Inc. NY 1998.
5. A. Sinha: Linear Systems: Optimal and Robust Control, CRC Press, 2007.

M. Tech. (Electrical)(C&A), Ist year, Semester I

L	T	P	Credit
3	0	2	04

INDUSTRIAL AUTOMATION

ELCA103

1. Course Outcomes (COs):

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

CO1	Understand the need of industrial automations
CO2	Learn the overview of Programmable Logic Controller (PLC) systems
CO3	Explain the various Instructions for PLC programming
CO4	Design the ladder logic using PLC
CO5	Develop the ladder logic for various industrial applications

2. Syllabus

- **INTRODUCTION TO INDUSTRIAL AUTOMATION** **(04 Hours)**
  Introduction, overview of Industrial Automation, Need for an industrial automation, overview of various controllers.
- **PROGRAMMABLE LOGIC CONTROLLER (PLC)** **(10 Hours)**
  Definition, overview of PLC systems, scan time, scan cycle, power supply, input-output connections, input-output isolations. PLC installation, troubleshooting and maintenance General PLC programming procedures, programming on-off inputs/ outputs.
- **PLC PROGRAMING INSTRUCTIONS/FUNCTIONS** **(16 Hours)**
  Bit logic, timer, Counter instructions, data move, compare, convert instructions, Arithmetic instructions, Analog value processing using PLC. Design of interlocks, sequential logics using PLC, creating ladder diagrams for process control applications.
- **INTRODUCTION TO DISTRIBUTED CONTROL SYSTEMS (DCS)** **(06 Hours)**
  Definition, Local Control Unit (LCU) architecture, LCU languages, LCU - Process interfacing issues, communication facilities, configuration of DCS, displays, redundancy concept Data loggers, Data Acquisition Systems (DAS), Direct Digital Control (DDC). Introduction to Supervisory Control And Data Acquisition Systems (SCADA).
- **CASE STUDY** **(06 Hours)**
  Development of ladder logic for mixing plant, bottle filling plant etc.

Total Hours: 42

List Of Experiments

1. Application of bit logic instructions
2. To develop ladder logic for operating a motor on Jog mode.
3. To develop ladder logic to operate the machine with left and right start button.
4. To develop ladder logic to operate the motor in direct online mode.
5. To develop ladder logic to Control of 35ft long machine with three different operating stations.
6. To develop ladder logic to operate motor in both forward or reverse direction.
7. Application of timers
8. To develop ladder logic in such a way that, when Motor-I is ON, after 10 seconds, Motor-II should be ON automatically. When Motor-I is OFF, Motor-II is OFF automatically.
9. To develop ladder logic to operate three motors in such a way that, when start push button is pressed, Motor-I should turn on, after 5seconds Motor-II will turn on and then after 5seconds Motor-III will turn on. When stop push button is pressed, all motors should stop together.
10. To develop ladder logic to operate two motors in such that, when first motor is on after 5 seconds, second motor is on. When first motor stops then after 5 seconds, second motor stops.
11. To develop ladder logic to operate wood cutting machine and blower such that, as soon as wood cutting machine starts, blower should also start. When machine stops blower should stop after 50 seconds.
12. To develop ladder logic to operate two hooters alternatively ON and OFF for 5 seconds continuously.
13. Application of counters
14. To develop ladder logic to turn on indicator after counting six bottles.
15. To develop ladder logic using counters with compare instructions.
16. To demonstrate data Conversion instructions i.e. Byte-Integer, Integer-Double Integer, Double Integer-Real, Real-Double Integer and Move data from one location to another.
17. To develop ladder logic to process analog inputs.
18. To develop a ladder logic to process analog input and outputs.
19. To demonstrate and develop the ladder logic for PLC based conveyor system.
20. To demonstrate and develop the ladder logic for PLC based pneumatic system.
21. To demonstration closed loop control of speed, temperature, pressure and flow of Air Blower system with PLC and SCADA.

3. Books Recommended:

1. John W. Webb, Programmable controllers, Merrill publishing company, 1988.
2. Poporic Bhatkar, Distributed computer control for industrial equation, Marcel Dekker pub, 1990.
3. Liptak B. G., Process control handbook, Chilton book company,1995.
4. W. Bolton, Programmable Logic Controllers, Newnes; 4 edition, 2006.
5. Kevin Collins, PLC Programming for Industrial Automation, Exposure Publishing, 2007

M. Tech. (Electrical)(C&A), Ist year, Semester I

L	T	P	Credit
3	0	2	04

PROCESS DYNAMICS AND CONTROL

ELCA104

1. Course Outcomes (COs):

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

CO1	Understand the principles of mathematical modelling such that transfer function and state-space models can be developed
CO2	Understand the dynamic behaviour of simple as well as complex processes
CO3	Design, implement and tune controllers for different complex as well as unstable systems
CO4	Design, implement and evaluate the performance of controllers for benchmark process control problems
CO5	Identify, formulate and solve problems in the process control domain

2. Syllabus

- **INTRODUCTION TO PROCESS MODELING** **(10 Hours)**
  Terms, motivation and objectives. Piping and instrumentation diagram, instrument terms and symbols. Definition of process variables. General modelling principles: steady state and unsteady state. Dynamic models of representative processes: thermal and liquid storage system. Development of transfer function and state-space models, interacting and non-interacting processes. Linearization of nonlinear models, degrees of freedom analysis.
- **DYNAMIC BEHAVIOUR OF PROCESSES** **(10 Hours)**
  Standard process inputs and their significance, dynamic behaviour of first and second order processes. Processes with numerator dynamics and their response to standard inputs: first and second order. Process with time delay, Pade's approximations, Skogestad's "Half Rule". Approximation of higher order systems to first and second order with time delay.
- **FEEDBACK CONTROLLERS** **(10 Hours)**
  Basic control modes: On-Off control, proportional, integral and derivative control, features and limitations. Proportional-integral-derivative control, features, elimination of derivative and proportional kick, reset windup. Typical responses of feedback controllers.
- **DESIGN OF FEEDBACK CONTROLLERS** **(12 Hours)**
  Model based design methods: direct synthesis method, internal model control. Online controller tuning: continuous cycling method, step test method. Design of controllers for simple and complex processes. Elimination of offset, control of unstable systems, integrating processes. Evaluation criteria: IAE, ISE, ITAE. Implementation of control algorithms to benchmark process control problems: coupled-tanks/quadruple tank system.

Total Hours: 42

List of Experiments

1. Analysis of step responses of first order time delayed system and their approximated models with and without controllers
2. Study of offset in step response of first order process with proportional controllers and its elimination using PI controllers
3. Stability analysis of first order unstable process with P and PI controllers
4. Design and Implementation evaluate the performance of P, PI and PID controllers by using Ziegler-Nichols method and Tyreus-Luyben method
5. Design of PID controllers using direct synthesis method for a second order plus time delay system and evaluating the accuracy
6. IMC based PID controller design for first order and second order system
7. Design of PID controller for an integrating process with time delay using direct synthesis method.
8. Modeling, design and implementation of PI controller for a coupled-tank system

3. Books Recommended:

1. Dale E. Seborg, Thomas F. Edgar, Duncan A. Mellichamp, Francis J. Doyle III, Process Dynamics and Control, 3rd Edition, John Wiley & Sons, Inc., 2011.
2. B. Wayne Bequette, Process Control: Modeling, Design, and Simulation, Prentice Hall, Prentice Hall, 2003.
3. Curtis D. Johnson, Process Control Instrumentation Technology, 8th Edition, Pearson Education India, 2015.
4. George Stephanopoulos, Chemical Process Control: An Introduction to Theory and Practice, Pearson Education India, 2015.
5. Bela G. Liptak, Process Control, 3rd Edition, Butterworth-Heinemann, 2013.

ELECTIVE-I

M. Tech. (Electrical)(C&A), Ist year, Semester I

L	T	P	Credit
3	0	0	03

DIGITAL SIGNAL PROCESSING

ELCA110

1. Course Outcomes (COs):

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

CO1	Discuss various signals, systems and its properties
CO2	Analyze various discrete time signals and linear time invariant systems
CO3	Apply DFT, FFT to any discrete time signals
CO4	Design various FIR and IIR filters for given specifications and evaluate using MATLAB
CO5	Discuss various applications of DSP in control engineering

2. Syllabus

- **INTRODUCTION TO SIGNALS AND SYSTEMS** **(08 Hours)**
  Signals, systems and signal processing, classification of signal concepts of discrete-time signals, sampling of analog signal and sampling Theorem, anatomy of digital filters.
- **DISCRETE-TIME SIGNALS AND SYSTEMS** **(10 Hours)**
  Classification, analysis of discrete-time signals and systems, implementation of discrete-time systems, correlation of discrete-time signals, z-transform and its application to the analysis of linear time-invariant systems.
- **DISCRETE AND FAST FOURIER TRANSFORMS** **(10 Hours)**
  Frequency domain sampling, proportion of DFT, efficient computation of DFT: FFT algorithms, Quantization effects in the computation of the DFT.
- **DIGITAL FILTERS** **(08 Hours)**
  Structures of FIR and IIR filters, design of FIR filters using windows, optimum approximations of FIR filters using Parks-McClellan algorithm, Design of IIR filters from analog filters by bilinear transformations; impulse invariance method.
- **APPLICATIONS OF DSP** **(06 Hours)**
  Applications of DSP to Instrumentation and control engineering

Total Hours: 42

3. Books Recommended:

1. Sanjit K. Mitra, Digital Signal Processing: a computer-based approach, McGraw-Hill, 2010.
2. A. V. Oppenheim, R W Schafer, J. R. Buck, Discrete-Time Signal Processing, Prentice Hall, 1998.
3. John G Proakis, Dimitris G. Manolikis, Digital Signal Processing, Principles, Algorithms and Applications, Prentice Hall, 1996.
4. Emmanuel C. Ifeachor, Barrie W. Jervis, Digital Signal Processing A Practical Approach, Pearson Education, 2002.
5. Shlomo Engelberg, Digital Signal Processing An Experimental Approach, Springer, 2008.

