Dual Degree

(B Tech in Electrical Engineering + M Tech in Power Electronics and Drives)

School of Electrical Sciences

IIT Bhubaneswar

Curriculum for Dual Degree B. Tech. (EE) + M. Tech (PED) of School of Electrical Sciences

Subject Name	Subject Code	L-T-P	Credit	Contact Hour
SEMESTER - I				
Mathematics – 1	MA1L001	3-1-0	4	4
Physics / Chemistry	PH1L001 / CY1L001	3-1-0	4	4
Mechanics / English for Communications or Learning English	ME1L001 / HS1L001 or HS1L002	3-1-0/ 3-0-2 or 3-1-0	4	4/5 or 4
Electrical Technology / Introduction to Programing and Data Structures	EE1L001 / CS1L001	3-1-0	4	4
Introduction to Manufacturing Processes / Engineering Drawing and Graphics	ME1P001 / CE1P001	0-0-3/ 1-0-3	2/3	3/4
Physics Laboratory / Chemistry Laboratory	PH1P001 / CY1P001	0-0-3	2	3
Electrical Technology Laboratory / Introduction to Programing and Data Structures Laboratory	EE1P001 / CS1P001	0-0-3	2	3
Extra Academic Activity – 1	ID1T001	0-0-3	1	3
		Total	**23/24**	**28/29**
SEMESTER - II				
Mathematics – 2	MA1L002	3-1-0	4	4
Chemistry / Physics	CY1L001 / PH1L001	3-1-0	4	4
English for Communication or Learning English / Mechanics	HS1L001 or HS1L002 / ME1L001	3-0-2 or 3-1-0/3-1-0	4	5 or 4/4
Introduction to Programing and Data Structures / Electrical Technology	CS1L001 / EE1L001	3-1-0	4	4
Engineering Drawing and Graphics / Introduction to Manufacturing Processes	CE1P001 / ME1P001	1-0-3/ 0-0-3	3 / 2	4/3
Chemistry Laboratory / Physics Laboratory	CY1P001 / PH1P001	0-0-3	2	3
Introduction to Programing and Data Structures Laboratory / Electrical Technology Laboratory	CS1P001 / EE1P001	0-0-3	2	3
Extra Academic Activity – 2	ID1T002	0-0-3	1	3
		Total	**24/26**	**30 or 28/29**
SEMESTER - III				
Breadth – 1		3-0-0	3	3
Introduction to Electronics	EC2L001	3-1-0	4	4
Introduction to Material Science and Engineering	ID2L001	2-0-0	2	2
Introduction to Bio Science and Technology	ID2L002	2-0-0	2	2
Probability Statistics and Stochastic Processes	MA2L003	3-1-0	4	4
Signals and Systems	EC2L002	3-1-0	4	4
Introduction to Electronics Laboratory	EC2P001	0-0-3	2	3
Signals and Systems Laboratory	EC2P002	0-0-3	2	3
Seminar	EE2S001	0-0-3	2	3
		Total	**25**	**28**
SEMESTER – IV				
Lateral -1		3-0-0/3-1-0	3/4	3/4
Breadth – 2		3-0-0/3-1-0	3/4	3/4
Environmental Science Technology and Management	ID2L003	2-0-0	2	2
Network Theory	EE2L001	3-1-0	4	4
Electric Machines	EE2L003	3-1-0	4	4
Digital Electronics and Microprocessor	EC2L006	3-1-0	4	4
Electric Machines Laboratory	EE2P003	0-0-3	2	3
Digital Electronics and Microprocessor Laboratory	EC2P006	0-0-3	2	3
		Total	**23/25**	**25/27**

Subject Name	Subject Code	L-T-P	Credit	Contact Hour
SEMESTER – V				
Lateral - 2		3-0-0/3-1-0	3/4	3/4
Breadth - 3		3-0-0	3	3
Power Electronics	EE3L004	3-1-0	4	4
Electrical Power Transmission and Distribution	EE3L007	3-1-0	4	4
Measurement and Instrumentation	EE3L010	3-0-0	3	3
Electromagnetic Field Theory	EE3L011	3-0-0	3	3
Power Electronics Laboratory	EE3P004	0-0-3	2	3
Measurement and Instrumentation Laboratory	EE3P005	0-0-3	2	3
		Total	**24/25**	**26/27**
SEMESTER - VI				
Lateral -3		3-0-0/3-1-0	3/4	3/4
Breadth – 4		3-0-0/3-1-0	3/4	3/4
Control Systems	EE3L003	3-1-0	4	4
Digital Signal Processing	EC3L003	3-1-0	4	4
Power System Operation and Control	EE3L012	3-1-0	4	4
Control Systems Laboratory	EE3P002	0-0-3	2	3
Digital Signal Processing Laboratory	EC3P002	0-0-3	2	3
Power Systems Laboratory	EE3P006	0-0-3	2	3
		Total	**24/26**	**27/29**
SEMESTER – VII				
Switched Mode Power Conversion	EE6L051	3-1-0	4	4
Digital Control Systems	EE4L005	3-0-0	3	3
Renewable Energy Systems	EE4L006	3-0-0	3	3
Theory and Analysis of Electric Drives	EE6L052	3-1-0	4	4
Switched Mode Power Conversion Laboratory	EE6P052	0-0-3	2	3
Industrial Training Defence	EE4T001	0-0-0	2	0
Project Part- 1 (EE)	EE4D001	0-0-6	4	0
		Total	**22**	**17**
SEMESTER – VIII				
Advanced Power Electronic Converters	EE6L053	3-0-0	3	3
Advanced Machine Drives	EE6L055	3-1-0	4	4
Grid Integration of Renewable Energy Systems	EE6L013	3-0-0	3	3
Power Converter and Electric Drives Laboratory	EE6P053	0-0-3	2	3
Renewable Energy Systems Laboratory	EE4P002	0-0-3	2	3
Project Part- 2 (EE)	EE4D002	0-0-9	6	0
		Total	**20**	**16**
SEMESTER – IX				
Elective I		3-0-0	3	3
Elective II		3-0-0 / 3-1-0	3 / 4	3 / 4
Power Electronics System Simulation Laboratory	EE6P051	0-0-3	2	3
Thesis Part I	EE6D051	0-0-0	12	0
		Total	**20/21**	**9/10**
SEMESTER – X				
Elective III		3-0-0 / 3-1-0	3 / 4	3 / 4
Thesis Part II	EE6D053	0-0-0	13	0
		Total	**16/17**	**3/4**

List of Elective Courses

Subject Name	Subject Code	L-T-P	Credit	Contact Hour
Elective – I, II				
Semiconductor Devices	EC4L001	3-0-0	3	3
Dynamics of Linear Systems	XXXXXX	3-0-0	3	3
Statistical Signal Processing	EC6L005	3-0-0	3	3
Machine Learning	CS6L004	3-0-0	3	3
High Voltage Engineering	EE6L009	3-0-0	3	3
Energy Storage Systems	EE6L011	3-0-0	3	3
Opto-Electronics	EC4L002	3-0-0	3	3
Optical Communication	EC6L012	3-0-0	3	3
Image and Video Processing	EC6L002	3-1-0	4	4
Electric Power Quality	EE6L002	3-0-0	3	3
Industrial Instrumentation	EE6L007	3-0-0	3	3
Artificial Intelligence	CS4L003	3-0-0	3	3
Elective – III				
VLSI Design	EC4L003	3-0-0	3	3
Biomedical Signal Processing	EC6L015	3-0-0	3	3
Fiber Optic Sensors	EC6L019	3-0-0	3	3
Embedded Systems	EC4L008	3-0-0	3	3
Pattern Recognition	EC6L027	3-0-0	3	3
Array Signal Processing	EC6L024	3-0-0	3	3
Power System Protection	EE6L004	4-0-0	4	4
Distribution System Engineering	EE6L017	3-0-0	3	3
Computational Electromagnetics	EC6L016	3-0-0	3	3
Adaptive Signal Processing	EC6L023	3-0-0	3	3
HVDC and Flexible AC Transmission Systems	EE6L005	3-0-0	3	3
Smart Grid Technology	EE6L014	3-0-0	3	3
Computer Vision	EC6L029	3-0-0	3	3
Semiconductor Device Modelling	EC6L017	3-0-0	3	3
Advanced High Voltage Engg.	EE6L015	3-0-0	3	3
Power System Planning	EE6L018	3-0-0	3	3

List of Lateral Courses for Other Schools

Subject Name	Code	L-T-P	Credit	Contact Hour
Lateral – 1 (Any one will be offered)				
Transducers, Sensors and Measurement	EE2L002	3-0-0	3	3
Introduction to Electromagnetic Engineering	EE2L004	3-0-0	3	3
Lateral – 2 (Any one will be offered)				
Control System Technology	EE3L005	3-0-0	3	3
Signals and Circuits	EE3L006	3-0-0	3	3
Lateral – 3 (Any one will be offered)				
Soft Computing and Applications	EE3L008	3-0-0	3	3
Utilization of Electric Power	EE3L009	3-0-0	3	3

Syllabus

Common Core:

Subject Code: EE1L001	Name: Electrical Technology	L-T-P: 3-1-0	Credits: 4

Prerequisite: None

Introduction: Sources of energy; General structure of electrical power systems, Power transmission and distribution via overhead lines and underground cables, Steam, Hydel, and Nuclear power generation; DC Networks: Kirchhoff's laws, node voltage and mesh current methods, Delta-star and star-delta conversion, Superposition principle, Thevenin's, Norton's theorems and Maximum power transfer theorem; DC Transient: Transient Analysis of RL and RC circuits, Single phase AC Circuits: Single phase EMF generation, average and effective values of sinusoids, solution of R,L,C series circuits, the j operator, complex representation of impedances, phasor diagram, power factor, power in complex notation, solution of parallel and series – parallel circuits; Three phase AC Circuits: Three phase EMF generation, delta and Y – connections, line and phase quantities, solution of three phase circuits, balanced supply voltage and balanced load, phasor diagram, measurement of power in three phase circuits, Three phase four wire circuits; Magnetic Circuits: Ampere's circuital law, B – H curve, solution of magnetic circuits, hysteresis and eddy current losses; Transformers: Construction, EMF equation, ratings, phasor diagram on no load and full load, equivalent circuit, regulation and efficiency calculations, open and short circuit tests, auto-transformers; DC Machines: Construction, EMF and Torque equations, Characteristics of DC generators and motors, speed control of DC motors and DC motor starters; Electrical Measuring Instruments: DC PMMC instruments, shunt and multipliers, multimeters, Moving iron ammeters and voltmeters, dynamometer, wattmeter, AC watthour meter, extension of instrument ranges.

Text Books:

1. E. Hughes, "Electrical Technology," Pearson Education, 2010.
2. V. Del Toro, "Electrical Engg Fundamentals," PHI Learning, 2009.

Reference Books:

1. I. J. Nagrath and D. P. Kothari, 'Basic Electrical Engineering' TATA McGraw Hill Education, 2009.
2. D. A. Bell, "Electric Circuits," 7th Ed., Oxford Higher Education, 2009.

Subject Code: CS1L001	Name: Introduction to Programming and Data Structure	L-T-P: 3-1-0	Credits: 4

Prerequisite: None

Digital computer fundamentals, concepts of algorithms and introduction to programming – examples; Constants and variables – data types, operators and expressions - type conversions, types of expressions; Assignment statements, input-output statements - concepts of data formats; Control statements: branching – if-else statements; iteration – while, do-while, for statements. nested control structures, switch, break and continue statements; Functions and recursion – examples; concepts of parameter passing by values and by reference; Arrays – single and multidimensional, examples – searching and sorting; Introduction to pointers, character strings and arrays, pointers and arrays; Structures, linked lists, dynamic allocation, stacks and queues, binary trees and tree traversals; Data files – creating, opening, closing and operating data files; (The programming language C to be used as the basis language).

Text Books:

1. B. Gottfried, "Schaum' s Programming with C," Tata McGraw-Hill, 1998.
2. E. Balaguruswamy, "Programming in ANSI C," Tata McGraw-Hill, 2012.
3. Y. Kanetkar, "Let us C," BPB Publications, 2012.
4. S. Lipschutz, "Data Structures, Schaum's Outlines Series," Tata McGraw-Hill, 2010.

Reference Books:

1. Brian W. Kernighan and Dennis M. Ritchie, "The C Programming Language," 2nd Ed., Prentice Hall of India, 2015.
2. Ellis Horowitz, Satraj Sahni and Susan Anderson-Freed, "Fundamentals of Data Structures in C," 2nd Ed., Orient Long Man, 2008.
3. Andrew M. Tanenbaum, "Data Structure using C", 1st Ed. Pearson India, 1998.

Subject Code: EC2L001	**Name: Introduction to Electronics**	**L-T-P: 3-1-0**	**Credits: 4**
Prerequisite: None			

Introduction to Electronic Devices: passive devices, Diode, bipolar junction transistor (BJT), metal oxide semiconductor field-effect transistor (MOSFET); Diode: basic structure and types, operating principle, current-voltage characteristic, large and small signal models; Diode Applications: rectifier circuits, zener voltage regulator Regards, clipper and clamper circuits; BJT and their Application: structure and modes of operation; NPN and PNP transistor in active mode, DC analysis, BJT as a switch and amplifier, small signal equivalent circuits, single stage CE amplifier; MOSFET and Applications: switch and amplifier; Operational Amplifier and applications: Basics, summing amplifier, inverting and non-inverting configuration, voltage follower, differentiator and integrator; Feedback: Basic concepts of feedback, ideal feedback topologies; Oscillators: Basic principle of sinusoidal oscillation, phase-shift oscillator, wien-bridge oscillator; Digital Electronics: Boolean algebra and rules of simplification and combinational circuits.

Text Books:

1. S. Sedra, K. C. Smith, "Microelectronic Circuits," Oxford University Press, India, 2005.
2. A Malvino, D J Bates; "Electronic Principles," Tata McGraw Hill, India, 2007.

Reference Books:

1. R C Jaeger, T N Blalock, Microelectronic Circuit Design; Tata McGraw Hill, India, 2006.

Subject Code: EC2L005	Name: Basic Electronics	L-T-P: 3-1-0	Credits: 4
Prerequisite: None			

Semiconductor devices: Diode, BJT, MOSFET, their structures and principle of operations; Amplifiers: Functionality, specifications (voltage gain, current gain, input resistance, output resistance, dynamic range, bandwidth, linearity, power efficiency etc.), effect of cascading, various applications and typical circuits; Filters: Low pass, high pass, band pass and band stop filters, single and higher order passive filter topologies (RC and LC); Feedback: Basic concept of negative and positive feedback, application of negative feedback in amplifiers, effect on gain, bandwidth, input resistance, output resistance and desensitivity to parameter variations; Oscillators: Barkhausen criterion, sinusoidal and non-sinusoidal oscillators, applications and typical circuits; Operational amplifier: Differential mode of operation, common mode rejection, typical op-amp specifications, inverting amplifier, non-inverting amplifier, integrator, differentiator, summing amplifier etc., concept of active filters; Power electronics: Half wave and full wave rectification, filtering, regulation with zener diode and linear regulators, switched mode power supply; Digital electronics: Review of Boolean algebra and signed number representation schemes in binary, implementation of Boolean functions using various logic gates, concept of combinatorial and sequential circuits, registers and counters from functional viewpoint, concept of programmable processors and microcontrollers.

Text Books:

1. A. Malvino and D. J Bates "Electronic Principles," Tata McGraw - Hill Education, 2006.
2. D. A. Neamen, "Electronic Circuits," Tata McGraw - Hill Education, 2006.

Reference Books:

1. Malvino and Brown, "Digital Computer Electronics," Tata McGraw - Hill Education, 2001.
2. Samuel C. Lee, "Digital Circuits and Logic Design," PHI Learning, 2009.
3. R. A. Gayakwad, "Op-Amps and Linear Integrated Circuits," PHI Learning, 2009.

Lateral Theory:

Subject Code: EE2L002	Name: Transducers, Sensors and Measurement	L-T-P: 3-0-0	Credits: 3
Prerequisite: None			

Introduction: Components of a sensor, Types of sensors, Applications; Static characteristics: Static calibration, static error, correction, range, span, accuracy, precision, sensitivity, linearity, hysteresis, dead time, dead zone, resolution, loading effect; Errors: Types of errors, Random errors: mean, variance, Gaussian curve of errors, precision errors and precision index; Dynamic characteristics: Modelling a sensor, zero, first and second order systems; Primary sensing elements: Stain gauge, variable capacitance transducer, variable inductance transducer (LVDT), optical sensors, piezoelectric transducers, hall effect transducer; Mechanical measurements: Measurement of force, pressure, flow, displacement, acceleration, velocity; Temperature measurement: RTD, thermistor and thermocouple; Signal conditioning circuit: Amplifiers, Filters, Bridge circuits, A/D and D/A converters, Modern data acquisition systems.

Text Books:

1. E. O. Doebelin, "Measurement System: Application and Design," 5th Ed., McGraw-Hill Education, 2003.
2. D. Patranabis, "Principles of industrial instrumentation," 2nd Ed.,Tata McGraw-Hill Education, 2001.
3. A.K Sawhney, "Electrical and Electronics Measurements and Instrumentation," 19th Ed., Dhanpat Rai & Co., 2011.

Subject Code: EE2L004	Name: Introduction to Electromagnetic Engineering	L-T-P: 3-0-0	Credits: 3
Prerequisite: None			

Introduction: Sources and effects of electromagnetic fields – Vector fields – Different coordinate systems; Vector calculus – Gradient, Divergence and Curl - Divergence theorem – Stoke's theorem; Electrostatics: Coulomb's Law – Electric field intensity – Field due to point and continuous charges – Gauss's law and application – Electric potential – Electric field and equipotential plots – Electric field in free space, conductors, dielectric -Dielectric polarization - Dielectric strength - Electric field in multiple dielectrics – Boundary conditions, Poisson's and Laplace's equations – Capacitance- Energy density; Magnetostatics: Lorentz Law of force, magnetic field intensity – Biot–savart Law - Ampere's Law – Magnetic field due to straight conductors, circular loop, infinite sheet of current – Magnetic flux density (B) – B in free space, conductor, magnetic materials – Magnetization – Magnetic field in multiple media – Boundary conditions – Scalar and vector potential – Magnetic force – Torque – Inductance – Energy density – Magnetic circuits; Electrodynamic Fields: Faraday's laws, induced emf – Transformer and motional EMF – Forces and Energy in quasistationary Electromagnetic Fields - Maxwell's equations (differential and integral forms) – Displacement current – Relation between field theory and circuit theory; Electromagnetic Waves: Generation – Electro Magnetic Wave equations – Wave parameters; velocity, intrinsic impedance, propagation constant – Waves in free space, lossy and lossless dielectrics, conductors-skin depth, Poynting vector – Plane wave reflection and refraction – Transmission lines – Line equations – Input impedances – Standing wave ratio and power.

Text Books:

1. Mathew N. O. SADIKU, 'Elements of Electromagnetics', Oxford University press Inc. First India edition, 2007.
2. Ashutosh Pramanik, 'Electromagnetism – Theory and Applications', Prentice-Hall of India Private Limited, New Delhi, 2006.

3. Joseph. A.Edminister, 'Theory and Problems of Electromagnetics', Second edition, Schaum Series, Tata McGraw Hill, 1993.
4. William H.Hayt, 'Engineering Electromagnetics', Tata McGraw Hill edition, 2001.
5. Kraus and Fleish, 'Electromagnetics with Applications', McGraw Hill International Editions, Fifth Edition, 1999.

Subject Code: EE3L005	Name: Control System Technology	L-T-P: 3-0-0	Credits: 3

Prerequisite: None

Introduction to Control Systems: Definition, Examples of control systems, Open loop and closed-loop control systems, Review of Laplace and inverse Laplace transforms; System Modeling: Signal flow graph, Block diagram, Transfer function, Poles and zeros, Block diagram reduction using signal flow graph and block diagram reduction techniques, Mechanical, electrical and electromechanical systems, First and second order models; Control System Components: Introduction, Linear approximation of nonlinear systems, Electrical systems, Stepper motor, Hydraulic systems, Pneumatic systems, Gyroscopes; Transient Response and Steady State Error Analysis: Definitions of transient response parameters, analysis of second order system as prototype, Routh-Hurwitz stability criterion, Classification of systems based on steady state characteristics, Steady state error coefficients; Root Locus Method: Definition of root locus, Properties of root locus, Sketching of root locus, Effect of open loop poles and zeros, Root locus design concepts; Frequency Response Analysis: Bode diagram, Polar plot, Nichols plot, Nyquist stability criterion: nonmathematical description of Nyquist criterion, interpretation of stability, Relative stability – Gain and Phase margin, Closed loop frequency response – M and N contours, Nichols chart; Compensation Techniques: Compensation techniques: lag, lead and lag-lead compensation, PD, PI and PID controllers, Cascade compensation based on root locus method, Introduction to feedback compensation.

Text Books:

1. R. Stefani, B. Shahrian, C. Savant & G. Hostetter, "Design of Feedback Control Systems", Oxford University Press, 2002.
2. K. Ogata, "Modern Control Engineering", Prentice Hall, 1997.
3. B. C. Kuo & F. Golnaraghi, "Automatic Control Systems", John Wiley, 2003.
4. M. Gopal, "Control Systems: Principles and Designs", 2nd Edition, McGraw Hill, 2002.
5. R. C. Dorf & R. H. Bishop, "Modern Control Systems", Prentice Hall, 2000.

Subject Code: EE3L008	Name: Soft Computing and Applications	L-T-P: 3-0-0	Credits: 3

Prerequisite: None

Artificial Neural Networks (Theory and Applications): Single and multi-layer artificial neural networks, radial basis function networks, recurrent neural network, functional link artificial neural networks. Fuzzy logic (Theory and applications): Mamdani fuzzy models, T-S fuzzy model, neuro-fuzzy systems, ANFIS. Evolutionary computing (Algorithms and Applications): Genetic algorithms and variants, Differential evolution, Particle swarm optimization (PSO) and variants, Bacterial foraging optimization (BFO), Ant colony optimization - travelling salesman problem, Artificial immune systems, cat swarm optimization. Multi-objective evolutionary algorithms: NSGA –II, multi-objective PSO and variants.

Text Books:

1. S. Haykin, 'Neural Networks and Learning Machines', Prentice Hall, 2009.
2. Y.H. Pao, 'Adaptive pattern recognition and neural networks', Addison-Wesley, 1989.
3. Rich, E., Knight, K. and Nair, S.B., 'Artificial Intelligence', 3rd Ed., Tata McGraw Hill. 2009
4. Deb, K., 'Optimization for Engineering Design Algorithms and Examples', Prentice Hall of India. 2009.
5. Jang, J.S.R., Sun, C.T. and Mizutani, E., 'Neuro-fuzzy and Soft Computing: A Computational Approach to Learning and Machine Intelligence', Prentice Hall, 2009.
6. Hagan, M., 'Neural Network Design', Nelson Candad, 2008.
7. K.A.D. Jong, 'Evolutionary Computation – A Unified Approach', PHI Learning, 2009.

Subject Code: EE3L009	Name: Utilization of Electric Power	L-T-P: 3-0-0	Credits: 3
Prerequisite: Electrical Technology			

Electric Drives: Advantages of electric drives, Types of motors used in electric drive, Electric braking; Illumination: Definition: Luminous flux, solid angle, luminous intensity, illumination, luminous, efficiency, depreciation factor, coefficient, of utilization, space to height ratio, reflection factor, glare, shadow, lux. Laws of illumination. Different type of lamps, construction and working of in candescent and dischage lamps – their characteristics. Calculation of number of light points for interior illumination; Electric Heating: Advantages of electrical heating, Heating methods- Resistance heating, Induction heating; Electric arc heating, Dielectric heating; Electric Welding: Advantages of electric welding, Welding method, Principles of resistance welding, Principle of arc production, electric arc welding; Electrolytic Processes: Need of electro-deposition, Laws of electrolysis, process of electro-deposition - clearing, operation, deposition of metals, polishing, buffing, Equipment and accessories for electroplating; Electric Traction: Advantages of electric traction, Different systems of electric traction, DC and AC systems, diesel electric system, types of services – urban, sub-urban, and main lines and their speed-time curves, Different accessories for track electrification; such as overhead capacitor wire, conductor rail system, current collector-pantograph.

Text Books:

1. J B Gupta, “Utilization of Electrical Energy and Traction”, Kataria Publications, 2014.
2. O E Taylor, “Utilization of Electrical Energy”, University Press-Hyderabad, 1981.
3. G. C. Garg, “Utilization of Electric Power and Electric Traction” Khanna Publishers, 2004.
4. Sivanagaraju “Generation and Utilization of Electrical Energy”, Pearson India, 2010.

Vertical Theory (Core):

Subject Code: EC2L002	**Name: Signals and Systems**	**L-T-P: 3-1-0**	**Credits: 4**
Prerequisite: Mathematics – 1			

Objective and overview, signal and system types and classifications, LTI system: Causality, stability, step response, impulse response and convolution integral; Periodic signal analysis: Fourier series and properties; Aperiodic signal analysis : Fourier Transform - its properties and sinusoidal steady state analysis of systems; Discrete-time Fourier transform; Fourier transform for periodic signals; Time and frequency characterization of signals and systems: magnitude-phase representation of Fourier transforms; Unilateral and Bilateral Laplace Transforms and properties: Analysis and characterization of LTI systems using Laplace transform; System function and block diagram representation, Bode plot; Discrete signals: Sampling, digitization and reconstruction of analog signals; Fourier transform of discrete signals: DFT, z-transforms; Discrete systems, transfer functions and convolution; Analog filter design: Butterworth, Sallen Key, frequency transformation and scaling.