M. Tech. (Electrical)(C&A), Ist year, Semester I

L	T	P	Credit
3	0	0	03

EMBEDDED CONTROL

ELCA111

1. Course Outcomes (COs):

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

CO1	Understand the fundamentals of different architectures of micro controllers
CO2	Design programs for the 32-bit processor using embedded C language
CO3	Understand the architecture of ARM cortex M
CO4	Implement algorithms on processors for instrumentation and control applications
CO5	Implement algorithms on processors for power electronics and drives

2. Syllabus

- **INTRODUCTION TO ARM CORTEX M ARCHITECTURE (06 Hours)**
  RISC and CISC architecture, Harvard and Von Neumann architecture, Cortex M architecture, assembly instructions set, Core buses, on chip peripherals, Memory systems and registers, interrupt processing, bit banding.
- **EMBEDDED C PROGRAMMING (08 Hours)**
  Embedded 'C' programming for 32-bit controllers, Introduction to IDE, Registers and variables, Pointers, structures and union, pointer to structure enumeration, conditional compilation directives, pointers to functions, addressing scheme for memory mapped registers, bit filled structure addressing, Interrupt functions in 'C'.
- **INTRODUCTION TO STM 32 (MCU) ARCHITECTURE (20 Hours)**
  ARM Cortex M core, bus matrix, AHB and APB buses, different clock domains on MCU, Architecture and Programming of peripherals like GPIO, Timers, PWM Timers, UART, DAC/ADC, SPI, I2C Ports, Hardware debugging techniques.
- **APPLICATIONS (08 Hours)**
  Application of 32-bit controllers in instrumentation, control and power electronics and drives.

Total Hours: 42

List Of Experiments

1. Arithmetic operations of Signed and Unsigned Numbers
2. Memory Block Movements (Forward, reverse, overlapping)
3. Ascending and descending arrangement of data string.
4. Code conversion. (Hexadecimal, BCD, Binary, ASCII etc.)
5. Toggling of port pin with time delay
6. Sensing of push button keys
7. Generating different duty cycle and different switching frequency waveform with timer T0 and T2.
8. Generating PWM signal using timer T2 and PCA timer.
9. Generating sine wave and triangular wave using DAC
10. Measuring voltage and current using ADC

3. Books Recommended:

1. Trevor Martin, The Insider's Guide to The STM 32, Published by Hitex (UK) Ltd., April 2005.
2. Joseph Yiu, The Definite Guide to Cortex –M3/M4, Elsevier publication, 2007.
3. Datasheet and user manual of STM F4 series MCU, www.st.com, 2015.
4. Mark Fisher, ARM® Cortex® M4 Cookbook, Packt Publishing, 2016.
5. Yifeng Zhu, Embedded Systems with Arm Cortex-M3 Microcontrollers in Assembly Language and C, E-Man Press LLC, 2014.

M. Tech. (Electrical)(C&A), Ist year, Semester I

L	T	P	Credit
3	0	0	03

AUTONOMOUS VEHICLES

ELCA 112

1. Course Outcomes (COs):

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

CO1	Understand the rational for and evolution of automotive electronics
CO2	Understand the fundamental theory of operation of electronic control systems
CO3	Understand the concept of remote sensing and the types of sensor technology required
CO4	Understand the basic concepts of wireless communications and wireless data networks
CO5	Understand the principles of ADAS and future autonomous vehicles

2. Syllabus

- **Introduction to Automated Vehicles** **(12 Hours)**
  Introduction to Automated, Connected, and Intelligent Vehicles, Introduction to the Concept of Automotive Electronics, Automotive Electronics Overview, History & Evolution, Infotainment, Body, Chassis, and Powertrain Electronics, Advanced Driver Assistance Electronic Systems, Connected and Autonomous Vehicle Technology, Basic Control System Theory applied to Automobiles, Overview of the Operation of ECUs, Basic Cyber-Physical System Theory and Autonomous Vehicles, Role of Surroundings Sensing Systems and Autonomy, Role of Wireless Data Networks and Autonomy.
- **Sensor Technology for Driver Assistance** **(12 Hours)**
  Sensor Technology for Advanced Driver Assistance Systems, Basics of Radar Technology and Systems, Ultrasonic Sonar Systems, Lidar Sensor Technology and Systems, Camera Technology, Night Vision Technology, Other Sensors, Use of Sensor Data Fusion, Integration of Sensor Data to On-Board Control Systems.
- **Connected Car and Driver Assistance Technology** **(10 Hours)**
  Connectivity Fundamentals, Navigation and other applications, vehicle-to-vehicle technology and applications, vehicle-to-roadside and infrastructure applications, Basic theory of driver assistance, integration of ADAS technology into vehicle electronics, role of sensor data fusion
- **Wireless Networking and Applications to Vehicle Autonomy** **(08 Hours)**
  Basics of computer networking- the internet of things, wireless networking fundamentals, integration of wireless networking and on-boardvehicle networks, connected car display technology, Examples of present advanced driver assistance system technology.

Total Hours: 42

3.Books Recommended:

1. D. Paret, H. Rebaine, B. A. Engel, Autonomous and Connected Vehicles: Network Architectures from Legacy Networks to Automotive Ethernet, 1st Edition, Wiley, 2022

2. G. Mullet, Wireless Telecommunications Systems and Networks, Thomson-Delmar Learning, 2006

M. Tech. (Electrical)(C&A), Ist year, Semester I

ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

ELCA113

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	Identify potential areas for automation
CO2	Explain "Artificial" Intelligence and how to identify systems with Artificial Intelligence.
CO3	Impart knowledge about the concepts of machine learning
CO4	Implement Machine Learning method for the problems of dynamics

2. Syllabus

- **INTRODUCTION TO ARTIFICIAL INTELLIGENCE** **(20 Hours)**
  Introduction: Overview and Historical Perspective, Turing test, Physical Symbol Systems and the scope of Symbolic AI, Agents. State Space Search: Depth First Search, Breadth First Search, DFID. Heuristic Search: Best First Search, Hill Climbing, Beam Search, Tabu Search. Randomized Search: Simulated Annealing, Genetic Algorithms, Ant Colony Optimization. Finding Optimal Paths: Branch and Bound, A*, IDA*, Divide and Conquer approaches, Beam Stack Search.
  Problem Decomposition: Goal Trees, AO*, Rule Based Systems, Rete Net. Game Playing: Minimax Algorithm, AlphaBeta Algorithm, SSS*. Planning and Constraint Satisfaction: Domains, Forward and Backward Search, Logic and Inferences: Propositional Logic, First Order Logic, Soundness and Completeness, Forward and Backward chaining.
- **MACHINE LEARNING CONCEPTS** **(22 Hours)**
  Machine learning basics: capacity, over fitting and under fitting, hyper parameters and validation sets, bias & variance; PAC model; Rademacher complexity; growth function; VC-dimension; fundamental concepts of artificial neural networks; mathematical preliminaries and data visualization, supervised and unsupervised learning, logistic regression, Neural networks: CNN, RNN, LSTM, deep networks.
  Machine Learning methods and techniques in computational dynamical systems and control. Data-driven models, models from first principles, their computational complexity and Machine Learning methods.

Total Hours: 42

3. Books Recommended:

1. Deepak Khemani, *A First Course in Artificial Intelligence*, McGraw Hill Education (India), 2013.
2. Stuart Russell and Peter Norvig, *Artificial Intelligence: A Modern Approach*, 3rd ed., Prentice Hall, 2009.

3. Mohri, M., Rostamizadedh, A., and Talwalkar, A., *Foundations of Machine Learning*, The MIT Press (2012).
4. Jordon, M. I. and Mitchell, T. M., *Machine Learning: Trends, perspectives, and prospects*, Vol. 349, Issue 6245, pp. 255-260, Science 2015.
5. John D. Kelleher, Brian M. Namee and Aoife D'Arcy, *Fundamentals of Machine Learning for Predictive Data Analytics*: Algorithms, Worked Examples, and Case Studies, The MIT Press, 2015.

M. Tech. (Electrical)(C&A), Ist year, Semester I

L	T	P	Credit
3	0	0	03

MATHEMATICAL METHODS IN CONTROL

ELCA114

1. Course Outcomes (COs):

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

CO1	Understand the fundamentals of vector space and bases in reference to transformations
CO2	Solve system of linear equations using direct and iterative methods
CO3	Use the idea of eigen values and eigen vectors for the application of SVD
CO4	Describe the basic notions of discrete and continuous probability distributions
CO5	Find out responses of linear systems using statistical and probability tools

2. Syllabus

- **ALGEBRAIC METHODS in Control** **(21 Hours)**
  , Linear transformations, Matrix form of linear transformations, Norms, Matrix Factorization, Solution of linear equations, Eigen values and eigen vectors, Complex vectors and Matrices, Jacobi method & Givens method for symmetric matrices, Orthogonal vectors and orthogonal bases, Gram-Schmidt orthogonalization process, SVD and Applications, Controllability Space, Sum of the Vector Space, Direct Sum, Orthogonal Projection Lemma, Jordan Forms of matrices, Diffeomorphism
- **PROBABILITY THEORY** **(21 Hours)**
  Probability: Random variables, Probability distributions: Binomial, Poisson, Normal distributions, Joint probability distribution (discrete and continuous), Functions of random variables and random vectors, Moments, Central moments, Characteristic functions and correlation matrices, Probability generating and moment generating functions, Gaussian, Weibull and Erlang distributions with examples.

3. Books Recommended:

1. David C.Lay, Steven R.Lay and J.J.McDonald: Linear Algebra and its Applications, 5 th Edition, Pearson Education Ltd., 2015.
2. Gilbert Strang, Introduction to Linear Algebra, 5 th Edition, Wellesley-Cambridge Press, 2016.
3. A. Papoulis & S U Pillai, Probability, Random Variables and Stochastic Process, 4 th Edition, Mc Graw Hill, 2002.
4. H. Stark & J.W. Woods, Probability and Random processes with Applications to Signal Processing, Pearson Education Asia, 2002.
5. J A Gubner: Probability and Random processes for Electrical and Computer engineers, Cambridge Univ. Press. 2006.

ELECTIVE-II

M. Tech. (Electrical)(C&A), Ist year, Semester I

L	T	P	Credit
3	0	0	03

POWER ELECTRONIC CONVRTERS

ELCA 121

1. Course Outcomes (COs):

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

CO1	Explain the basic principle of power devices and circuit
CO2	Derive the equations and applications for dc/dc converters
CO3	Derive the equations and applications for inverters
CO4	Application and performance analysis of Power Electronic circuits
CO5	Analyze the performance of control algorithm in Power Electronic circuits

2. Syllabus

- **BASICS OF POWER SEMICONDUCTOR DEVICES AND CIRCUITS (09 Hours)**
  Characteristics and specification of power devices- Thyristor, IGBT, MOSFET, GTO, diodes and new developments, development of control circuits, Application of freewheeling diodes, response of inductor and capacitor, Power and power factor, Single and three phase control and uncontrolled rectifiers, semi converters, AC voltage controllers- control and applications.
- **DC-DC CONVERTERS (09 Hours)**
  Buck converter, Boost converter, Buck- Boost converters, CUK converter, Fly-back converter, Forward converter, Push-pull converter, Full bridge and Half bridge converters, Single input and multi output converters, Open loop and closed loop control, switching scheme, Design considerations and comparison, Application in selected area- transportation and lighting system etc.
- **INVERTERS (08 Hours)**
  Review of single-phase bridge inverters, 3-phase bridge inverters, Pulse width modulated inverters, 1-pulse Selective and multi pulse modulation, Sinusoidal PWM, Space Vector PWM, other PWM techniques, Reduction of harmonics Harmonic Elimination Technique, interface of power circuit and control circuit, UPS: types, Design and control.
- **APPLICATION OF POWER ELECTRONICS (09 Hours)**
- Active filters- Design and control, standards, Power quality, Application of power electronics in renewable energy system- Solar, Wind and Hydro and others, various type of generators, Parameter estimation and control for ac drives- induction motor and synchronous motors.
- **CONTROL ALGORITHM FOR POWER ELECTRONIC CIRCUITS (07 Hours)**
  Adaptive control algorithms for power electronics circuit-Least means square methods, Design of observers, PI and PID controller- conventional and auto gain tunning, Frequency

domain control, Application of soft computing methods.

Total Hours: 42

3. Books Recommended:

1. Rashid, M. H., Power Electronics Circuits, Devices, and Applications, third edition, Pearson education, New Delhi, , 2009.
2. Ned Mohan, Tore M. Undeland and William P. Robbins,Power Electronics Converters, Applications, and Design, John Willey & Sons, Inc., 2nd Edition, 1995.
3. Rashid, M. H., Power Electronics: Hand book, Academic Press, California, 2001.
4. Simon Haykin, Adaptive filter Theory, Pearson education Inc., Delhi, 2002.
5. Jang, T. Sun and E. Mizutani, Neuro-Fuzzy and Soft computing: a computational approach to learning and machine intelligence, Pearson Education Inc, Delhi, 1997.
6. S.N. Sivanandam and S.N. Deepa, Principles of soft computing, 2ed edition, Wiley India, New Delhi, 2011.

M. Tech. (Electrical)(C&A), Ist year, Semester I

GUIDANCE AND FLIGHT CONTROL SYSTEM

ELIC122

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	Derive equations of motion of an aircraft and analyze its stability
CO2	Understand the principles of navigation and various sensors used
CO3	Understand, design, and implement various guidance laws
CO4	Understand, design, and implement the integration of state estimation with guidance and control
CO5	Case studies with simulation for guidance problems defined in two and three dimensions

2. Syllabus

- **Equations of Motion and Rigid Body Dynamics** **(12 Hours)**
  Equations of Motion: rigid body dynamics, coordinate transformation, Euler angle & quaternion formulation, Dynamics of Generic Fixed Wing Aircraft: 6-DoF equations of motion, linearized equations of motion, linearized longitudinal & lateral equations, aerodynamic derivatives, LTI system basics, Stability of Uncontrolled Motion: linearized longitudinal & lateral dynamics, modes of motion, Response to Control Inputs: transfer function, step response & frequency response characteristics, Feedback Control: stability augmentation, PID control, root-locus technique for controller design, State-space formulations.
- **Principles of Navigation** **(10 Hours)**
  Navigation: Principles of Inertial Navigation: Components, two-dimensional navigation, Coordinate systems, 3D strapdown navigation system, Strapdown system mechanizations, Attitude representation, Navigation equations expressed in component form, Effects of elliptic earth, Inertial Sensors: Gyroscope principles, single-axis rate gyroscope, accelerometers, rate integrating gyroscope.
- **Guidance and Control** **(14 Hours)**
  Guidance and Control: Elements of guidance system, Guidance phases, Guidance trajectories, Guidance sensors, Classification of Guidance and Navigation Systems: Basic navigation systems, combined navigation systems, Classification of guidance systems: Three-point tactical guidance laws, Two-point Tactical Guidance Laws: Strategic guidance laws, pursuit, LOS and PN laws, Guidance of UAVs; Control: Linear time-invariant systems, transfer functions and state space modeling, analysis and synthesis of linear control systems, applications to aerospace engineering.
- **Introduction to Autopilot; simulation studies** **(06 Hours)**
  Introduction to Autopilot and design, integration of linear and non-linear state estimators with guidance laws. Case studies involving simulations in two and three dimensions.

Total Hours: 42

3. Books Recommended:

1. Anderson, J. D., Aircraft Performance and Design, Tata McGraw-Hill (1998)
2. Siouris, G. M., Missile Guidance and Control Systems, AIAA (2004)
3. Zarchan, P., Tactical and Strategic Missile Guidance, AIAA Publications, 4th Edition, (2002)
4. Nise, N. S., Control Systems Engineering, Wiley India (2004)

M. Tech. (Electrical)(C and A), Ist year, Semester I

L	T	P	Credit
3	0	0	03

CONTROL OF RENEWABLE ENERGY SYSTEMS

ELCA 123

1. Course Outcomes (COs):

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

CO1	Understand and explain present energy status and renewable energy needs
CO2	Analyze the photovoltaic fundamentals and the photovoltaic applications
CO3	Analyze the wind turbine characteristics and the wind power system generation
CO4	Understand and select different electrical machines and power converters for wind energy generation
CO5	Explain different hybrid renewable energy generation systems and their power control

2. Syllabus

- **PRESENT STATUS OF FOSSIL FUELS BASED GENERATION AND NEED FOR RENEWABLES (03Hours)**
  Present status of fossil fuel resources in the world and India, limitations of the fossil fuel electricity generation, need for renewable energy and present status in India.
- **SOLAR PHOTOVOLTAICS DEVICES AND CHARACTERISTICS (06 Hours)**
  Review of p-n junction diode, exposure to sunlight, PV characteristics and environmental impact, PV devices and modelling, need for maximum power point tracking
- **PHOTOVOLTAICS POWER ELECTRONICS CONVERTERS, THEIR CONTROL AND GRID INTEGRATION (07 Hours)**
  PV-MPPT algorithms, basic DC-DC converters (buck, boost, buck-boost) and their controls, single-phase and three-phase grid connected PV inverters and their control, design of standalone PV systems for irrigation pump and domestic applications.
- **PHOTOVOLTAIC-BATTERY ENERGY STORAGE (07 Hours)**
  Types of batteries, battery terminology, characteristics and modelling, battery charging methods, integrating battery-charge control with MPPT, design of standalone PV-battery system.
- **WIND TURBINES AND CHARACTERISTICS (06 Hours)**
  Wind data in terms of speed-frequency distribution, power density-speed duration curves, different wind turbines and their characteristics, wind power and energy computations, components of wind turbine system.
- **ELECTRICAL MACHINES, POWER ELECTRONICS CONVERTERS AND GRID INTERFACE FOR WIND ENERGY (07 Hours)**
  Fixed and variable wind speed turbines, induction and synchronous machines for wind

energy conversion, different power electronics interface based on full and partial converters, wind-MPPT algorithms, wind-farm configurations.

- **SOLAR AND WIND HYBRID SYSTEMS** **(06 Hours)**

Hybrid systems and their needs, solar-diesel-battery systems, wind-solar-battery system, solar-wind-fuel cell system and its control.

Total Hours: 42

3. Books Recommended:

1. Chetan Singh Solanki, Solar Photovoltaics: Fundamentals, Technologies and Applications, Third Edition, PHI Learning Private Limited, New Delhi, 2015.
2. Weidong Xiao, Photovoltaic Power Systems: Modelling, design and control, First Edition, John Wiley & Sons Limited, NJ USA, 2017.
3. Thomas Ackermann, Wind Power in Power System, John Willey & Sons, 2005.
4. J. K. Nayak and S. P. Sukhatme, Solar Energy - Principles of Thermal Collection and Storage, Fourth Edition, Tata McGraw Hill, New Delhi, 2017.
5. R. Teodorrescu, Marco Liserre and Pedro Rodriguez, Grid Converters for Photovoltaic and Wind Power Systems, First Edition, John Wiley & Sons Limited, UK, 2011.

M. Tech. (Electrical)(C&A), Ist year, Semester I

ROBOTICS AND AUTOMATION

L	T	P	Credit
3	0	0	03

ELCA124

1. Course Outcomes (COs):

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

CO1	Discuss need and anatomy of industrial robots
CO2	Apply the forward kinematics, inverse kinematics and dynamics for serial and parallel robots
CO3	Analyze the manipulator including actuator, drive and sensor issues
CO4	Analyze the robot cell design for different applications
CO5	Discuss various robot programming methods and need of Artificial Intelligence in robotic applications

2. Syllabus

- **INTRODUCTION AND ROBOT KINEMATICS (12 Hours)**
  Definition, need and scope of industrial robots, robot anatomy, work volume, precision movement, end effectors, sensors. Robot kinematics: direct and inverse kinematics, control of robot manipulators, robot dynamics.
- **ROBOT DRIVES AND CONTROL (09 Hours)**
  Controlling the robot motion, position and velocity sensing devices, design of drive systems, hydraulic and Pneumatic drives, linear and rotary actuators and control valves, electro hydraulic servo valves, electric drives, Motors, designing of end effectors, vacuum, magnetic and air operated grippers.
- **ROBOT SENSORS (09 Hours)**
  Transducers and sensors, sensors in robot, tactile sensor, proximity and range sensors, sensing joint forces, robotic vision system, Image grabbing, image processing and analysis, image segmentation, pattern recognition, training of vision system.
- **ROBOT CELL DESIGN AND APPLICATION (06 Hours)**
  Robot work cell design and control, safety in robotics, robot cell layouts, multiple robots and machine interference, robots cycle time analysis, industrial application of robots.
- **ROBOT PROGRAMMING AND ARTIFICIAL INTELLIGENCE (06 Hours)**
  Methods of robot programming, characteristics of task level languages lead through programming methods, motion interpolation, artificial intelligence, basics, goals of artificial intelligence, AI techniques, problem representation in AI, problem reduction and solution techniques, application of AI in Robots.