Text Books:

1. A. V. Oppenheim, A. S. Willsky and S. H. Nawab, "Signals and Systems," 2^{nd} Ed., Pearson Prentice Hall, 2008.
2. S. Haykin and B. V. Veen, "Signals and Systems," 2^{nd} Ed., Wiley India, 2007.

Reference Books:

1. H. P. Hsu, "Signals and Systems – Schaum's Outline Series," McGraw Hill, 1995.

Subject Code: EE2L001	**Name: Network Theory**	**L-T-P: 3-1-0**	**Credits: 4**
Prerequisite: Signals and Systems			

Nodal and Loop Analysis: review, modified nodal analysis; Network Theorems: Substitution theorem, Compensation theorem, Reciprocity theorem, Maximum power transfer theorem, Millman's theorem, Tellegen's theorem; Transient analysis of RLC circuit and higher order circuits; Frequency domain analysis of dynamic circuits using Fourier series, Fourier transforms and Laplace transforms; Network functions: poles and zeros, driving point and transfer functions, restrictions on poles and zeros for network functions, time domain behaviour, frequency response plots; Two-port networks and passive filters: z-parameters, y-parameters, h-parameters, and ABCD parameters; reciprocity and symmetry in two-port networks; Introduction to network topology: Graph theory: Tree, Co-tree, fundamental cut-set, fundamental loop analysis of network; State variable analysis of networks.

Text Books:

1. M. E. Valkenburg, "Network Analysis," 3^{rd} Ed., Pearson Prentice Hall, 2006.
2. F. F. Kuo, "Network Analysis and Synthesis," 2^{nd} Ed., Wiley India, 2007.

Reference Books:

1. W. H. Hyat, J. E. Kemmerly and S. M. Durbin, "Engineering Circuit Analysis," 6^{th} Edition, Tata McGraw Hill, 2007.
2. R. A. DeCarlo and P-M Lin, "Linear Circuit Analysis," 2^{nd} Ed., Oxford University Press, 2007.

Subject Code: EE3L001	**Name: Electric Machines**	**L-T-P: 3-1-0**	**Credits: 4**
Prerequisite: Electrical Technology			

Production of rotating magnetic field with proof, Magneto motive force and flux distribution on AC machines, Induced voltage and torque; Generator Construction, Winding configuration, Internal Generated Voltage, Equivalent Circuit, Phasor Diagram, Power and Torque, Losses & Efficiency, Regulation, Effect of Load Changes on a Synchronous Generator operation, Parallel operation of AC Generators, Frequency-power and Voltage-Reactive Power characteristics, Parallel Operation; Equivalent Circuit, Steady state operation of synchronous motor, Power and torque, Torque-Speed characteristic, Losses & Efficiency, Effect of load and field current changes, Different methods of starting; Induction Motor Construction, Basic Induction Motor Concepts, Torque and Power in Induction Motor, Torque-Speed Characteristics, Equivalent Circuit of an Induction Motor, Losses & Efficiency, Starting, Tests; Construction and operation of 3-phase transformer, Different configurations including Y-Y, Y-Δ , Δ- Y and Δ- Δ, Phase Angle Displacement and Phase Rotation (Different Vector Group), Zigzag Connection, Three-Phase to Two-Phase conversion, Scott Connection, Autotransformer, Three winding Transformer.

Text Books:

1. S. J. Chapman "Electric Machinery Fundamental," 4th Ed., MG Hill International Edition, 2006.
2. A. E. Fitzgerald, C. Kingsley, Jr, and S. D. Umans, "Electric Machinery," 6th Ed., Mc Graw Hill International Edition, 2002.
3. P.S Bimbhra, "Generalized Theory of Electrical Machines," Khana Publisher.

Subject Code: EC2L006	**Name: Digital Electronics and Microprocessor**	**L-T-P: 3-1-0**	**Credits: 4**

Prerequisite: Introduction to Electronics

Introduction to Boolean algebra and Switching Function, Boolean minimization; Combinational Logic Design using MSI circuits : Full Adder / Subtractor, BCD Adder, Decoder, MUX/DEMUX three structure, Combinational logic design using ROM array, Applications of MSI designs; Integrated Circuits: Difference between combinational and sequential circuits, Flip Flops, Counters, Shift Registers and PLA; Analysis and Synthesis of Sequential Circuits: Basic models of sequential M/C, Analysis of Asynchronous and Synchronous circuits, Synthesis of completely and incompletely specified synchronous sequential M/Cs; Introduction to Microprocessor: Overview of architecture of Intel 8085 Microprocessor (Register, Stack, Interrupt) Instruction set and programming; Introduction to 16 Bit Microprocessor : Architecture of 8086 CPU architecture, Internal operations, Machine Language instructions, Addressing mode, Instruction Format, Instruction executions, Addressing mode, Instruction Format, Instruction execution timing, comparison of 8088 with 8086; Assembly language programming and Instructions: Assembler instruction format, Data Transfer, Arithmetic, Branch, Flag manipulation, Logical, Shift and Rotate. String Manipulation Stack Manipulation, all and return instructions, REP Prefix, segment override prefix, and simple assembler directives such as real, variable, DB, DW, DD, EQU, END, Assume, pointer (byte, word, double word, Near, Short, and Far).

Text Books:

1. S. Lee, "Digital Circuits and Logic Design" Prentice Hall India.
2. D. P. Leach, A. P. Malvino and G. Saha, "Digital Principles and Applications," Tata McGraw Hill.
3. M. Morris Mano, "Digital Logic and Computer Design," Prentice Hall.

Reference Books:

1. B. N Jain and R. P. Jain, Modern Digital Electronics, Tata McGraw Hill, 2006.
2. B. B. Bray, The Intel Microprocessors- 8086/8088, 80186, 80286, 80386, and 80486-Architecture, Programming and Interfacing, Prentice Hall, 2000.
3. D. V. Hall, Microprocessor and Interfacing programming & Hardware, TMH, 2001.
4. A. K. Ray and K. M. Bhurchandi, Advanced Microprocessors & Peripherals: Architecture, Programming & Interfacing, TMH, 2008.

Subject Code: EE3L004	Name: Power Electronics	L-T-P: 3-1-0	Credits: 4
Prerequisite: Introduction to Electronics			

Characteristics of Power Semiconductor Devices: Power diode, power transistors (BJT, MOSFET,IGBT) and Thyristors (SCR, GTO, TRIAC), Gate drive circuit, Desired characteristics of controllable switches, Snubber circuits, Cooling and heat sinks; Rectifiers: Analysis and design of diode rectifier circuits and controlled rectifier circuits, Phase control, power factor, DC load voltage, Polyphase rectifiers, Current and voltage waveforms analysis, Applications for DC motor drives; AC-AC Phase control: Static switch, integral cycle control, Application of AC-AC Phase Control, Single-phase and polyphase control circuits, Applications for AC motor drives; DC-DC Converters: Chopper circuits using GTOs , buck, boost and buck-boost chopper, Discontinuous current analysis, Non-ideal effects and dynamic performance, Applications for DC motor drives; Inverters: Split source, half-bridge inverters, full bridge inverters, Output control, polyphase inverters, power factor, Current and voltage waveforms analysis, Applications for AC motor drives, Pulse Width Modulation (PWM): Types of PWM, Microprocessor control, Harmonics and reactive power; Power Supply Applications: Switching power supplies, Electrical isolation, Protection circuits, Power supply specifications, Power line disturbances, Power conditioners, Uninterruptible power supplies.

Text Books:

1. Muhammad H. Rashid, “Power Electronics: Circuits, Device and Applications”, 2nd Ed. 1993, Prentice-Hall, Inc.
2. Ned Mohan, T M Undeland, W P Robbins, “Power Electronics: Converters, Application and Design”, John Wiley, 3rd Edition, 2003
3. Thedore Wildi , “Electrical Machines, Drives and Power System”, Prentice Hall International, Inc, 1997

Subject Code: EE3L007	Name: Electrical Power Transmission and Distribution	L-T-P: 3-1-0	Credits: 4
Prerequisite: Electrical Technology, Network Theory			

Power System Network: Basic structure of power system, Transmission voltages, Bundled conductors, Choice of economics voltages, Transmission of Network in India; Line Parameters: Line resistance, Inductance, Flux Linkages within the conductor producing the flux, Flux linkage outside the conductor producing the flux, Inductance of bundled conductor lines, capacitance of two wire line, Capacitance of three phase line with equilateral spacing, Capacitance of three phase line with Unsymmetrical spacing, Capacitance of bundled conductor of lines, Double circuit three phase lines; Performance of Transmission Lines: Representation of lines, Per unit method, Short transmission line, Medium length transmission line, Long transmission line, Evaluation of ABCD parameters, Equivalent and T circuits, Application of Matrix methods, Line voltage regulation and compensation, Regulating transformer; Overhead Line Insulators: Insulator materials, Types of insulators, voltage distribution over insulator string, Improvement of string efficiency, Insulator failure, testing of insulators; Mechanical Design of Overhead Lines: General consideration, Line supports, Span conductor configuration, spacing and clearances, sag and tension calculations, Conductor vibration; Corona: The phenomenon of corona, Corona loss, Factors and conditions affecting coronal loss, Coronal in bundled conductor lines; Interference between Power and

Communication Lines: Electromagnetic Induction, Electro Static induction, Reduction of interference; Underground Cables: Classification of cables, Pressurized cables, Effective conductor register, conductor inductive reactance, parameters of single core cables, Capacitance of three core belted cable; Power System Transients : Circuit closing transient, Sudden symmetrical short circuit of alternator, Recovery transient due to removal of short circuit, Travelling waves on transmission lines, Wave equations, Arcing grounds, Line design based on direct strokes, Surge arrestors Insulation coordination; Extra High Voltage Transmission: Need for EHV transmission, Use of bundled conductors, Radio noise from EHV lines, Shunt compensation static-var systems, Series compensation, EHV systems in India; Distribution: Comparison of various distribution systems, voltage drop in distribution, Kelvin's Law, General design consideration, Load estimation; Design of Transmission Lines: Choice of voltage, Selection of conductor size, Choice of span, number of circuit, conductor, configuration; Power System Earthing.

Text Books:

1. C. L. Wadhwa, Electrical Power Systems, New Age.
2. L. M. Faulkenberry and W. Coffer, Electrical Power Distribution and Transmission, PHI, 1996.
3. W. D. Stevenson, Elements of Power System analysis, McGraw Hill, 1982.

Subject Code: EE3L010	**Name: Measurement and Instrumentation**	**L-T-P: 3-0-0**	**Credits: 3**
Prerequisite: Introduction to Electronics			

Measurement of Electrical Quantities Standards of Measurement & Errors, Voltmeter, Ammeter, Multimeter Wattmeter and Energy meter; Measurement of Electrical Elements : Measurement of low, medium and high resistances, insulation resistance measurement AC bridges for inductance and capacitance measurement; Instrument Transformers Current and Potential transformers, ratio and phase angle errors; Electronic Measurements: Electronic voltmeter, multimeter, wattmeter & energy meter. Time, Frequency and phase angle measurements using CRO; Spectrum & Wave analyzer.; Digital counter, frequency meter, voltmeter, multimeter and storage oscilloscope; Instrumentation: Transducers, classification & selection of transducers, strain gauges, inductive & capacitive transducers, piezoelectric and Hall-effect transducers, thermisters, thermocouples, photo-diodes & photo-transistors, encoder type digital transducers, Signal conditioning and telemetry, basic concepts of smart sensors and applications. Data Acquisition Systems.

Text Books:

1. A. K. Sawhney, "Electronics Measurements & Instrumentation," Dhanpat Rai & Co., 2012.
2. A. D. Helfrick and W. D. Cooper, "Modern Electronic Instrumentation and Measurement Techniques," PHI Learning, 2011.
3. A. S. Morris, R. Langari and Butterworth-Heinemannm,, "Measurement and Instrumentation: Theory and Application," 1st Ed., Butterworth-Heinemann Ltd, USA, 2011.
4. H. M. Berlin and F. C. Getz, "Principle of Electronics Instrumentation and Measurement," Prentice Hall College Div., 1988.
5. E.W. Golding and F.C. Widdis, "Electrical Measurements and Measuring Instruments," Reem Publications, 2011.