Total Hours: 42

3. Books Recommended:

1. Fu K. S., Gonzalez, R. C. and Lee, C. S. G., Robotics: Control, Sensing, Vision and Intelligence, McGraw Hill, 1987.
2. Richard, D, Klafter, Thomas, A, Chmielowski, Michael Negin, Robotics Engineering: an Integrated approach, PHI, 1987.
3. J. Norberto Pires, Industrial Robots Programming: Building Applications for the Factories of the Future, Springer, 2007.
4. Rex Miller, Mark R. Miller, Robots and Robotics: Principles, Systems, and Industrial Applications, McGraw Hill, 2017.
5. Mark W Spong, M. Vidyasagar , Robot Dynamics and Control, Wiley India Pvt. Limited, 2008.

M. Tech. (Electrical)(C&A), Ist year, Semester I

L	T	P	Credit
3	0	0	03

Cyber-Physical Systems

ELCA125

1.Course Outcomes (COs):

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

CO1	Understand the core principles behind CPS
CO2	Identify safety specifications and critical properties
CO3	Understand the abstraction in system design
CO4	Understand AI based CPS

2.Syllabus

- **Introduction** **(06 Hours)**
  Cyber-physical systems (CPS) introduction, Key features of CPS, the application domain of CPS, Basic principles of design and validation of CPS, Challenges in CPS
- **Dynamical Systems Modeling** **(10 Hours)**
  Cyber-Physical Systems (CPS) in the real world, Dynamical Systems: stability and performance, Different notions of stability, Controller Design techniques, Logic based system specification, Controller Synthesis as a logic problem
- **CPS Compute/Communicate/Scheduling** **(16 Hours)**
  Real-time scheduling theory, CAN bus scheduling, Wireless CPS, Packet drops and their effects on stability/performance, Delay/Deadline-miss aware control design. CPS performance analysis: effect of scheduling, bus latency, sense and actuation faults on control performance.Methods for safety assurance of CPS, Advanced automata-based modeling and analysis, basic introduction and examples, timed and hybrid automata, definition of trajectories, Flow pipe construction, reachability analysis.
- **Safe-AI based and Secure CPS** **(10 Hours)**
  Safe Reinforcement learning for CPS, MPC plus Gaussian Process learning for CPS, Distributed CPS: Cooperative driving, Attack detection, and mitigation in CPS, Smart Grid Security and Privacy: Automated Generation Control attacks and privacy aware metering. State estimation for attack detection. Automotive case study: vehicle ABS hacking, Power distribution case study: Attacks on Smart Grids

Total Hours: 42

3.Books Recommended:

1. E.A. Lee, S.A. Seshia, Introduction to Embedded Systems: A Cyber-Physical Systems approach, 2011
2. R. Alur, Principles of Cyber-Physical Systems, MIT Press, 2015
3. T.D. Lewis, Network Science: Theory and Applications, Wiley, 2009
4. P. Tabuada, Verification and Control of Hybrid Systems: A Symbolic Approach, Springer-Verlag, 2009.

M. Tech. (Electrical)(C&A), Ist year, Semester I

IMAGE PROCESSING

L	T	P	Credit
3	0	0	03

ELCA126

2. Course Outcomes (COs):

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

CO1	Discuss Fourier transform for image processing in frequency domain and compare the image compression techniques in spatial and frequency domains.
CO2	Apply techniques for image enhancement both in spatial and frequency domains.
CO3	Analyze causes for image degradation and apply restoration techniques.
CO4	Evaluate different image segmentation techniques.
CO5	Develop solutions using morphological concepts.

3. Syllabus

- **INTRODUCTION DIGITAL IMAGE FUNDAMENTALS (8 Hours)**
  Digital Image, Image Processing origins; Imaging in X-Rays, Ultraviolet, Visible Infrared, Visible, Microwave and Radio Bands; Fundamentals of Image Processing; Components of Image Processing Systems.
  Visual Perception — Human Eye, Brightness Adaptation and Discrimination, Electromagnetic Spectrum; Image Sensing and Acquisition — Single, Strip and Array Sensors, Image Formation Models; Image Sampling and Quantization — Basic Concepts, Representation of Image, Special and Gray Level Resolution, Aliasing, Zooming and Shrinking; Relationships Between Pixels-Nearest Neighbor, Adjacency, Connectivity, Regions, and Boundaries; Distance Measures; Image Operations on a Pixel Basis; Linear and Nonlinear Operations.

- **IMAGE ENHANCEMENT (8 Hours)**
  Gray Level Transformations-Image Negatives, Log, Power-Law and Piecewise Linear Transformation Functions; Histogram Processing -Equalization, Matching; Enhancement Operations - Arithmetic, Logic, Subtraction and Averaging; Spatial Filtering -Linear and Order-Statistics for Smoothing, First and Second Derivatives/Gradients for Sharpening, 2-D Fourier Transform, Its Inverse and Properties; Discrete and Fast Fourier Transform; Convolution and Correlation Theorems; Filtering in Frequency Domain - Low Pass Smoothing, High Pass Sharpening, Homomorphic Filtering.
- **IMAGE RESTORATION AND COMPRESSION (12 Hours)**
  Image Degradation and Restoration Processes; Noise 'Models - Spatial Properties, Noise Probability Density Functions, Periodic Noise, Estimation Of Noise Parameters; Restoration in the Presence Of Noise and Mean Filters, Order-Statistics Filters, Adaptive Filters; Linear Position-Invariant Degradations and Estimation; Geometric Transformations - Spatial Transformation, Gray-Level Interpolation.
  Fundamentals of Compression, Image Compression Model, and Error free Compression,

Lossy Predictive Coding, and Transform Coding.

- **MORPHOLOGICAL IMAGE PROCESSING (4 Hours)**
  Preliminaries-Set Theory and Logic Operations in Binary Images; Basic Morphological Operations - Opening, Closing Operators, Dilation and Erosion, Morphological Algorithms - Boundary Extraction, Region Filling, Extraction of Connected Components, Convex Hull, Thinning, Thickening, Skeletons; Extension of Morphological Operations to Gray-Scale Images.

- **IMAGE SEGMENTATION, REPRESENTATION AND DESCRIPTION (10 Hours)**
  Detection of Discontinuities - Point, Line and Edges; Edge Linking and Boundary Detection, Local Processing, Global Processing Using Hough Transform; Thresholding - Local, Global and Adaptive; Region-Based Segmentation - Region Growing, Region Splitting and Merging; Motion Detection.
  Representations - Chain Codes, Polygonal Approximations, Signatures, Boundary Segments, Skeletons; Boundary Descriptors - Shape Numbers, Statistical Moments; Regional Descriptors - Topological, Texture and Moments Of 2-D Functions

Total Hours: 42

4. Books Recommended:

1. Gonzalez R. C. and Woods R. E, "Digital Image Processing", 3rd Ed., Pearson Prentice Hall,
   2008.
2. Sonka M. Hlavac V., Boyle R., "Image Processing, Analysis and Machine Vision", Cengage Learning, 2nd Ed. Indian Reprint, 2009.
3. Jain R., Kasturi R. and Schunk B., "Machine Vision", 1st Ed., McGraw - Hill, 1995.
4. Jain A. K., "Fundamentals of Digital Image Processing", 1st Ed., PHI, 1989.
5. W Pratt, “Digital Image Processing”, Wiley, 2001

M. Tech. (Electrical)(C&A), Ist year, Semester I

L	T	P	Credit
3	0	0	03

WIDE AREA POWER SYSTEM CONTROL

ELCA 127

1. Course Outcomes (COs):

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

CO1	Explain various Synchrophasor Measurement Techniques
CO2	Implement and test wide area measurement systems
CO3	Realize optimal placement of PMU and state estimation using PMU data
CO4	Monitor, analyse and control power system conditions in real time
CO5	Interpret wide area PMU measurements

2. Syllabus

- **PHASOR MEASUREMENT TECHNIQUES** **(11 Hours)**
  Phasor Measurement Techniques: Basic Concepts and Definitions SCADA vs PMU, Synchrophasors, Frequency, and ROCOF, Steady-State and Dynamic Conditions in Power Systems, Classical Phasor Versus Dynamic Phasor, Basic Definitions of Accuracy Indexes, Algorithms for Synchrophasors, Frequency, and ROCOF, Methods to Calculate Synchrophasors based on a Steady-State Model and Dynamic Signal Model, Evaluation of Frequency and ROCOF, Dynamic Behavior of Phasor Measurement Algorithms.
- **PHASOR MEASUREMENT UNITS AND PHASOR DATA CONCENTRATORS** **(10 Hours)**
  Phasor measurement units and Phasor data concentrators: WAMS architecture, Sensors for PMUs, International Standards for Instrument Transformers, Accuracy of Instrument Transformers, Transducer Impact on PMU Accuracy, Hardware for PMU and PMU Integration, PMU Architecture, Data Acquisition System, Synchronization Sources, Communication and Data Collector, Distributed PMU, International Standards for PMU and Tests for Compliance, IEC 61850.
- **STATE ESTIMATION** **(11 Hours)**
  State Estimation and PMUs: Formulation of the SE Problem, Network Observability-SE Measurement Model, SE Classification, State estimation with phasor measurents, Linear state estimation, Dynamic estimators. Optimal PMU placement, meta-heuristic and deterministic algorithms, Integer Linear Programming Technique.
- **WIDE AREA MONITERING SYSTEM** **(10 Hours)**
  WAMS applications- real-time analysis and technologies to detect, locate and characterize power system disturbances, monitoring power system oscillatory dynamics- Interpretation and visualization of wide-area PMU measurements, power system control with phasor feedback, discrete event control.