Subject Code: EE3L011	**Name: Electromagnetic Field Theory**	**L-T-P: 3-0-0**	**Credits: 3**
Prerequisite: Mathematics – 1, Mathematics – 2			

Review of Electrostatic & Electromagnetics, Maxwell's equations, Boundary conditions in Electromagnetic Field, Energy Theorems and Pointing Vector, Electromagnetic Wave Equation in Dielectrics and Conductors, Solution of Wave equation in Cartesian Coordinates in homogeneous Dissipative and Non dissipative Regions, Waves at interface between conductors and Dielectrics; Transmission Lines: Introduction, Line Transmission Theory, Variation of Voltage and Current at distance x from the sending end, Primary Line Constant, Phase Velocity and Line wavelength, Characteristics impedance, The Propagation Coefficient, Computation of Primary constants from values of short circuit and open circuit impedances, Phase and Group velocities, Standing Waves, Lossless Lines at Radio Frequencies, Voltage Standing Wave Ratio, Reflection Coefficient, Transmission Lines as Circuit Elements, Smith Chart, Solution of problems using Smith Chart, Stub Matching; Wave Guides: Introduction, Physical Mechanism of Wave Guide Propagation, Phase and Group Velocities, Rectangular Wave Guides, Cut off in a Rectangular Wave Guide, Wave Guide dimension, Wave Guide Impedance; Antennas: Introduction, Antenna Equivalent Circuits, Coordinate System, Radiation Fields, Polarization, The Isotropic Radiator, Power Gain of an Antenna, Effective Area of an Antenna, The Hertzian Dipole, Half Wave Dipole, Vertical Antennas, Folded Elements, Non-Resonant Antennas, Driven Arrays, Parasitic Arrays.

Text Books:

1. D. J. Griffiths, 'Introduction to Electrodynamics', Addison Wesley, 1999.
2. D. K. Cheng, 'Field and Wave Electromagnetics', Addison Wesley, 1999.
3. W. H. Hayt, 'Engineering Electromagnetic', Fifth Edition. TMH, 1999.
4. N. N. Rao, 'Elements of Engineering Electromagnetics', Pearson Education, Inc, 2004.

Subject Code: EE3L003	**Name: Control Systems**	**L-T-P: 3-1-0**	**Credits: 3**
Prerequisite: Signals and Systems			

Introduction to Control Systems: Definition, Examples of control systems, Open loop and closed-loop control systems, Review of Laplace and inverse Laplace transforms; System Modeling: Signal flow graph, Block diagram, Transfer function, Poles and zeros, Block diagram reduction using signal flow graph and block diagram reduction techniques, Mechanical, electrical and electromechanical systems, First and second order models; Transient Response and Steady State Error Analysis: Definitions of transient response parameters, analysis of second order system as prototype, Routh-Hurwitz stability criterion, Classification of systems based on steady state characteristics, Steady state error coefficients; Root Locus Method: Definition of root locus, Properties of root locus, Sketching of root locus, Effect of open loop poles and zeros, Root locus design concepts; Frequency Response Analysis: Bode diagram, Polar plot, Nichols plot, Nyquist stability criterion: nonmathematical description of Nyquist criterion, interpretation of stability, Relative stability – Gain and Phase margin, Closed loop frequency response – M and N contours, Nichols chart; Compensation Techniques: Compensation techniques: lag, lead and lag-lead compensation, PD, PI and PID controllers, Cascade compensation based on root locus method, Introduction to feedback compensation; State Space Analysis: Concepts of state, state variables, and state model, State models for linear continuous-time systems, Diagonalization, Solution of state equations, Concepts of Controllability and Observability. Nonlinear Systems: Common physical nonlinearities, Phase plane method, Singular points, Stability of nonlinear systems, Phase trajectories, Describing function method and stability analysis, Lyapunov's stability criterion.

Text Books:

1. R. Stefani, B. Shahrian, C. Savant & G. Hostetter, "Design of Feedback Control Systems", Oxford University Press, 2002.
2. K. Ogata, "Modern Control Engineering", Prentice Hall, 1997.

Reference Books:

1. B. C. Kuo & F. Golnaraghi, “Automatic Control Systems”, John Wiley, 2003.
2. M. Gopal, “Control Systems: Principles and Designs”, 2nd Edition, McGraw Hill, 2002.
3. R. C. Dorf & R. H. Bishop, “Modern Control Systems”, Prentice Hall, 2000.

Subject Code: EC3L003	**Name: Digital Signal Processing**	**L-T-P: 3-1-0**	**Credits: 4**
Prerequisite: Signals & Systems			

Introduction to DSP, Signals and Systems Characterization, FIR and IIR : Recursive and Non Recursive, Z-Transform, Discrete Time Signals and Systems in Frequency Domain, Sampling, Quantization, Discrete Fourier Transform, Fast Fourier Transform, Short-time Fourier Transform, Digital Filter Structure, Analog Filter Design, Digital Filter Design.

Text Books:

1. J. G. Proakis and D. G. Manolakis, “Digital Signal Processing: Principles, Algorithms and Applications, 4th Ed., Pearson, 2012.
2. A. V. Oppenheim and R. W. Shafer, “Discrete-Time Signal Processing,” Prentice Hall, 2009.

Reference Books:

1. R. G. Lyons, “Understanding Digital Signal Processing,” 3rd Ed., Prentice Hall, 2010.
2. V. K. Ingle and J. G. Proakis, “Digital Signal Processing using MATLAB,” Thomson Learning, 2000.

Subject Code: EE3L012	**Name: Power System Operation and Control**	**L-T-P: 3-1-0**	**Credits: 4**
Prerequisite: Electrical Power Transmission and Distribution			

Fundamentals of Power System : Concepts of real and reactive powers, complex power, per-unit representation of power system, Transmission capacity, load characteristics, real power balance and its effect on system frequency, load frequency mechanism, reactive power, balance and its effect, on-load tap changing transformer and regulating transformer; Power Circle diagram: Receiving and sending end power circle diagram, universal power circle diagram, use of power circle diagram; Load flow analysis: Static load flow equation for a low-bus system, characteristics of a load flow equation, generalization to n-bus system, Gauss-Seidel and Newton-Raphson method of solution of load flow equations for 2 bus and 3 bus system; Load frequency control : Automatic voltage, regulator, exciter modelling, generator modelling and static performances of AVR loop, automatic load frequency, control of single area systems, speed governing system, hydraulic valve actuator, turbine generator response, static performance of speed governor, closing the ALFC loop, Concept of control area static response of primary ALFC loop, dynamic response of ALFC loop, ALFC for multicontrol area system, the two area system, modelling of the tie-line block diagram representation of two are system, static response of two area system, dynamic response of two area system, dynamic response of two area system tie-line bias control, tie-line bias control of two area system, static response, steady state instabilities; Economic Operation of power system : Distribution of load between units within a plant, transmission loss as function of plant generation, calculation of loss-coefficient, distribution of loads between plants with special reference to steam and hydel plants, automatic load dispatching; Power system stability: Steady state stability, transient stability, swing equation, equal area criteria for stability methods of improvement of transient stability.

Text Books:

1. John J. Grainger & W. D. Stevenson, Jr, "Power System Analysis", Tata Mcgraw-Hill, 2003 Edition, 15th Reprint, 2010.
2. Stephen J Chapman, "Electric Machinery and Power System Fundamentals", Mc Graw Hill, International Edition, 2002.
3. C.L Wadhwa, "Electrical Power System", New age International (p) Limited Publisher, Reprint, 2008.
4. I. J. Nagrath and D. P. Kothari, Modern Power System Analysis, TMH, 2003.

Subject Code: EE4L005	Name: Digital Control System	L-T-P: 3-0-0	Credits: 3

Prerequisite: Control Systems

Introduction: Basic structure of digital control systems, Sampled-data control systems, DAC, ADC, Sample-and-hold operation, Sampling and reconstruction: ZOH and frequency domain considerations, Shanon's sampling theorem, Frequency spectrum; Transform Analysis of Sampled-Data Systems: Linear difference equation, Pulse response, Z-transform: review of properties and theorems, Inverse Z-transform, Relationship between z-plane and s-plane, Transform pairs; Discrete-Time System Modeling: Pulse transfer function, z-transfer function, discrete-time system with cascaded elements separated and not-separated by a sampler, Pulse transfer function of ZOH, Closed-loop systems, Characteristic equation, Sampled signal flow graph, Mason's gain formula; Stability Analysis: Introduction, Theorems, Stability tests: Bilinear transformation method and Jury's test, Performance specifications in time domain, Prototype second order system and response analysis, Steady state error analysis, Root loci; Frequency Domain Analysis: Introduction, Polar Plot, Nyquist stability criterion, Bode plot, Gain and phase margin, Closed-loop frequency response, z-domain equivalents of s-domain transfer functions; State Space Analysis: State equations and state transition equations with S/H devices, Relationship between state equations and transfer functions, Diagonalization, Computation of state transition matrix, State diagram, Decomposition of transfer functions, Realization of digital filters, Controllability and observability; Pole Placement Design and State Observers: Introduction, State feedback, Pole assignment by state feedback, Ackerman's formula, Deadbeat control, State observers, Deadbeat observer, The Separation Principle, Reduce order observer; Design of Digital Compensators: Frequency response based designs: Lead compensator, Lag compensator, Lead-lag compensator, Design using root locus plots: Lead compensator, Lag compensator, Lead-lag compensator, Digital PID controller design.

Text Books:

1. B. C. Kuo, "Digital Control Systems", 2nd Edition, Oxford University Press, 2012.
2. K. Ogata, "Discrete-Time Control Systems", 2nd Edition, Prentice Hall, 2009.
3. Charles L. Phillips , Troy Nagle , James Brickley, "Digital Control System Analysis and Design", Prentice Hall, 2014.
4. M. Gopal, "Digital Control Engineering", New Age International Publishers, 1996.

Subject Code: EE4L006	Name: Renewable Energy Systems	L-T-P: 3-0-0	Credits: 0

Prerequisite: Power Electronics, Power System Operation and Control

Brief idea on renewable and distributed sources, their usefulness and advantages; Wind Energy Systems: Estimates of wind energy potential, wind maps, Instrumentation for wind velocity measurements, Aerodynamic and mechanical aspects of wind machine design, Conversion to electrical energy, Aspects of location of wind farms, Wind speed and energy, Speed and power relations, Power extraction from wind, Tip speed ratio (TSR), Functional structure of wind energy conversion systems, Pitch and speed control, Power-speed-TSR characteristics, Fixed speed and variable speed wind turbine control, Power optimization, Electrical generators, Self-Excited and Doubly-Fed Induction Generators operation and control; Solar PV Systems: Present and new technological developments in photovoltaic, estimation of solar irradiance, components of solar energy systems, solar-thermal system applications to power generation, heating, Types of PV systems, Modeling of PV cell, current-voltage and power-voltage characteristics, Effects of temperature, Solar array simulator, Sun tracking, Peak power operations, PV system, MPPT techniques, Effects of partial shading on the characteristic curves and associated MPPT techniques; Hydel Power: Water power estimates, use of hydrographs, hydraulic turbine, characteristics and part load performance, design of wheels, draft tubes and penstocks, plant layouts; Brief idea of other sources viz., tidal, geothermal, gas-based, etc. Requirements of hybrid/combined use of different renewable and distributed sources, Need of energy storage; Control of frequency and voltage of distributed generation in Stand-alone and Grid-connected mode, use of energy storage and power electronics interfaces for the connection to grid and loads, Design and optimization of size of renewable sources and storages; Concept of microgrid, operation of microgrid in grid-connected as well as isolated mode, power quality problems and fault-ride through capability of microgrid; Integration of large capacity renewable sources to grid: Operation and control, trends and challenges, future needs viz., advanced characteristics of renewable energy generating units and plants, improved flexibility in conventional generation, transmission technology.

Text Books:

1. Math J. Bollen, Fainan Hassan 'Integration of Distributed Generation in the Power System', IEEE Press, 2011.
2. Loi Lei Lai and Tze Fun Chan 'Distributed Generation: Induction and Permanent Magnet Generators', Wiley-IEEE Press, 2007.
3. Studies' Craig Anderson and Rudolf I. Howard 'Wind and Hydropower Integration: Concepts, Considerations and Case, Nova Publisher, 2012.
4. Amanda E. Niemi and Cory M. Fincher 'Hydropower from Small and Low-Head Hydro Technologies', Nova Publisher, 2011.
5. D. Yogi Goswami, Frank Kreith and Jan F. Kreider 'Principles of Solar Engineering', Taylor & Francis 2000.
6. G. N. Tiwari 'Solar Energy Technology', Nova Science Publishers, 2005.
7. Math J. Bollen, Fainan Hassan 'Integration of Distributed Generation in the Power System', IEEE Press, 2011.
8. S. Heier and R. Waddington 'Grid Intergration of Wind Energy Conversion Systems', Wiley, 2006.

Subject Code: EE6L051	Name: Switched Mode Power Conversion	L-T-P: 3-1-0	Credits: 4

Linear voltage regulators, basic structures, advantages and disadvantages; Steady state analysis of basic DC-DC converters (Buck, boost, buck-boost) Steady state analysis of derived DC-DC (Cuk, SEPIC, Quadratic) converters. Steady state analysis of transformer isolated DC-DC converters (Forward, Flyback, push-pull, bridge) Switched mode voltage regulator specifications, block diagram, Modeling approach, assumptions and approximations. Dynamic models and transfer functions of hard switched converters in CCM and DCM modes. Regulator design example Current Programmed converters, Block diagram, stabilization, modeling and transfer functions. Single phase PFC circuits. Resonant Converters, Soft switching principles: ZVS, ZCS, ZVZCS Resonant Load Converters: Variable frequency series and parallel resonant converters (Resonant Switch Converters (quasi resonant): Half and full wave operations and control. Resonant Transition Phase Modulated Converters, Reduction of VA ratings, fixed frequency operation and advantageous usages of device and transformer non-idealities; Soft Switched Bidirectional DC-DC Converters (Dual Active Bridge): Soft-switching under buck mode and boost mode operations with or without active clamp PWM Converters with Auxiliary Switch, ZVT /ZCT PWM Converters: Isolated and Non-isolated topologies with auxiliary switch; Auxiliary Resonant Commutated Pole Inverters: ZVT and ZCT concepts used for Inverters;

Resonant DC Link Inverters: Forced oscillation of DC Link voltage by auxiliary switch.