Total Hours: 42

3. **Books Recommended:**

1. Antonello Monti, Carlo Muscas, Ferdinanda Ponci, Phasor Measurement Units and Wide Area Monitoring Systems, Academic Press, 2016.
2. A.G. Phadke, J.S. Thorp, Synchronized Phasor Measurement and Their Applications, Springer 2008.
3. Yong Li, Dechang Yang, Fang Liu, Yijia Cao, Christian Rehtanz, Interconnected Power Systems: Wide-Area Dynamic Monitoring and Control Applications, Springer, 2015.
4. Ali Abur, Antonio Gómez Expósito, Power System State Estimation: Theory and Implementation, CRC Press, 2004.
5. Ma J., Makarov Y., Dong Z, Phasor Measurement Unit and its Applications on Modern Power Systems, Springer, 2010.

SEMESTER II

M. Tech. (Electrical)(C&A), Ist year, Semester II

Nonlinear Systems and Control

L	T	P	Credit
3	0	0	03

ELIC201

1. Course Outcomes (COs):

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

CO1	Analyse nonlinear systems using classical techniques
CO2	Analyse stability of non linear systems using advanced techniques
CO3	Analyse nonlinear feedback systems using time and frequency domain techniques
CO4	Design controllers for nonlinear systems using advanced methods

2. Syllabus

- **Introduction and classical techniques** **(10 Hours)**
  Characteristics of nonlinear systems, examples of systems exhibiting nonlinear phenomena, secondorder nonlinear autonomous systems, vector field representation, classification of equilibrium points, qualitative behavior near equilibrium points, limit cycles, existence of periodic orbits, Poincare-Bendixon criterion, Poincare index of equilibrium points,stability of periodic solutions, analysis ofsystems with piecewise constant inputs using phase plane analysis, Jump response.
- **Lyapunov stability** **(10 Hours)**
  Existence and uniqueness of solutions of nonlinear state equations,stability of nonlinear systems, Lyapunov stability, local linearization and stability in the small Centre manifold theorem, Direct method of Lyapunov, generation of Lyapunov function for linear and nonlinear systems, Variablegradient method, La Salle's Invariance theorem, Input to state stability, L stability, L stability of state models, Small gain theorem, Passivity, Positive real transfer functions, L2 and Lyapunov stability, Passivity theorems, Loop transformation
- **Time domain analysis of feedback systems and perturbation techniques** **(12 Hours)**
  Absolute stability of feedback interconnections of a linear part and nonlinear part, Circle criterion, Popov criterion, Frequency theorem, Harmonic linearization, filter hypothesis, Describing function of standard nonlinearities, amplitude and frequency of limit cycle using SIDF, Pertubation techniques, Regular perturbation, Singular perturbation.
- **Nonlinear system design** **(10 Hours)**
  Control problems, stabilization via linearization, integral control via linearization, Gain scheduling, Feedback linearization, stabilization and tracking via state feedback control, Sliding mode control, Regulation via integral control, Control-Lupunov and Lyapunov design, Lasalle invariance principle, Lyapunov redesign, stabilization and nonlinear damping, Backstepping, Passivity based control, High gain observers. Linear Quadratic Regulators/Linear Quadratic Guassian Regulators, Numerical Solution for Riccatti Equations.

3. Books Recommended:

1. H. K. Khalil, ‘Nonlinear Systems’, Prentice - Hall International (UK), 1996
2. J.J.E. Slotine& W.LI, ‘Applied Nonlinear Control’, Prentice Hall, EngelwoodNewJersey, 1991
3. H. Nijmeijer& A.J. Van Der schaft, ‘Nonlinear Dynamic control Systems’, Springer Verlag Berlin, 1990
4. Z. Vukic & L. Kuljaca, ‘Nonlinear Control Systems’, Marcel Dekker, Inc., New York, 2003
5. Eduardo D. Sontag, Mathematical Control Theory, Second Edition, Springer, 1991.

M. Tech. (Electrical)(C&A), Ist year, Semester II

SYSTEM IDENTIFICATION AND ADAPTIVE CONTROL

ELCA202

L	T	P	Credit
4	0	0	04

4. Course Outcomes (COs):

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

CO1	Discretize continuous time system and understand sampling theorem
CO2	Acquire knowledge of various plant and disturbance models
CO3	Implement various estimation algorithms to identify system models
CO4	Analyze stability of equilibrium points
CO5	Design model reference adaptive and robust adaptive controllers

5. Syllabus

- **INTRODUCTION** **(05 Hours)**
  Motivation and overview of System Identification, Models of discrete time linear time invariant systems, Difference equation, Transfer functions, State space models, Discretization, Sampling and hold operations, Sampling theorem.
- **PLANT AND DISTURBANCE MODELS** **(04 Hours)**
  Impulse response, Step response and frequency response models, Disturbance models-random processes, Representation of stationary processes, White noise process, Auto-covariance function, ARMA models, Parametric model structures-ARX, ARMAX, OE, BJ, and PEM structures.
- **ESTIMATION OF MODELS** **(12 Hours)**
  Least square estimates, Statistical properties of LS estimates, Weighted least squares, Recursive least squares, Maximum likelihood estimation, Estimation of non-parametric models, Estimation of parametric models.
- **STABILITY OF EQUILIBRIUM POINTS** **(06 Hours)**
  Need for adaptive controllers, Stability of Equilibrium points, Asymptotic stability, Uniform stability, Lyapunov stability theorems, Lyapunov's direct method, Signal norms, Barbalat's Lemma.
- **ADAPTIVE CONTROL** **(15 Hours)**
  Effects of process variations, adaptive schemes, adaptive control problems, Deterministic self tuning regulators, pole-placement design, Indirect self-tuning regulators, continuous-time self tuners, direct self-tuning regulators. Model-reference adaptive systems, MIT rule, determination of adaptive gain, design of MRAS using Lyapunov theory

Total Hours: 42

6. Books Recommended:

1. Lennart Ljung, System Identification, Prentice Hall, 1999.

2. T. Soderstrom and P. Stoica, System Identification, Prentice Hall International, 1994.
3. Arun K. Tangirala, Principles of System Identification, CRC Press, 2015.
4. K. J. Astrom and B. Wittenmark, Adaptive Control, Dover Publications INC., New York, 2008.
5. J.J.E. Slotine, and W. Li, Applied Nonlinear Control, Prentice-Hall, 1991.

M. Tech. (Electrical)(C&A), Ist year, Semester II

Advanced Control and Instrumentation

ELCA203

L	T	P	Credit
3	0	0	03

1.Course Outcomes (COs):

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

CO1	Understand the concepts of multiple input multiple output systems
CO2	Analyze the control-loop interactions of MIMO systems and analyze the sensitivity
CO3	Design control strategy for MIMO systems based on multi-variable SISO framework
CO4	Learn the working and characteristics of transducers and sensors
CO5	Learn various interfacing techniques and standards for communication between instruments

2.Syllabus

- **ENHANCEMENTS TO FEEDBACK CONTROLLERS (08 Hours)**
  PID enhancements, Antireset windup, Autotuning techniques, Nonlinear PID controller, Gain scheduling, Ratio control, Selective and Override control, Spit-Range control, Limitation of feedback control, Cascade-control analysis and design, Cascade control based IMC and direct synthesis, Feed-Forward control analysis, and design, Combined Feed-Forward and Cascade control
- **MULTIVARIABLE SYSTEMS AND CONTROL-LOOP INTERACTION (08 Hours)**
  MIMO systems, motivating examples, Control-loop interaction, general pairing problem, relative gain array (RGA), Properties and applications of RGA, RGA and sensitivity, Using RGA to determine variable pairings through illustrative examples.
- **MULTIVARIABLE CONTROL (12 Hours)**
  Transmission zeros and subsequent performance limitations, calculation and illustration, Directional sensitivity and operability, Singular value decomposition, Decoupling: ideal, simplified and static decoupling, Feedback control using decoupling. IMC design procedure for MIMO systems. Implementation and analysis of benchmark control problems. Model Predictive Control, Dynamic matrix control.
- **FINAL CONTROL ELEMENTS AND SENSORS (06 Hours)**
  Pneumatic control valves, construction, types, characteristics and other final control elements. Differential pressure transmitter, rotameter and other sensors. Choice of sensors and their technical specifications for various industrial and laboratory scale processes such as quadruple tank sytem, coupled-tank system, Magnetic levitation system etc.

- **MODERN SENSORS AND INTERFACING (08 Hours)**
  Optical sensors, positioning sensors, distance and thickness sensors, micro-miniaturized sensing devices (MEMS), ultrasonic sensors, IR temperature detection, distributed fiber optic sensors, radio frequency tagging (RFID), intelligent sensors standard and protocols, introduction to wireless sensor network and protocols. Digital data communication, open system interconnection (OSI model), Data communication methodology, overview of EIA RS

232, RS 485 interface standard, 4-to-20mA current loop serial communication, Modbus protocol, overview of Industrial Ethernet & TCP/IP

Total Hours: 42

List Of Experiments

1. IMC based controller design for cascade control system
2. Combined feed forward-feedback controller design for first order process with disturbance
3. Feed forward-feedback controller design for systems having process higher order than disturbance transfer function
4. Control of time delayed process using smith predictor and PI controller
5. Design and implementation of cascade plus feed forward controller for first order system
6. Control system design for MIMO systems using MV-SISO approach
7. Design controllers based on IMC for MIMO systems
8. Control system design for MIMO systems using decoupling strategy
9. Design and implementation of feed forward plus feedback control strategy for a real-time level control problem
10. Design and implementation of cascade control strategy for a real-time level control problem

3.Books Recommended:

1. Dale E. Seborg, Thomas F. Edgar, Duncan A. Mellichamp, Francis J. Doyle III, Process Dynamics and Control, 3rd Edition, John Wiley & Sons, Inc., 2011.
2. B. Wayne Bequette, Process Control: Modeling, Design, and Simulation, Prentice Hall, Prentice Hall, 2003.
3. Curtis D. Johnson, Process Control Instrumentation Technology, 8th Edition, Pearson Education India, 2015.
4. Ernest O Doeblin, Measurement Systems: Application and Design, McGraw Hill (Int. edition) 1990.