Texts/References:

1. M H. Rashed, 'Power Electronics Circuits, Devices and Applications', Prentice Hall of India Pvt. Ltd, 2004.
2. R. W. Erickson and D. Maksimovic, 'Fundamental of Power Electronics', Springer International Edition, 2005.
3. N. Mohan, T. M. Underland, and W. Robbins, 'Power Electronics Converters, Applications and Design', John Wiley and Sons. Inc., 2004.

Subject Code: EE6L052	Name: Theory and Analysis of Electric Drives	L-T-P: 3-1-0	Credits: 4

Introduction and review of electrical machines; Principles of electromagnetic energy conversion: General expression of stored magnetic energy, co-energy and force/torque, example using single and doubly excited system. Calculation of air gap mmf and per phase machine inductance using physical machine data; Voltage and torque equation of dc machine, three phase symmetrical induction machine and salient pole synchronous machines in phase variable form. Introduction to reference frame theory: static and rotating reference frames, transformation relationships, examples using static symmetrical three phase passive circuits. Generalized theory of rotating electrical machine and Krons primitive machine; Modelling of D.C and 3-phase symmetrical induction and synchronous machines; voltage and torque equations, derivation of steady state phasor relationship from dynamic model. Analysis and dynamic modelling of two phase asymmetrical induction machine and single phase induction machine.

Introduction to Electric Drives – Need of electric drives, basic parts, present scenario of electric drives Mechanical Dynamics in an Electric Drive - Speed-torque characteristics of some common motors and loads, multi quadrant operation, equivalent values of drive parameters, stability of an electric drive General Block Diagram of a Closed Loop Drive System – Speed, torque and position control Selection of Motor Power Rating – Thermal model of motor for heating and cooling, classes of motor duty, determination of motor rating Chopper Controlled DC Motor Drive – Different types of choppers and their quadrants of operations, PWM strategies for different choppers, chopper control of series DC motor. Power Semiconductor Switches Used in an Electric Drive System - Basic structure, V-I characteristics and switching characteristics of thyristors and IGBTs, gate drive and protection circuits of thyristors and IGBTs. DC Motor Drive Using Phase Controlled Rectifier – DC motor drive using half controlled and fully controlled single phase and three phase rectifiers, continuous and discontinuous conduction modes of operation, 4-quadrant operation using dual converter. Closed Loop Control of DC Motor – Operating limits of a separately excited DC motor drive, dynamic model of DC motor, dynamic model of chopper and phase controlled rectifier, design of single loop speed controller, cascaded controller design for DC motor using inner current control loop and outer speed control loop, field weakening operation.

Texts/References:

1. P. C. Krause, O. Wasynczuk and S. D. Sudhoff,' Analysis of Electric Machinery and Drive Systems', John Wiley & Sons, New York, 2006.
2. Chee-Mun Ong, 'Dynamic Simulation of Electric Machinery using MATLAB', Prentice Hall PTR, 1998.
3. P. S. Bimbhra 'Generalized theory of electrical machines', Khanna Publishers Delhi, 1995.
4. G. K. Dubey, 'Fundamentals of Electrical Drives', CRC Press, 2002.

Subject Code: EE6L053	Name: Advanced Power Electronic Converters	L-T-P: 3-0-0	Credits: 3

High-Power Semiconductor Devices, Diodes, SCR, GTO, GCT, IGBT. Operation of series connected devices: main cause of unbalance, voltage equalizations for GCTs, IGBTs. Multi-pulse Diode and SCR Rectifiers, Definition of THD and PF, THD and PF of six-pulse diode rectifier, 12, 18, 24- pulse series-type and separate-type diode rectifiers, Six-pulse and 12-pulse SCR rectifier, Effect of line and leakage inductances, and Phase-Shifting Transformers, Harmonic current cancellation. Cascaded HBridge Multilevel Inverters, Introduction, Sinusoidal PWM, Space Vector PWM in two level voltage source inverters; H-bridge inverter, multilevel inverter topologies: CHB Inverter with equal dc voltages, H-bridges with unequal dc voltages, Carrier based PWM schemes: Phase shifted multi-carrier modulation, Level shifted multi-carrier modulation, overmodulation of cascaded H-bridges, Control of dc bus voltages of the H-bridges. Diode-Clamped Multilevel Inverters, Three level inverter: Converter configuration, switching states, Carrier based

PWM: Naturally sampled PD PWM, APOD and POD PWM; Space vector modulation: Optimized space vector sequences, modulator for selecting switching states, decomposition method, hexagonal co-ordinate system, optimal space vector position within a switching period; Neutral point voltage control, over modulation of three-level inverter, High-level diode clamped inverters. Hybrid Multilevel Inverters: Hybridization of Fundamental frequency switching (FFS) and PWM switching inverters: inverter topologies with isolation transformer, PWM switching strategy; Transformerless hybrid inverter: Binary H-bridge multilevel converter, Control of dc bus voltages of different modules. Multilevel Flying Capacitor Inverters: Inverter configuration, Modulation scheme. PWM Current Source Rectifiers and Inverters: Trapezoidal modulation, Selective harmonic Elimination, Space vector modulation, Parallel current source inverters, Single-bridge current source rectifier, Dual-bridge current source rectifier, Power factor control, Active Damping Control, Wide Band-gap devices and Performance and Design of Converters using Wide Band-gap devices.

Texts/References:

1. L. Umanand 'Power Electronics – Essentials and Applications', Wiley India Pvt. Ltd., 2009.
2. B. Wu, 'High Power Converter and AC Drives', IEEE Press Wiley Interscience, 2006.
3. M. P. Kazmierkowski, R. Krishnan and F. Blaabjerg 'Control in Power Electronics - Selected Problems', Academic Press Series in Engineering, 2002.

Subject Code: EE6L013	Name: Grid Integration of Renewable Energy Systems	L-T-P: 3-0-0	Credits: 3

Control of frequency and voltage of distributed generation in Stand-alone and Grid-connected mode, use of energy storage and power electronics interfaces for the connection to grid and loads. Design and optimization of size of renewable sources and storages.
Concept of microgrid, operation of microgrid in grid-connected as well as isolated mode, power quality problems and fault-ride through capability of microgrid.
Integration of large capacity renewable sources to grid: Operation and control, present trends, challenges, future technological needs viz., advanced characteristics of renewable energy generating units and plants, improved flexibility in conventional generation, transmission technology.

Texts/References:

1. Math J. Bollen, Fainan Hassan 'Integration of Distributed Generation in the Power System', IEEE Press, 2011.
2. S. Heier and R. Waddington 'Grid Intergration of Wind Energy Conversion Systems', Wiley, 2006.
3. Loi Lei Lai and Tze Fun Chan 'Distributed Generation: Induction and Permanent Magnet Generators', Wiley-IEEE Press, 2007.

Subject Code: EE6L055	Name: Advanced Machine Drives	L-T-P: 3-1-0	Credits: 4

Induction Motor Drives: Field oriented control- Direct and indirect field orientation, stator-flux, rotor-flux and airgap-flux orientation. Flux-torque decoupling, Extended speed operation and Field weakening. Direct torque control of Induction Motor, Flux and speed observers, Induction generators, Doubly Fed Induction Machines (DFIM): Different modes of operation, Equivalent circuit, Active and reactive power control, Vector control of DFIM. Identification of Induction Motor Parameters: Linear Model, Nonlinear least square identification, Parameter error indices. Speed sensor-less control: Signal injection and model based techniques, zero/low speed operation. Synchronous Motor Drives, Vector controlled Cycloconverter fed Drive, Parameter estimation and sensor-less control. Introduction to PM Synchronous Motor, Various rotor configurations of PMSM, Sinusoidal Back-Emf PMSM: Field oriented control, Direct torque control. Interior PM Machine: Maximum torque per ampere control, Field weakening Introduction to Brushless DC Motor: EMF and Torque of BLDC machine, Voltage Source Inverter fed BLDC: Half-wave and Full-wave operation, Speed control, Torque ripple minimization, Sensor-less operation. Stepper Motor Drives, Switched Reluctance Motor Drives, Linear Machine Drives.

Texts/References:

1. P. C. Krause, O. Wasynczuk and S. D. Sudhoff,‘ Analysis of Electric Machinery and Drive Systems’, John Wiley & Sons, New York, 2006.
2. B. K. Bose, ‘Modern Power Electronics and AC Drives’, Pearson Education, 2005.
3. W. Leonhard, ‘Control of Electric Drives’, Springer International Edition, 2001.

Vertical Theory (Elective-1,2):

Subject Code: EC4L001	**Name: Semiconductor Devices**	**L-T-P: 3-0-0**	**Credits: 3**
Prerequisite: Introduction to Electronics			

Semiconductor Fundamentals, Crystal Structure, Energy bands, Intrinsic and extrinsic semiconductors, Fermi Level, Carrier concentrations at thermal equilibrium, Carrier transport phenomenon: drift and diffusion, Scattering, Excess carriers in semiconductors: generation, recombination and injection of carriers, transient and steady state response, Basic governing equations in semiconductors; Physical description of p-n junctions, Transport equations, current-voltage characteristics, deviations from simple theory, small-signal ac analysis, metal-semiconductor junctions, hetero junctions; BJT fundamentals, operation regions, BJT equivalent circuits and modelling frequency response of transistors, pnpn diodes, SCR; MOS structure, flat-band threshold voltages, MOS static characteristics, small signal parameters and equivalent circuit, charge sheet model, strong, moderate and weak inversion, short channel effects, scaling laws of MOS transistors, LDD MOSFET, NMOS and CMOS IC technology, CMOS latch-up phenomenon; optical absorption in a semiconductors, photovoltaic effect, solar cell, photoconductors, PIN photodiode, avalanche photodiode, LED, semiconductor lasers; Negative conductance in semiconductors, transit time devices, IMPATT, Gunn device, BiCMOS devices.

Texts/References:

1. Ben G Streetman, S K Banarjee, Solid State Electronic Devices, 6th edition, PHI India, New Delhi, 2007.
2. R S Muller, T.I.Kamins, Device Electronics for Integrated Circuits, 3rd edition, Wiley-India, New Delhi, 2012.
3. S M Sze, K K Ng, Physics of Semiconductor Devices, 3rd edition, John Wiley, New Jersey, 2007.
4. P Bhattacharya, Semiconductor Optoelectronics, 2nd edition, Pearson, New Jersey, 1997.

Subject Code:	**Name: Dynamics of Linear Systems**	**L-T-P: 3-0-0**	**Credits: 3**

Background material on matrix algebra, differential equations, linear operators, Representation of dynamic systems, equilibrium points and linearization of nonlinear systems, Jordan form, functions of matrices, norms of vectors and matrices, Stability of systems, Lyapunov matrix equation, Natural and forced response of state equations, state space descriptions, canonical realizations, Observability and controllability, minimal realization, canonical decomposition, controllability and observability indices in MIMO systems, Linear state variable feedback, stabilization, pole-placement, methods for obtaining feedback gains in MIMO systems, Asymptotic observers, compensator design, and separation principle, reduced order observers, Considerations for system gains, Discretization of CT systems.

Texts/References:

1. Chi-Tsong Chen, Linear Systems Theory and Design, 2nd edition, HBJ 1984.
2. K. Ogata, Modern Control Engineering, Prentice Hall, 2006.

Subject Code: EC6L005	Name: Statistical Signal Processing	L-T-P: 3-0-0	Credits: 3
Prerequisite: Digital Signal Processing			

Review of Probability and Stochastic Process; Estimation Theory: Minimum-variance unbiased estimator (MVUE), Cramer-Rao Lower bound, Best Linear Unbiased Estimator, Maximum likelihood Estimator, General Bayesian Estimator**,** Detection Theory: Neyman Pearson Theorem, Receiver Operating Characteristics, Matched Filters, Composite Hypothesis Testing; Nonparametric Spectral Estimation: Estimation of power spectrum of stationary random signal using periodogram-various methods, Joint signal analysis and estimation of cross power spectrum; Linear Signal Model: Synthesis of coloring filter and Analysis of whitening filter, Rational power spectra (AR, MA, ARMA), Relationship between filter parameters and autocorrelation sequences, Lattice-Ladder filter realization; Parametric Spectral Estimation: Order selection criterion of AR model , Minimum-variance, Maximum entropy and Maximum likelihood spectrum estimation Harmonic models and frequency estimation techniques Harmonic Decomposition, MUSIC algorithm, ESPRIT algorithm; Linear Optimum Filter: Optimum FIR Filter, PCA of optimum linear estimator and its frequency domain interpretation, Forward and Backward Linear prediction and optimum reflection coefficients Optimum causal and non-causal IIR Filters, De-convolution and Signal restoration Algorithms and Structure of Optimum Linear Filters Levinson Recursion for optimum estimate, Order-recursive algorithms for optimum FIR filters and its lattice structures.

Texts/References:

1. S. M. Kay, Fundamentals of Statistical Signal Processing, Vol I: EstimationTheory, Vol II: Detection Theory, Prentice Hall, 1998.
2. Harry L. Van Trees, Detection, Estimation, and Modulation Theory, Part I, Wiley-Inter science, 2001
3. Monson H. Hayes, Statistical Digital Signal Processing and Modeling, John Wiley, 1996.

Subject Code: xxx	Name: Machine Learning	L-T-P: 3-0-0	Credits: 3
Prerequisite: None			

Basic Principles: Introduction, Experimental Evaluation: Over-fitting, Cross-Validation. PAC learning. Sample complexity. VC-dimension, Reinforcement Learning. Supervised Learning: Decision Tree Learning, k-NN classification, SVMs, Ensemble learning: boosting, bagging. Artificial Neural Networks: Perceptrons, Multilayer networks and back-propagation.
Probabilistic Models: Maximum Likelihood Estimation, MAP, Bayes Classifiers, Naive Bayes. Markov Networks, Bayesian Networks, Factor Graphs, Inference in Graphical Models.
Unsupervised Learning: K-means and Hierarchical Clustering, Gaussian Mixture Models, EM algorithm, Hidden Markov Models.

Texts/References:

1. Tom Mitchell. Machine Learning. McGraw Hill, 1997.
2. Christopher M. Bishop. Pattern Recognition and Machine Learning. Springer 2006.
3. Richard O. Duda, Peter E. Hart, David G. Stork. Pattern Classification. John Wiley & Sons, 2006.
4. Trevor Hastie, Robert Tibshirani, Jerome Friedman. The Elements of Statistical Learning: Data Mining, Inference, and Prediction. Springer 2009.

Subject Code: EE6L009	Name: High Voltage Engineering	L-T-P: 3-0-0	Credits: 3
Prerequisite: None			

Break Down in Solid Dielectrics: Intrinsic breakdown, electromechanical breakdown, thermal breakdown, breakdown of solid dielectrics in practice, Breakdown in composite dielectrics, solid dielectrics used in practice; Break Down in Gaseous and Liquid Dielectrics: Gases as insulating media, collision process, Ionization process, Townsend's criteria of breakdown in gases, Paschen's law; Generation of High Voltages and Currents: Generation of High Direct Current Voltages, Generation of High alternating voltages, Generation of Impulse Voltages, Generation of Impulse currents, Tripping and control of impulse generators; Measurement of High Voltages and Currents: Measurement of High Direct Current voltages, Measurement of High Voltages alternating and impulse, Measurement of High Currents-direct, alternating and Impulse, Oscilloscope for impulse voltage and current measurements.

Texts/References:

1. E. Kuffel, and W. S. Zaengl, J. Kuffel, "High Voltage Engineering: Fundamentals," CBS Publishers, 2005.
2. R. Arora and W. Mosch, 'High Voltage and Electrical Insulation Engineering' John Wiley & Sons, 2011.
3. W. Peek, and F. W. Peek "Dielectric Phenomena in High Voltage Engineering,: Rough Draft Printing, 2008.
4. L. L. Alston, "High Voltage Technology," Oxford University Press, 2011.

Subject Code: EE6L011	**Name: Energy Storage Systems**	**L-T-P: 3-0-0**	**Credits: 3**
Prerequisite: Introduction to Electronics			

Energy Storage Need of energy storage; Different modes of Energy Storage. Potential energy: Pumped hydro storage; KE and Compressed gas system: Flywheel storage, compressed air energy storage; Electrical and magnetic energy storage: Capacitors, electromagnets; Chemical Energy storage: Thermo-chemical, photo-chemical, bio-chemical, electro-chemical, fossil fuels and synthetic fuels. Hydrogen for energy storage. Solar Ponds for energy storage. Electrochemical Energy Storage Systems Batteries: Primary, Secondary, Lithium, Solid-state and molten solvent batteries; Lead Lead acid batteries; Nickel Cadmium Batteries; Advanced Batteries. Role of carbon nano-tubes in electrodes. Magnetic and Electric Energy Storage Systems Superconducting Magnet Energy Storage(SMES) systems; Capacitor and Batteries: Comparison and application; Super capacitor: Electrochemical Double Layer Capacitor (EDLC), principle of working, structure, performance and application, role of activated carbon and carbon nano-tube.

Texts/References:

1. R. Huggins, Robert 'Energy Storage', Springer, 2010.
2. Ter-Gazarian 'Energy Storage for Power Systems', Institution of Engineering and Technology, 1994.

Subject Code: EC4L002	**Name: Opto-Electronics**	**L-T-P: 3-0-0**	**Credits: 3**
Prerequisite: Introduction to Electronics			

Review of basic principles from physics, optical wave representation, interferometers, optical resonators, planar mirror resonators, modes of resonators, spherical mirror resonators, confinement, gaussian beams, photons and matter, energy levels; Photon optics: interactions of photons and atoms, population inversion, spontaneous and stimulated emission; Lasers: gain mechanism, rate equations, pumping, gain and gain coefficient, laser oscillation theory, laser types, power and spectral distribution , polarization, mode selection, light emitting diodes, fabry-perot lasers, erbium-doped fiber amplifiers (edfa); Photo detectors: properties of photo detectors, photoconductors, photodiodes. Avalanche photodiodes, phototransistors and noise mechanisms, signal-to-noise analysis, and modulation of optical signals, formats, and receivers; Noise and detection: types of noise and distortion which affects optical signals, methods of reducing effects of noise and distortion, optimal detection methods and devices; Overview of opto-electronic networks: fddi, fiber channel, sonnet.

Text Books:

1. Saleh and Teich, "Fundamentals of Photonics," Wiley Interscience, 2nd edition, 2007.
2. J. Senior, "Optical Fiber Communications. Principle and Practice," Prentice Hall.

Reference Books:

1. Wilson and Hawkes, "Optoelectronics: An Introduction, Prentice Hall; 3rd Ed., 1997.
2. Journal Readings (IET- Optoelectronics)

Subject Code: EC6L002	**Name: Image and Video Processing**	**L-T-P: 3-0-0**	**Credits: 3**

Prerequisite: Digital Signal Processing

Introduction to digital image processing, intensity transformation, spatial filtering, frequency domain filtering, point and line detection, edge detection, Hough Transform, image restoration, color processing, thresholding, image segmentation, affine transformation, image transforms, multi-resolution image analysis, shape and texture representation and description, introduction to object recognition, image compression, JPEG, introduction to digital video, video compression standards, motion estimation.

Texts/References:

1. Gonzalez and Woods, "Digital Image processing," 3rd Ed., Pearson and Prentice Hall, 2009.
2. W.K. Pratt, "Digital image processing," 4th Ed., Wiley India, 2007.
3. K.R. Castleman, "Digital image processing," 2nd Ed., Pearson, 2012.
4. A.K. Jain, "Fundamentals of digital image processing," Prentice Hall, 1989.

Subject Code: EE6L002	**Name: Electric Power Quality**	**L-T-P: 3-0-0**	**Credits: 3**

Prerequisite: Electrical Technology, Power Electronics

Brief review of various power quality (PQ) problems: Source of generation and their impacts on equipment and systems, need of monitoring, international power quality standards, Passive Filters: Control of harmonics using passive L-C filters, tuned and de-tuned filters, their design criterion and implementation, Active Power Filters: Power factor improvement, reactive power compensation, mitigation of harmonics and voltage sag compensation using active power filters. Study of various active power filters viz., static shunt compensators (STATCOM), dynamic voltage restorer (DVR), unified power quality conditioner (UPQC), etc. Suitability of type of active filters for mitigation of various power quality problems, Design of active power filters, various topologies and control schemes.

Texts/References:

1. A. Ghosh and Gerard Ledwich 'Power Quality Enhancement Using Custom Power Devices (Power Electronics and Power Systems)', Springer; 2002.
2. S. Santoso, H. W. Beaty, R. C. Dugan, and M. F. McGranaghan, 'Electrical Power Systems Quality', McGraw-Hill Professional, 2002.
3. M. H. Bollen 'Understanding Power Quality Problems: Voltage Sags and Interruptions', Wiley-IEEE Press, 1999.
4. N. G. Hingorani and L. Gyugy 'Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems', Wiley-IEEE Press, 1999.

Subject Code: EE6L007	**Name: Industrial Instrumentation**	**L-T-P: 3-0-0**	**Credits: 3**

Prerequisite: Measurement and Electronic Instruments

Introduction to Instrumentation system; Static and Dynamic characteristics of Instrument; Pressure measurement: Elastic transducers (Bourdon Gauge, Bellow and Diaphragm Gauge); Temperature measurement: Thermocouple, Resistance Temperature Detector (RTD), Thermistor, Radiation Pyrometer; Flow and pressure measurements: Differential Pressure flow meter, Variable area flow meter, Variable reluctance transducer, Turbine flow meter, Ultrasonic flow meter (Both transit time and Doppler Shift), Electromagnetic flow meter and Mass flow meter; Measurement of level: Capacitance based and Float based method; Measurement of strain: Strain Gauge; Position sensor: Linear Variable Differential Transformer (LVDT), Synchro; Load and torque cell; pH probe and viscosity measurement; Piezoelectric sensors; Ultrasonic sensors; Pollution measurement; Smart sensors; Actuators and Control valves; Signal conditioning; Pneumatic and Hydraulic Instrumentation system.

Texts/References:

1. D. Patranabis, 'Principles of Industrial Instrumentation', Tata Mcgraw-Hill, 2001.
2. W. C. Dunn, 'Fundamentals of Industrial Instrumentation and Process Control', Mcgraw-Hill, 2005.
3. N. A. Anderson, 'Instrumentation for process measurement and control', CRC press, 1998.
4. E. Doebelin 'Measurement Systems: Application and Design', Mcgraw-Hill, 2003.

Subject Code: CS4L003	**Name: Artificial Intelligence**	**L-T-P: 3-0-0**	**Credits: 3**
Prerequisite: Introduction to Programing and Data Structures			

Introduction to AI, Brief history. Different agent architectures, Problem formulation and search, Heuristic search, A*, local search and optimization, Constraint satisfaction problems, Game playing and adversarial search, Knowledge representation. Logical reasoning. Propositional logic. Planning, Production system, Semantic network and Frame, Propositional logic, First order predicate logic, Other methods for reasoning, An Introduction to Pattern Recognition, Supervised learning methods, Decision trees. Reinforcement learning, Game theory, Robotics.

Text/Reference Book:

1. S. Russell and P. Norvig. "Artificial Intelligence: A Modern Approach," 3rd Ed., Prentice Hall, 2009.
2. G. F. Luger, "Artificial Intelligence: Structures and Strategies for Complex Problem Solving", 4/e, Addison-Wesley, 2002.,
3. J. Finlay and A. Dix, "An Introduction to Artificial Intelligence", UCL Press, 1996.

Vertical Theory (Elective-3):

Subject Code: EC4L003	**Name: Introduction to VLSI Design**	**L-T-P:3-0-0**	**Credits: 3**
Pre-requisite: Semiconductor Devices, Digital Electronics and Microprocessors			

Introduction: Design hierarchy, layers of abstraction, integration density and Moore's law, VLSI design styles, packaging styles, design automation principles; Fabrication Technology: Basic steps of fabrication, bipolar, CMOS and Bi-CMOS fabrication processes, layout design rules; MOS and Bi-CMOS characteristics and circuits: MOS transistor characteristics, MOS switch and inverter, Bi-CMOS inverter, latch-up in CMOS inverter, super-buffers, propagation delay models, switching delay in logic circuits, CMOS analog amplifier; Logic Design: switch logic, gate restoring logic, various logic families and logic gates, PLA; Dynamic Circuits: Basic concept, noise considerations, charge sharing, cascading dynamic gates, domino logic, clocking schemes; Sequential Circuits: Basic regenerative circuits, bi-stable circuit elements, CMOS SR latch, clocked latch and flip-flops; Low-power Circuits: low-power design through voltage scaling, estimation and optimization of switching activity, reduction of switched capacitance, adiabatic logic circuits; Subsystem Design: design of arithmetic building blocks like adders, multipliers, shifters, area-speed-power tradeoff; Semiconductor Memories: SRAM, DRAM, non-volatile memories; Bipolar ECL Inverter: Features of ECL gate, logic design in ECL, single-ended and differential ECL gates; Testability of VLSI: Fault models, scan-based techniques, BIST, test vector generation; Physical Design: Brief ideas on partitioning, placement, routing and compaction.