M. Tech. (Electrical)(C&A), Ist year, Semester II

L	T	P	Credit
3	0	2	04

ADVANCED AUTOMATION

ELCA204

1. Course Outcomes (COs):

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

CO1	Explain the advanced controller for Industrial automation
CO2	Develop the ladder logic with high end PLC instructions
CO3	Discuss industrial communication
CO4	Develop and configure SCADA and HMI with PLC
CO5	Design the ladder logic for various industrial applications with PLC and SCADA

2. Syllabus

- **ADVANCED CONTROLLERS FOR INDUSTRIAL AUTOMATION (20 Hours)**
  Introduction, definition, High end PLC programming Instructions, arithmetic functions, comparison functions, analog input and output, subroutine instructions, interrupt instruction. PID Tuning, close loop speed control, closed loop temperature control. Design of ladder diagrams for various applications.
- **INDUSTRIAL COMMUNICATION (04 Hours)**
  Industrial Instrumentation Communication and Networking– RS232, RS485, Modbus, HART, Fieldbus, Profibus, Serial Communications, etc.
- **SCADA AND HMI (12 Hours)**
  Basics of SCADA, creating new SCADA applications, tag generation, screen development, Buttons, numeric display and input, animated object, trends, report, alarm, SCADA communication and protocols etc. Communication of SCADA with PLC.
  HMI Basics and types of HMI, creating new HMI program, tag generation, screen development, buttons, numeric display and input, alarm, HMI communication and protocols, etc.
  IoT based control systems.

- **CASE STUDY (06 Hours)**
  Industrial automation in various industries, like chemical, textile, oil and Gas, food and beverages etc.

Total Hours: 42

List Of Experiments

Experiments will be performed based on the case studies related to industrial processes and drives applications using PLC, VFD and HMI/SCADA.

3. Books Recommended:

1. John Webb, Programmable Logic Controllers Principles & Applications, Prentice Hall of India, 1st Edition, 2013.
2. Andrews, Applied Instrumentation in Process Industries, Gulf Professional Publishing; 2nd Edition, 1979.
3. D. Patranabis, Principles of Process Control, Tata Mcgraw Hill, 3rd Edition, 2017.
4. S. K. Singh, Computer Aided Process Control, Prentice Hall of India, 2004.
5. Kevin Collins, PLC Programming for Industrial Automation, Exposure Publishing, 2006.

ELECTIVE-III

M. Tech. (Electrical)(C&A), Ist year, Semester II

ESTIMATION OF SIGNALS AND SYSTEMS

ELIC210

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	Make use of the concepts of random processes for formulating problems in stochastic estimation framework
CO2	Implement Kalman filter to solve linear estimation problems, and to analyze the estimation accuracy
CO3	Implement nonlinear Kalman filters for solving nonlinear estimation problems, and to analyze the estimation accuracy
CO4	Develop estimators for different types of linear and nonlinear systems
CO5	Analyse and decide the usefulness of estimators for the trajectory estimation and control of autonomous systems, and process control problems

2. Syllabus

- **ESTIMATION AND PRELIMINARIES** (**14 Hours**)
  Definition for state and parameter estimation, Need of estimation in control, Concepts of random experiments, sample space, probability function, random variable, scalar and vector random variables, cumulative distribution function, probability density function, and their properties. Commonly used random variables, scalar and multivariate Gaussian probability density, properties, moments of random variables: mean, autocorrelation, variance, covariance, cross-correlation, crosscovariance. Marginal and conditional probability density, Bayes' rule, independent and identically distributed random variables.
- **BASICS OF ESTIMATION: LINEAR SYSTEMS** (**18 Hours**)
  Estimation of a constant vector from noisy measurements: weighted least squares (WLS) estimator, minimum variance linear estimator, best linear unbiased estimator (BLUE). Minimum variance linear estimator with prior knowledge, maximum likelihood estimation (MLE), maximum a posteriori estimate (MAP).
  Initial state estimation using a batch of data: WLS and recursive WLS. Recursive linear minimum mean square error (LMMSE), Bayesian framework for estimation, Kalman filter, assumptions and conditions for optimality.
- **NONLINEAR ESTIMATION IN CONTROL** (**10 Hours**)
  Bayesian framework for nonlinear state estimation, extended Kalman filter (EKF), unscented Kalman filter (UKF), implementation of Kalman filters for solving control problems in tracking and navigation problems, process control problems etc. Wiener's theory of optimization, application of Wiener's theory in the compensator design for feedback control systems

Total Hours: 42

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

1. A. H. Jazwinski, Stochastic Processes and Filtering Theory, Academic Press, 1970.
2. P. S. Maybeck, Stochastic Models, Estimation and Control: Volume 1, Academic Press,1979.
3. H. J. Kushner, Stochastic Stability and Control, New York: Academic Press, 1967.
4. Y. Bar-Shalom, X. R. Li, T. Kirubarajan, Estimation with Applications to Tracking and Navigation: Theory, Algorithms and Software, John Wiley & Sons, Inc., 2002.
5. D. Simon, Optimal State Estimation: Kalman, H Infinity, and Nonlinear Approaches, John Wiley & Sons, Inc., 2006.

M. Tech. (Electrical)(C&A), Ist year, Semester II

L	T	P	Credit
3	0	0	03

INTERNET OF THINGS

ELCA 211

1. Course Outcomes (COs):

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

CO1	Discover the application areas of IoT
CO2	Realize the revolution of Internet in Mobile Devices, Cloud & Sensor Networks
CO3	Describe the building blocks of Internet of Things and characteristics
CO4	Explain cloud-based sensor data analysis
CO5	Designing an IoT system

2. Syllabus

- **ELEMENTS OF AN IoT** **(10 Hours)**
  Elements of an IoT ecosystem, Technology drivers, Business drivers, Typical IoT applications, Overview of IoT supported Hardware platforms such as: Raspberry pi, ARM Cortex Processors, Arduino and Intel Galileo boards, IoT architecture: History of IoT, M2M - Machine to Machine, Web of Things, IoT protocols, Internet of Things (IoT) and Web of Things (WoT), Internet and Web Layering Business aspects of the Internet of Things, Representational State Transfer (REST) and Activity Streams, Business Cases & Concepts Persuasive Technologies.
- **NETWORKING EQUIPMENT** **(10 Hours)**
  Overview and working principle of Wired Networking equipment, Router, Switches, Overview and working principle of Wireless Networking equipment, Access Points, Hubs, etc. Linux Network configuration concepts: Networking configurations in Linux Accessing Hardware & Device Files interactions.
- **NETWORK FUNDAMENTALS** **(12 Hours)**
  Network Fundamentals: Anatomy of a Sensor Network, Examples of Sensor Networks, Topology of a Sensor Network Communication Media. Wired Networks, Wireless Networks, Hybrid Networks. Types of Sensor Nodes, How Sensors Measure Storing Sensor Data. XBee Primer, Building an XBee-ZB Mesh Network, Arduino-Based Sensor Nodes, Hosting Sensors with Raspberry Pi.
- **IoT TUTORIAL AND MINI-PROJECT** **(10 Hours)**
  Storing Sensor Data, Storage Methods - Local Storage Options for the Arduino, Local Storage Options for the Raspberry Pi, Remote Storage Options, MySQL Local processing on the sensor nodes, Connecting devices at the edge and to the cloud, Processing data offline and in the cloud, Mini-project: Designing an IoT system.

Total Hours: 42

3. **Books Recommended:**

1. J. Biron and J. Follett, Foundational Elements of an IoT Solution, O'Reilly Media, 2016.
2. Charles Bell, Beginning Sensor Networks with Arduino and Raspberry Pi , Apress, 2013.
3. D. Evans, The Internet of Things: How the Next Evolution of the Internet Is Changing Everything, Cisco Internet Business Solutions Group, 2011.
4. McKinsey&Company, The Internet of Things: Mapping the value beyond the hype, McKinseyGlobal Institute, 2015.
5. European Alliance for Innovation (EAI), Internet of Things: Exploring the potential, InnovationAcademy Magazine, Issue No. 03, 2015.

M. Tech. (Electrical)(C&A), Ist year, Semester II

L	T	P	Credit
3	0	0	03

ELECTRIC VEHICLES

ELCA212

1.Course Outcomes (COs):

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

CO1	Explain the basics of electric and hybrid electric vehicles, their architecture, technologies and fundamentals
CO2	Analyze the use of different power electronics converters and electrical machines in electric vehicles
CO3	Able to interpret the working of different configurations of electric vehicles and its components, hybrid vehicle configurations
CO4	Explain the use of different energy storage systems used for electric vehicles, their control techniques, and select appropriate energy balancing technology
CO5	Ability to understand the control and configurations of HEV charging stations

2.Syllabus

- **INTRODUCTION** (**10 Hours**)
  Vehicle Basics, vehicle model, Vehicle Resistance: Rolling Resistance, Aerodynamic Drag, Grading Resistance, Dynamic Equation Tire–Ground Adhesion and Maximum Tractive Effort, Power Train Tractive Effort and Vehicle Speed, EV Powertrain Component Sizing. Hybridization of the Automobile: Basics of the EV, Basics of the HEV, Basics of Plug-In Hybrid Electric Vehicle (PHEV) and vehicle architectures
- **POWER ELECTRONICS IN EV** (**10Hours**)
  Power electronics circuits used for control and distribution of electric power in DC-DC, AC-DC, DC-AC converters used for EV. Electric Machines and Drives in EVs: Fundamental of Drives and Control of EV Using DC motor, Induction Motor, Permanent Magnet Motor, Switched Reluctance Motor, BLDC motor, Design and Sizing of Traction Motors.
- **ENERGY STORAGE ELEMENTS** (**10 Hours**)
  Batteries, Ultracapacitor, Fuel Cells, and Controls: Introduction, Different batteries for EV, Battery Characterization, Comparison of Different Energy Storage Technologies for HEVs, Battery Charging Control, Charge Management of Storage Devices, Flywheel Energy Storage System, Fuel Cells and Hybrid Fuel Cell Energy Storage System and Battery Management System
- **EV CHARGING TECHNOLOGIES** **(12 Hours)**
  Classification of different charging technology for EV charging station, introduction to Grid-to-Vehicle, Vehicle to Grid (V2G) or Vehicle to Buildings (V2B) or Vehicle to Home (V2H) operations, bi-directional EV charging systems, energy management strategies used in hybrid and electric vehicle, Wireless power transfer (WPT) technique for EV charging.

Total Hours: 42

3.**Books Recommended:**

1. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004
2. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003
3. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003
4. Chris Mi, M. Abul Masrur, David Wenzhong Gao, Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives, John Wiley & Sons Ltd., 2011

M. Tech. (Electrical)(C&A), Ist year, Semester II

NETWORKED CONTROL SYSTEMS

ELCA213

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	Integrate the basic concepts to formulate networked control problems
CO2	Describe various decentralized control strategies for networked control systems
CO3	Develop various control strategies for multi-agent robotics
CO4	Develop models and strategies for mobile sensor and communication networks
CO5	Develop decentralized control strategies

2. Syllabus

- **BASIC CONCEPTS IN NETWORKED CONTROL (10 Hours)**
  Review of Graph Theory-Connected Graph-Incidence Matrix-Tree-cutset-loop/cycles-Minimum Spanning Tree-Network Models -graphs, random graphs, random geometric graphs, state-dependent graphs-Networked control systems-Proximity graphs - Algebraic and spectral graph theory - Connectivity: Cheeger's inequality -switching networks- From biological swarms to graph-based models-Rendezvous: A canonical problem
- **DECENTRALIZED CONTROL (10 Hours)**
  The agreement protocol: static case- Reaching decentralized agreements- Consensus equation: Static case- Leader networks and distributed estimation- Discrete time consensus. The agreement protocol: dynamic case: Switched networks- Lyapunov-based stability- Consensus equation: Dynamic case-Biological models: Flocking and swarming- Alignment and Kuramoto's coupled oscillators. Distributed estimation -Computational, communications, and controls resources in networked control systems-Distributed control- Convex Optimization - Optimization-based control design.
- **MULTI AGENT ROBOTICS (11 Hours)**
  Formations - Graph rigidity -Persistence -Formation control, sensor and actuation models-distance based formations, rigidity, position based formations, formation infeasibility - Consensus problem- static, dynamic, distributed estimation, leader-follower architectures for consensus-Reaching decentralized agreements through cooperative control- leader-follower networks-Network controllability- Network feedback- Averaging Systems-Positive Systems-nonholonomic, double integrator, rigid body dynamics-Collision avoidance: potential fields, navigation functions. Introduction to artificial intelligence & deep learning for multi-agent robotics.
- **MOBILE SENSOR AND COMMUNICATION NETWORKS (11 Hours)**
  Sensor networks: Coverage control- Coverage and detection problems-Gabriel and Voronoi graphsvoronoi-based cooperation strategies-Random graphs - LANdroids: Communication networks - Communication models- mobile communications networks- connectivity, connectivity maintainance, sampling, delays, packet losses, quantization, security -Swarming-

sensor networks: sensing constraints, aggregation, dispersion, coverage control, deployment, flocking. Internet of things (IOT).

Total Hours: 42

3. Books Recommended:

1. Mehran Mesbahi and Magnus Egerstedt, 'Graph Theoretic Methods in Multiagent Networks,' Princeton University Press, 2010.
2. F. Bullo, J. Cortes, and S. Martinez, 'Distributed Control of Robotic Networks', Princeton, 2009.
3. C. Godsil and G. Royle, 'Algebraic Graph Theory', Springer, 2001.
4. P. J. Antsaklis and P. Tabuada,, 'Networked Embedded Sensing and Control', Springer 2006.
5. C. Godsil and G. Royle, 'Algebraic Graph Theory', Springer, 2001.

M. Tech. (Electrical)(C&A), Ist year, Semester II

L	T	P	Credit
3	0	0	03

ADVANCED COMMUNICATIONS

ELCA214

1.Course Outcomes (COs):

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

CO1	Describe the basic knowledge of data communication methods, centralized/distributed networking architectures, OSI reference model, networking issues, protocols
CO2	Illustrate the suitable network protocols at various layers in computer networks along with the constraints
CO3	Apply the protocols and techniques in developing the standard networks using standard tools or software overcoming the constraints
CO4	Analyze the performance of various techniques and protocols in a given network topology, case study and problem solving as per given data.
CO5	Design the codes for the given protocols using appropriate tools

2.Syllabus

- **DATA COMMUNICATION AND NETWORKING OVERVIEW (06 Hours)**
  A Communication Model, Data Communication, Networking Concept, Topology and Transmission Media, Subnet, Concept of Client and Server, An Example Configuration, The Need for Protocol Architecture, Protocol Architecture and peer processes, OSI Reference Model, The TCP/IP Protocol Stack.
- **DATA LINK CONTROL (05 Hours)**
  Medium Access Control (MAC) And Logical Link Control (LLC) Sublayer Issues, Flow Control, Error Control, Access Control, Sliding Window Protocol, Polling, High-Level Data Link Control (HDLC), PPP, Performance Issues.
- **LOCAL AREA NETWORKS — OVERVIEW (05 Hours)**
  LAN Protocol Architecture, Bridges, Emergence of High-Speed LANs, Ethernet, Wireless LAN Technology (Wi-Fi) Protocols.
- **ROUTING AND CONGESTION CONTROL (06 Hours)**
  Logical Addresses, Circuit-Switching and Packet Switching Networks, Classful Addressing, Classless Addressing (CIDR), Subnetting, Super netting, Network Address Translation, Routing In Packet-Switching Networks, Broadcasting, Multicasting, Flooding, Routing Algorithms, Effects Of Congestion, Congestion Control In Packet-Switching Networks. IP address classes, Ad-Hoc network Routing constraints. Mobile IP and its architecture
- **INTERNETWORK PROTOCOLS (05 Hours)**
  Basic Protocol Functions, Principles of Internetworking, Fragmentation Concept, Connectionless Internetworking, Gateway and Routers, The Internet with IPv4 and IPv6 packet formats, ARP, RARP, DHCP, ICMP, IGMP.
- **TRANSPORT PROTOCOLS (04 Hours)**

Port Addresses, Quality of Service Parameter, TCP, UDP and SCTP Protocols Mobile TCP

- **NETWORK SECURITY** **(04 Hours)**
  Security Requirement and Attacks, Cryptography, Classical Ciphers, Modern Ciphers, Confidentiality with Encryption, Message Authentication And Hash Functions, Public-Key Encryption And Digital Signatures
- **DISTRIBUTED APPLICATIONS** **(07 Hours)**
  Network Virtual Terminal (TELNET), File Transfer Protocol (FTP), Electronic Mail - SMTP And MIME, Hyper Transfer Protocol (HTTP), Network Management - SNMP, Domain Name Server (DNS), URL, WWW.

Total Hours: 42

3.Books Recommended:

1. Tanenbaum Andrew S., "Computer Networks", PHI, 5th Ed., 2011.
2. Stalling William, "Data and Computer Communications", PHI, 10th Ed., 2014.
3. Forouzan Behrouz A., "Data Communications and Networking", Tata McGraw-Hill, 5th Ed., 2013.
4. Gallager R. G. And Bertsekas D., "Data Networks", PHI, 2nd Ed., 1992.
5. Garcia Leon and Wadjaja I., "Communication Networks", Tata McGraw-Hill, 2nd Ed., 2004.

INSTITUTE ELECTIVE

M. Tech. (Electrical)(C&A), Ist year, Semester II
AUTOMOTIVE CONTROL SYSTEMS

L	T	P	Credit
3	0	0	03

ELCA230

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1. Course Outcomes (COs):

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

CO1	Discuss need of automotive control systems
CO2	Comprehend basic Engine Operation and various aspects of engine control system
CO3	Explain driveline modeling and control
CO4	Calculate various vehicle parameters
CO5	Perform state estimation and vehicle dynamics control

2. Syllabus

- **Automotive Engine modeling an driveline control** **(20 Hours)**
  Introduction to automotive systems, need of control systems for automobiles and a brief history of automotive control systems, engines and working principle, engine operation and engine control. Engine Control Systems: Lambda Control; Speed Control; Knock Control; Cylinder Balancing

  Driveline Control: Driveline modeling, Modeling of neutral gear, state space modeling of driveline control; Driveline control with LQG / LTR; Driveline control for speed, control for gear shifting and anti-jerk control of passengers.

- **Vehicle Dynamics Modeling, estimation and control** **(22 Hours)**
  Wheel Model, Complete Vehicle Model, Vehicle parameters and states. Estimation of vehicle velocity and Yaw rate, trajectory reconstruction, identification of vehicle parameters and its approximation, Observers, Kalman filters, Body Side Slip Angle observer, determination of road gradient. Vehicle Control Systems: ABS control systems, control of Yaw Dynamics, road and driver models. Modeling of automotive control systems in MATLAB/SIMULINK environment.