Text Books:

1. S. Kang and Y Leblebici, "CMOS Digital Integrated Circuits: Analysis and Design," 3rd Ed., Tata McGraw Hill, New Delhi, 2003.
2. J. P. Uyemura, "Introduction to VLSI circuits and Systems," John Wiley, New Delhi, 2002.

Reference Books:

1. L Wang, C.Wu and X. wen, VLSI Test Principles and Architecture, Morgan Kaufmann, San Francisco, 2006.

Subject Code: EC6L015	**Name: Biomedical Signal Processing**	**L-T-P: 3-0-0**	**Credits: 3**

Prerequisite: Digital Signal Processing

Nature of biomedical signals, Artifacts removal, Event detection, Wave shape analysis, Frequency-domain characterization, Biomedical system modeling, Non-stationary signal analysis, Detection of region of interests in biomedical images, Shape and texture analysis, oriented pattern analysis, Image reconstruction of projections, Pattern classification and diagnostic decision, presentation of different case studies.

Texts/References:

1. R. M. Rangayyan, "Biomedical signal analysis," Wiley, 2011.
2. R. M. Rangayyan, "Biomedical image analysis," CRC press, 2005.
3. D. C. Reddy, Biomedical signal processing: principles and techniques, Tata McGraw Hill, 2012.
4. Tompkins, Biomedical digital signal processing, Prentice Hall India, 1995.

Subject Code: EC6L019	**Name: Fiber Optic Sensors**	**L-T-P: 3-0-0**	**Credits: 3**

Prerequisite: None

Classification of sensors, modulation and demodulation mechanism of sensors, interferometric sensors, optical fibres Doppler systems, polarization modulation sensors, fibre optic sensors for the measurement of temperature, pressure, displacement, turbidity, pollution, etc., multiplexed sensor systems, other sensor applications.

Text/References Books:

1. R. Kasyap, 'Fiber Bragg Gratings', Academic Press, 2009.
2. B. Glisic, D. Inaudi, 'Fibre Optic Methods for Structural Health Monitoring', Wiley, 2008.

Subject Code: EC4L008	**Name: Embedded Systems**	**L-T-P: 3-0-0**	**Credits: 3**

Prerequisite: Digital Electronics and Microprocessor

Embedded Processing Systems: Introduction, Components of Embedded Systems – Embedded Processor, Microcontrollers (PIC and ARM architectures), DSP and ASICs and SoC, Memory Devices: ROM and RAM family, Interfacing Memory, Simple I/O programming, Interrupts and their servicing, Timing Devices and Interfacing, Analog I/O Techniques, Introduction to HDL, Design of Embedded Processors and Components, Design Case Studies, Embedded Communication: Parallel Bus Standards, Serial Bus Standards, Networking Standards and Wireless Standards, Real Time Operating Systems (RTOS): Introduction, Memory Management, I/O Management and Device Drivers, Scheduling, Introduction to Software Design: Embedded System Life Cycle, Multicore and Heterogeneous Embedded Systems.

Text Books:

1. W. Wolf, Computers as Components: Principles of Embedded Computing System Design, 2nd Ed., Burlington, 2008.
2. T Noergaard, Embedded Systems Architecture: A comprehensive Guide for Engineers and Prgrammers, Elsevier,Oxford, 2005.

Reference Books:

1. Steve Heath, Embedded System Design, 2nd Edition, Newnes, Burlington, 2003.

Subject Code: EC6L027	**Name: Pattern Recognition**	**L-T-P: 3-0-0**	**Credits: 3**
Prerequisite: Digital signal processing, Probability and stochastic processes			

Introduction to pattern recognition; Bayesian decision theory : Classifiers, Discriminant functions, Decision surface, Normal density and discriminant functions, Parameter estimation methods: Maximum-Likelihood estimation, Gaussian mixture models, Expectation-maximization method, Bayesian estimation, Hidden Markov models: Discrete hidden Markov models, Continuous density hidden Markov models; Dimensionality reduction methods: Fisher discriminant analysis, Principal component analysis; Non-parametric techniques for density estimation: Parzen-window method, K-Nearest Neighbour method, Linear discriminant function based classifiers: Perceptron , Support vector machines, Non-metric methods for pattern classification: Non-numeric data or nominal data
Decision trees, Unsupervised learning and clustering: Criterion functions for clustering Algorithms for clustering: K-means, Hierarchical and other methods, Cluster validation.

Texts/References:

1. R.O.Duda, P.E.Hart and D.G.Stork, “Pattern Classification,” John Wiley, 2001.
2. S.Theodoridis and K.Koutroumbas, “Pattern Recognition,” 4th Ed., Academic Press, 2009.
3. C.M.Bishop, “Pattern Recognition and Machine Learning,” Springer, 2006.

Subject Code: EC6L024	**Name: Array Signal Processing**	**L-T-P: 3-0-0**	**Credits: 3**
Prerequisites: Digital Signal Processing, Probability and Statistics processes			

Introduction: Array Processing and Applications, Arrays and Spatial Filters: Uniform Linear Array, Array Steering, Array Performance, Linear Aperture, Synthesis of Linear Arrays and Apertures: Spectral Weighting, Array Polynomials, Minimum Beamwidth, Null Steering, Spatially Non-uniform Linear Arrays, Broadband Arrays, Planar Arrays and Apertures: Rectangular Arrays, Circular Arrays, Circular Apertures, Non-planar Arrays, Characterization of Space-time Processes: Snapshot Models, Space-time Random Process, Optimum Waveform Estimation: Optimum Beamformers, MVDR and MPDR Beamformers, LCMV and LCMP Beamformers, Eigenspace Beamformer, Beamspace Beamformer, Broadband Beamformer, Adaptive Beamformers: Parametric Estimation, RLS, LMS, Gradient Algorithms, Parameter Estimation and Direction of Arrival Estimation: Cramer-Rao Bounds, Maximum Likelihood Estimation, Capon methods, Subspace methods - MUSIC, Minimum-Norm and ESPRIT techniques.

Text Books:

1. Harry L. Van Trees, Optimum Array Processing (Part IV of Detection, Estimation, and Modulation Theory), Wiley-Interscience, 2002.

Reference Books:

1. D. E. Dugeon and D. H. Johnson, “Array Signal Processing: Concepts and Techniques,” Prentice Hall, 1993.
2. P. Stoica and R. L. Moses, “Spectral Analysis of Signals,” Prentice Hall, 2005.

Subject Code: EE6L004	**Name: Power System Protection**	**L-T-P: 4-0-0**	**Credits: 4**
Prerequisites: Electrical Power Transmission and Distribution			

Generation, propagation and interaction of electrical transients in electric power systems. Analysis of single and multiple transients including three phase and switching transients. Mathematical modeling of transmission lines and other power equipment in the presence of surge phenomena. Evolution in Protection systems, Characteristic of protective relays, Basic elements of Digital protection, signal conditioning and conversion, Fourier analysis and least square based techniques, Differential equation based techniques for transmission line applications, Fundamentals of travelling wave based techniques, Digital differential protection of transformers and transmission systems. Intelligent protection using ANN and Fuzzy systems, Application of advanced DSP in numerical relaying.

Texts/References Books:

1. A. T. Johns and S. Kalman 'Digital Protection for Power Systems', IET, 1997.
2. A. G. Phadke and J. Thorp 'Computer Relaying for Power Systems', Wiley, 2009.
3. A. Greenwood 'Electrical Transient in Power Systems', McGraw Hill, 1990.

Subject Code: EE6L017	**Name: Distribution System Engineering**	**L-T-P: 3-0-0**	**Credits: 3**
Prerequisites: Electrical Power Transmission and Distribution			

Introduction to power distribution system, Distribution transformer, Substation Bus Schemes, Substation Location, The Rating of a Distribution Substation , Substation Service Area with n Primary Feeders , Comparison of the Four-and Six-Feeder Patterns, Derivation of the K Constant, Substation Application Curves, Interpretation of the Percent Voltage Drop Formula, Advanced SCADA Concepts and Substation Automation, substation grounding, Radial and Loop Type Primary Feeder, Primary Network, Primary-Feeder Voltage Levels and Loading, Radial Feeders with Uniformly and Nonuniformly Distributed Load, A,B,C,D General Circuit Constants to Radial Feeders, Design of Radial Primary and Secondary Distribution Systems, Secondary Voltage Levels and Networks, Economic Design, Three-Phase Balanced Primary Lines, Non three-Phase Primary Lines, Four-Wire Multigrounded Common Neutral Distribution System, Distribution Costs, Economic Analysis of Equipment Losses, Capacitors in Distribution Systems and Optimum allocation, Dynamic Behavior of Distribution Systems, Quality of Service and Voltage Standards, Voltage Control, Feeder Voltage Regulators, Line-Drop Compensation, Distribution Capacitor Automation, Voltage Fluctuations.

Text Books:

1. J. J. Burke "Power Distribution Engineering: Fundamentals and Applications", CRC Press, 1994.
2. T. Gönen "Electric power distribution system engineering", McGraw-Hill, 1986

Reference Book:

1. Pabla, "Electric Power Distribution", McGraw-Hill Education, 2005

Subject Code: EC6L016	**Name: Computational Electromagnetics**	**L-T-P: 3-0-0**	**Credits: 3**
Prerequisite: Electromagnetic Field Theory			

Applications of electromagnetics in the 21st century. Numerical Methods: ODE solvers, Euler, Runge-Kutta. Review of Basic Electromagnetics: Electrostatics, Magnetostatics, Wave Equations. Numerical Techniques: Method of Moements, Finite Difference Method, Finite Element method, Charge Simulation Method, Monte carlo method. Time Varying Electromagnetic Fiels: Eddy currents & skin depth, introduction to wavelets, families of wavelets. Microwaves, Optics, Micromagnetics, Bio-electromagnetics. Tutorials and demonstration on PC, programming assignments.

Text/ Reference Books:

1. M.N.O. Sadiku, "Numerical Techniques in Electromagnetic," 2nd Ed., CRC Press.
2. E. Weber, "Electromagnetic Fields," Dover, 1951.
3. P. P. Silvester, and R. L. Ferrari, "Finite Elements for Electrical Engineers," Cambridge University Press 1996.
4. J. Kiusalaas, "Numerical Methods in Engineering with Python," Cambridge.

Subject Code: EC6L023	Name: Adaptive Digital Signal Processing	L-T-P: 3-0-0	Credits: 3
Prerequisite: Digital Signal Processing			

Introduction to adaptive filters, optimal estimation, linear estimation: normal equation, orthogonality principle, linear models. Constrained linear estimation: minimum variance unbiased estimation, steepest descent algorithms, stochastic gradient algorithms: LMS algorithm, normalized LMS algorithm, RLS algorithm. Steady-state performance of adaptive filters, transient performance of adaptive filters, block adaptive filters, the least-squares criterion, recursive least-squares, lattice filters

Texts/Reference Books:

1. A. H. Sayed, "Fundamentals of Adaptive Filtering," Wiley, 2003.
2. S. Haykin, "Adaptive filter theory," Fourth edition, Pearson, 2012.
3. Widrow and Stearns, "Adaptive Signal Processing," Pearson, 2007.

Subject Code: EE6L005	Name: HVDC and Flexible AC Transmission Systems	L-T-P: 3-0-0	Credits: 3
Prerequisite: Power System Operation and Control, Power Electronics			

Description and application of HVDC transmission, DC System components and their functions, Converter configuration, Principles of DC Link control and Converter control characteristics, Firing angle, Current and extinction angle control, DC link power control, Reactive power control and VAR sources, MTDC system types; Power flow in AC Systems, Definition of FACTS, Constraints of maximum transmission line loading. Benefits of FACTS, Uncompensated line, shunt and series compensation, Phase angle control. SVC and STATCOM, Operation and Control of TSC, TRC and STATCOM, Compensator Control; TSSC, SSSC, Static voltage and phase angle regulators TCVR and TCPAR. Operation and Control applications, Unified Power Flow Controller, Circuit Arrangement, Basic Principle of P and Q Control, independent real and reactive power flow control, Applications; Introduction to interline power flow controller, Compensation Devices, STS, SSC, SVR, Backup energy supply devices, Special purpose FACTS controllers, Thyristor controlled voltage limiter and voltage regulator, Thyristor controlled braking resistor and current limiter.

Text Books:

1. N.G Hingorani, L. Gyugyi, "Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems", IEEE Press Book, Standard Publishers and Distributors, Delhi, 2001.
2. Padiyar K.R., "HVDC Power Transmission System", Wiely Eastern PVT Limited.

Reference Books:

1. E.W. Kimbark "Direct Current transmission", Vol.1, John Wielly, New York.
2. T,J.E Miller, "Reactive Power Control in Electric Systems", John Wiley & Sons.