Total Hours: 42

3. Books Recommended:

1. U. Kiencke and L. Nielsen, "Automotive Control Systems: For Engine, Driveline, and Vehicle," Springer-Verlag New York, LLC, 2004.
2. Shahram Azadi , Reza Kazemi, Hamidreza Rezaei Nedamani, “Vehicle Dynamics And Control Advanced Methodologies”, Elsevier Ltd. 2021

M. Tech. (Electrical)(C&A), I year, Semester II

MODERN INDUSTRIAL DRIVES AND AUTOMATION

L	T	P	Credit
3	0	0	03

ELCA231/EEPE231

1. Course Outcomes (COs):

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

CO1	Understand the modern industry drive and its installation and connections
CO2	Apply the various parameter setting
CO3	Explain the need of industrial automations
CO4	Develop the ladder logic for various industrial applications
CO5	Design the scheme to operate drive with PLC

2. Syllabus

- **MODERN INDUSTRIAL DRIVES** **(20 Hours)**
  Introduction, Applications of modern industrial drive, specification of Modern Industrial Drives, Installation, connections- control and power terminals, commissioning, parameter setting, open loop and close loop speed control, change of acceleration and de-acceleration time, over speeding, forward/reverse operating with operating two drive in synchronism, sensor less speed control, speed control with encoder, useof digital inputs and outputs of drive.
- **INDUSTRIAL AUTOMATION** **(22 Hours)**
  Need for an industrial automation, PLC definition, overview of PLC systems, input/output modules, power supplies and isolations. General PLC programming procedures, programming on-off inputs/ outputs, Bit logic, data move, timers, counters, compare, convert instructions. Arithmetic instructions. Analog value processing. Generation of Analog output to control drive, control of drive with digital output of PLC. Speed variation of industrial drive with digital and analog output of PLC.

Total Hours: 42

3. Books Recommended:

1. G.K.Dubey, Fundamentals of Electrical Drives, Narosa- 1995.
2. S.A. Nasar, Boldea , Electrical Drives, Second Edition, CRC Press – 2006.
3. M. A. ElSharkawi , Fundamentals of Electrical Drives , Thomson Learning -2000.
4. John W. Webb and Ronald A. Reis, Programmable Logic Controllers - Principles and Applications, Fourth edition, Prentice Hall Inc., New Jersey, 1998.
5. Frank D. Petruzella, Programmable Logic Controllers, Second edition, McGraw Hill, New York, 1997.

M. Tech. (Electrical)(C&A), Ist year, Semester II

OPTIMIZATION IN CONTROL AND AUTOMATION

ELCA232

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	Apply mathematical and numerical techniques of optimization theory to concrete Engineering problems.
CO2	Apply mathematical and numerical techniques of optimization theory to concrete Engineering problems.
CO3	Describe the mathematical properties of general linear programming problems and obtain the solution of linear programming problems using appropriate techniques.
CO4	Formulate real-world problems as Linear Programming models, apply the simplex method and dual simplex algorithms in solving the standard LP problem and interpret the results obtained.
CO5	Apply linear programming in various engineering applications

2.Syllabus

- **LINEAR PROGRAMMING** **(12 Hours)**
  Concepts of optimization: Engineering applications, Statement of optimization problem, Classification - type and size of the problem. Classical Optimization Techniques: Single and multivariable problems-Types of Constraints. Semi definite case-saddle point. Linear programming: Standard Form-Geometry of LP problems-Theorem of LP-Relation to convexity - formulation of LP problems - simplex method and algorithm -Matrix form- two phase method. Duality-dual simplex method- LU Decomposition. Sensitivity analysis. Artificial variables and complementary solutions-QP. Engineering Applications: Minimum cost flow problem, Network problems-transportation, assignment & allocation, scheduling.
- **NONLINEAR PROGRAMMING** **(10 Hours)**
  Nonlinear programming: Non linearity concepts-convex and concave functions- non-linear programming - gradient and Hessian. Unconstrained optimization: First & Second order necessary conditions-Minimization & MaximisationLocal & Global Convergence-Speed of convergence. Basic decent methods: Fibonacci & Golden section search - Gradient methods - Newton Method Lagrange multiplier method - Kuhn-tucker conditions. Quasi-Newton method- separable convex programming - Frank and Wolfe method, Engineering Applications.
- **CONSTRAINED NONLINEAR PROGRAMMING** **(10 Hours)**
  Nonlinear programming- Constrained optimization: Characteristics of constraints-Direct methods SLP, SQP-Indirect Methods-Transformation techniques-penalty function-Lagrange multiplier methods checking convergence- Engineering applications.
- **DYNAMIC PROGRAMMING** **(10 Hours)**
  Dynamic programming: Multistage decision process- Concept of sub optimization and principle of optimality- Computational procedure- Engineering applications. Genetic algorithms- Simulated Annealing Methods-Optimization programming, tools and Software.

Total Hours: 42

3.Books Recommended:

1. David G Luenberger, 'Linear and Non-Linear Programming'., 2nd Ed, Addison-Wesley Pub.Co., Massachusetts, 2003.
2. W.L.Winston, 'Operation Research-Applications & Algorithms',2nd Ed., PWS-KENT Pub.Co.,Boston, 2007.
3. S.S.Rao, 'Engineering Optimization'., 3rd Ed., New Age International (P) Ltd,New Delhi, 2007.
4. W.F.Stocker, 'Design of Thermal Systems', 3rd Ed., McGraw Hill, New York. 1990.
5. G.B.Dantzig, 'Linear Programming and Extensions'. Princeton University Press, N.J., 1963.

M. Tech. (Electrical)(C&A), Ist year, Semester II

L	T	P	Credit
3	0	0	03

SMART GRIDS

ELCA233

1. Course Outcomes (COs):

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

CO1	Get acquainted with the smart resources, smart meters and other smart devices
CO2	Describe how modern power distribution system functions
CO3	Identify suitable communication networks for smart grid applications
CO4	Formulate economic load dispatch problem as constrained optimization problem
CO5	Formulate and solve nonlinear and dynamic programming problems

2. Syllabus

- **INTRODUCTION** **(09 Hours)**
  Introduction, Evolution of Electric Grid, Smart Grid Concept, Need for Smart Grid, Functions, Opportunities, Benefits and challenges, Difference between conventional & Smart Grid,Technology Drivers, Indian smart grid, Key challenges for smart grid.
- **SMART DEVICES** **(12 Hours)**
  Energy Management System (EMS), Smart substations, Substation Automation, Feeder Automation, SCADA, Remote Terminal Unit, Intelligent Electronic Devices, Phasor Measurement Unit in wide area monitoring protection and control, Smart integration of energy resources withrenewable, intermittent power sources, Energy Storage, Distribution Management System (DMS) (Volt / VAR control), Fault Detection, Isolation and Service Restoration, Network Reconfiguration, Outage management System, Customer Information System, Geographical Information System, Effect of Plug in Hybrid Electric Vehicles.
- **OPTIMIZATION TECHNIQUES FOR SMART GRID** **(9 Hours)**
  Nonlinear programming, Constrained optimization: Characteristics of constraints, Direct methods such as SLP,SQP, Indirect methods, Transformation techniques like penalty function-Lagrange multiplier methods checking convergencefor power applications such as Economic load dispatch.
- **DYNAMIC PROGRAMMING** **(12 Hours)**
  Dynamic programming: Multistage decision process, Concept of sub optimization and principle of optimality, Genetic algorithms, Simulated Annealing Methods, Optimization programming, tools and Software packages, Artificial Intelligence techniques and applications in power system.

Total Hours: 42

3. Books Recommended:

1. Stuart Borlase , Smart Grid: Infrastructure, Technology and Solutions, CRC Press 2012.
2. JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, Smart Grid:Technology and Applications, Wiley, 2012.
3. Mini S. Thomas, John D McDonald, Power System SCADA and Smart Grids, CRC Press, 2015.
4. Kenneth C.Budka, Jayant G. Deshpande, Marina Thottan, Communication Networks for SmartGrids, Springer, 2014.

M. Tech. (Electrical)(C&A), Ist year, Semester II

Instrumentation-based System Design

L	T	P	Credit
3	0	0	03

ELIC234

1.Course Outcomes (COs):

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

CO1	Carry out research and development in the area of advanced instrumentation and signal conditioning.
CO2	Be well-versed with the sensor characteristics, basic signal conditioning circuits and sensor interfaces
CO3	Analyze and design different kinds of signal amplifiers, their non-idealities, and performances
CO4	Analyze and design noise and interference reduction circuits and improve the system performance
CO5	Solve practical and state-of-the-art problems related to sensor interfacing circuits and serve the related industries

2.Syllabus

- **INTRODUCTION** **(07 Hours)**
  Instrumentation and measurement system, Sensors, Primary sensing principles, Sensor performance characteristics, Sensor interfacing and signal conditioning circuit, integrated sensor system.
- **SIGNAL CONDITIONING CIRCUITS** **(08Hours)**
  Signal conditioning circuits for resistive, capacitive, and inductive sensors, electromagnetic and self-generating sensors, Error and Non-linearity reduction, Differential measurements.
- **SIGNAL AMPLIFIERS** **(10 Hours)**
  Non-idealities of Op-Amp, Effect of Non-idealities, Differential Amplifier, Trans-impedance Amplifier, Cascaded Amplifiers, CMRR, Performance Analysis of Amplifiers, Instrumentation amplifier, Charge amplifier, Programmable gain amplifier, Switched Capacitor amplifier.
- **INFERENCE AND NOISE** **(10 Hours)**
  Interference types and reduction, Signal circuit grounding, Shield grounding, and isolation amplifier. Types of Noise and Noise Sources, Offset and Noise reduction techniques: Auto-zeroing (AZ), Chopper-stabilization (CHS), Correlated double sampling (CDS), Sigma-Delta modulation
- **PACKAGING AND INTEGRATION** **(07 Hours)**
  Packaging and Encapsulation, Die and wafer level bonding, Types of packages, Sensor and Circuit integration: PCB, hybrid, monolithic, SOC and SIP.

Total Hours: 42

3.Books Recommended:

1. Ramon Pallas-Areny and John G. Webster, Sensors and Signal Conditioning, Wiley India Pvt Ltd, 2nd Edition, 2012
2. Ramon Pallas-Areny and John G. Webster, Analog Signal Processing, Wiley India Pvt Ltd, 2nd Edition, 2012
3. Anton F. P. van Putten, Electronic Measurement Systems, Theory and Practice, IOP Publishing, 2nd Edition, 1996
4. Jacob Fraden, Handbook of Modern Sensors- Physics, Designs, and Applications, Springer, Fourth Edition, 2010