Subject Code: EE6L014	Name: Smart Grid Technology	L-T-P: 3-0-0	Credits: 3
Prerequisite: Power System Operation and Control, Power Electronics			

Review of basic elements of electrical power systems, desirable traits of a modern grid, principal characteristics of the smart grid, key technology areas; Smart grid communication: Two way digital communication paradigm, network architectures, IP-based systems, Power line communications, advanced metering infrastructure; Renewable Generation: Renewable Resources: Wind and Solar, Microgrid Architecture, Tackling Intermittency, Distributed Storage and Reserves; Wide Area Measurement: Sensor Networks, Phasor Measurement Units, Communications Infrastructure, Fault Detection and Self-Healing Systems, Application and Challenges; Security and Privacy: Cyber Security Challenges in Smart Grid, Defense Mechanism, Privacy Challenges.

Texts/Reference Books:

1. J. Momoh 'Smart Grid: Fundamentals of Design and Analysis' Wiley-IEEE Press, 2012.
2. P. F. Schewe 'The Grid: A Journey through the Heart of our Electrified World' Joseph Henry Press, 2006.

Subject Code: EC4L005	Name: Computer Vision	L-T-P: 3-0-0	Credits: 3

Prerequisite: Image & Video Processing

Introduction to computer vision, geometric camera models, light and shading, local image features: SIFT, HOG, texture and shape descriptors, active contour, segmentation, deformable models, RANSAC, image registration, learning and classification strategies, image classification, object detection and recognition, stereopsis, tracking, applications

Texts/References:

1. Forsyth and Ponce, "Computer vision: a modern approach," 2nd Ed., Pearson, 2012.
2. Sonka, Hlavac and Boyle, "Digital image processing and computer vision," Cengage learning, 2008.
3. Rick Szeliski, "Computer Vision: Algorithms and Applications," Springer,2011.

Subject Code: EC6L017	Name: Semiconductor Device Modelling	L-T-P: 3-0-0	Credits: 3

Pre-requisite: Semiconductor Devices

Review of semiconductor physics: Quantum foundation, Carrier scattering, high field effects; P- N junction diode modeling: Static model, Large signal model and SPICE models; BJT modeling: Ebers - Moll, Static, large-signal, small- signal models. Gummel - Poon model. Temperature and area effects. Power BJT model, SPICE models, Limitations of GP model; Advanced Bipolar models: VBIC, HICUM and MEXTARM;MOS Transistors: LEVEL 1, LEVEL 2 ,LEVEL 3, BSIM, HISIMVEKV Models, Threshold voltage modeling, Punchthrough, Carrier velocity modeling, Short channel effects, Channel-length modulation, Barrier lowering, Hot carrier effects, Mobility modeling, Model parameters; Analytical and Numerical modeling of BJT and MOS transistors; Types of models for Heterojunction Bipolar Transistors, Compact modeling concepts, Modeling of HBTs, HBT noise models, Measurement and parameter extraction.

Text Books:

1. G. Massobrio, P. Antognetti, Semiconductor Device Modeling with SPICE, 2nd edition, McGraw-Hill, New York,1993.
2. M. Rudolph, Introduction to Modeling HBTs, Artech House, Boston, 2006.

Reference Books:

1. S. M. Sze, K. K. Ng, Physics of Semiconductor Devices, 3rd edition, John Wiley, New Jersey, 2007.
2. G. A. Armstrong, C. K. Maiti, Technology Computer Aided Design for Si, SiGe and GaAs Integrated Circuits ,IET Series, London, 2007.

Subject Code: EE6L015	Name: Advanced High Voltage Engineering	L-T-P: 3-0-0	Credits: 3

Prerequisite: High Voltage Engineering

High Voltage Testing of Electrical Apparatus: Testing of Insulators and bushings, Testing of Isolators and circuit breakers, Testing of cables, Testing of Transformers, Testing of Surge Arresters, Radio Interference measurements;

Partial discharges and their measurement: Introduction, Partial discharge degradation mechanisms, Partial discharge measurements; Non Thermal Atmospheric Pressure Plasma: Townsend and spark breakdown mechanisms, corona discharge, pulse corona discharge, dielectric barrier discharge, spark discharge, atmospheric pressure glows, Environmental Pollution Control Application.

Text/ Reference Books:

1. D. K. K. Feser, and Y. N. Rao "High-Voltage Test Techniques" Newnes, 2001.
2. D. A. Lloyd "Electrostatic Precipitator Handbook," Institute of Physics Publishing, 1988.
3. M. Haddad and D. Warne "Advances in High Voltage Engineering" IET, 2009.
4. J. Ernest Harry 'Introduction to Plasma Technology' Wiley-vch Verlag Gmbh, 2010.
5. J. Reece Roth, J. Reece Roth, and Roth J. Reece 'Industrial Plasma Engineering – Volume-2' Taylor & Francis Group, 2001.
6. B. M. Penetrante, 'Non-Thermal Plasma Techniques for Pollution Control: Part B: Electron Beam and Electrical Discharge Processing' Springer, 2012.

Subject Code: EE6L018	Name: Power System Planning	L-T-P: 3-0-0	Credits: 3

Prerequisite: Power System Operation and Control

Basic Planning Issues: Introduction, Power system elements and structure, Static and dynamic planning, Transmission and distribution planning; Ling-term and short-term planning, Basic issues in transmission planning; Optimization Techniques: Introduction; Problem definition and modelling, Mathematical and heuristic solution algorithms; Economic Principles: Introduction, Definition of various terms, Cash flow concept: time value of money and economic terms, Economic analysis: present worth method, annual cost method, Rate of return method, Example; Load Forecasting: Introduction, Load characteristics and driving parameters, Spatial load forecasting, Long-term forecasting methods: trend analysis, econometric modelling, end-use analysis, combined analysis, Examples - load forecasting of small and large scale utility; Single and Multi-bus Generation Expansion Planning: Problem description and mathematical formulation, Objective functions and constraints, Solution approaches; Substation Expansion Planning: Problem definition and formulation, Mathematical view: objection function and constraints, required data; Solution methodologies, Case studies; Network Expansion Planning: Problem definition and formulation: objective function and constraints, Solution methodologies: enumeration and heuristic methods, Case study; Reactive Power Planning: Introduction, Voltage profile and stability, Performance control parameters, Static and dynamic reactive power sources, Static reactive resource allocation and sizing, Dynamic reactive resource allocation and sizing, Solution methods, Case study; Planning with System Uncertainties: Introduction, Deregulation, Uncertainties in regulated and deregulated environment, Practical planning issues in deregulated environment, Dealing with uncertainties in planning: expected cost criterion, min-max regret criterion, Laplace criterion, and VNM criterion.

Text Books:

1. H. Seifi and M. S. Sepasian, "Electric Power System Planning: Issues, Algorithms and Solutions", 2011, Springer.
2. R. L. Sullivan, "Power System Planning", 1987, McGraw Hill.

Reference Books:

1. J. Schlabbach and K-H. Rofalsk, "Power System Engineering: Planning, Design, and Operation of Power Systems and Equipment", 2008, Wiley.

Laboratory Courses:

Subject Code: EE1P001	Name: Electrical Technology Laboratory	L-T-P: 0-0-3	Credits: 2
Study of V-I characteristics of incandescent lamp & Carbon lamp; Measurement of Power and Power factor of fluorescent lamp and Compact Fluorescent Lamp (CFL) at rated voltage and to find out its pick-up voltage and cut-off voltage; Verification of Thevenin's and Superposition theorems; Measurement of power and power factor of single- phase series R-L-C circuit; Measurement of power using two-wattmeter method in 3-phase balanced and unbalanced loads; Measurement of single phase power using 3-Ammeter and 3-Voltmeter methods; Open circuit characteristic of separately excited DC generator; Load characteristics of separately excited DC generator; Speed control of DC shunt motor; Load characteristic of DC motor; Open circuit and short circuit test of single phase transformer; Study of single phase energy meter. **Prerequisite:** Electrical Technology			
Subject Code: CS1P001	**Name: Introduction to Programming and Data Structures Laboratory**	**L-T-P: 0-0-3**	**Credits: 2**
Familiarization of a computer and the environment; Execution of sample programs related to Expression evaluation, Conditionals and branching, Iteration, Functions, Recursion, Tail-recursion, Arrays, String manipulation, Structures, Linked lists, Doubly-linked lists and Binary Trees. Execution of programs involving abstract data types like Stacks and Queues. **Prerequisite:** Introduction to Programing and Data Structures			
Subject Code: EC2P001	**Name: Introduction to Electronics Laboratory**	**L-T-P: 0-0-3**	**Credits: 2**
Familiarization with electronic components; Familiarization and usage with oscilloscope, signal generator, multimeter; Frequency-response of R-C, C-R and R-L networks; Square-wave testing, V-I characteristics of PN junction diode and zener diode; Voltage Rectifiers; Common-Emitter amplifiers; Analog circuits using OP-AMP; logic gates. **Prerequisite:** Introduction to Electronics			
Subject Code: EC2P002	**Name: Signals and Systems Laboratory**	**L-T-P: 0-0-3**	**Credits: 2**
Basic MATLAB Programming: Manipulation of Vectors, Arrays and Matrices, Arithmetic Operations, Logical Operations, Loops, M-files & Functions, Mathematical Functions; Graphics and 3-D Visualization: Plotting of One-dimensional and Two-dimensional Signals, Plotting Symbolic Functions, 3-D Plotting; Mathematical Functions: Finding Roots of Polynomials, Computing Integration and Differentiation, Solving Differential and Difference Equations, Polynomial Curve Fitting, Recording, Storing, Reading, and M-File; Functions: Recording and Playing Signals, Storing and Reading Data in Different Formats, Creating M-Functions for Generating Different Elementary Signals, Creating M-Functions for Computing Different Statistical Parameters; Analysis of Systems: Finding Convolution, Finding Laplace and Inverse Laplace Transforms, Finding Z-and Inverse-Z Transforms, Zero-Pole Analysis; Analysis of Signals and Systems: Sampling of Signals, Fourier Series of Signals, Finding Magnitude and Phase Spectrum of Signals, Frequency Response of System; Convolution and Filtering, Creating GUI in MATLAB, MATLAB Simulink Modelling. **Prerequisite:** Signals and Systems			
Subject Code: EC2P006	**Name: Digital Electronics and Microprocessor Laboratory**	**L-T-P: 0-0-3**	**Credits: 2**
Truth tables of Logic gates; Half Adder and Full Adder; Multiplexer and De-multiplexer; Comparators;			

Encoders; Schmitt Trigger; Multivibrators: Astable, Monostable and Bi-stable; Flip Flops: S-R, J-K and D; Asynchronous and Synchronous Counters: Up-Down, Ripple counter, Ring counter, Familiarization with 8/16 bit microprocessors/microcontroller kits and interfaces; Assembly and machine language programming, interfacing basic I/O devices like keypad, LED display, usage of timers and USART peripherals, multi-port device access, stepper motor movement control, DC motor speed control. **Prerequisite:** Digital Electronics and Microprocessor			
Subject Code: EE2P003	**Name: Electric Machines Laboratory**	**L-T-P: 0-0-3**	**Credits: 2**
Performance testing (regulation, efficiency) , characteristics (no-load and load characteristics) and parameters (equivalent circuit parameters, sequence components) of 3-phase alternator, performance test and characteristics of 3-phase synchronous motor, 3-phase induction motor, 1-phase induction motor, performance, characteristics and parameters of 1-phase and 3-phase transformers, type of connections of transformers, synchronization of alternators. **Prerequisite:** Electric Machines			
Subject Code: EE3P004	**Name: Power Electronics Laboratory**	**L-T-P: 0-0-3**	**Credits: 2**
Study the operation of controlled single phase bridge converter with different types of loads; Study the operation of single phase AC voltage regulator with different types of loads; Study the operation of a three-phase bridge rectifier; Study the working of a three phase sinusoidal PWM Inverter; Study the load voltage waveforms of first quadrant chopper and verify calculated output voltage with measured value with R Load; Verification of the output waveforms of single phase cyclo converter with R Load; Controlling of the speed of induction motor by Variable Voltage and Variable Frequency (VVVF) method; Controlling of the speed of a DC Shunt Motor by using single Quadrant Chopper; Controlling of the speed of a separately excited DC Motor by three phase controlled convertor; Controlling of the Speed of separately excited DC Motor by single phase fully controlled convertor. **Prerequisite:** Power Electronics			
Subject Code: EE3P005	**Name: Measurement and Instrumentation Laboratory**	**L-T-P: 0-0-3**	**Credits: 2**
Measurement of displacement by linearly variable differential transformer (LVDT); Measurement of inductance by linearly variable inductive transformer (LVIT) and Maxwell bridge; Measurement of resistance by linearly variable resistor transducer (LVRT) and Kelvin bridge; Measurement of strain by strain gauge, Measurement of tension and compression by load cell module; Measurement of deflection torque by torque transducer; Measurement of angular position by angular potentiometer; Measurement of capacitance by Schering bridge; Characteristics of vibrations of a mechanical system; Study of Piezo-electric and opto-electric transducers; Study of flow measurement and level measurement with DP transmitter; Study of thermistor and RTD characteristics; Measurements with pressure transducers and Hall effect transducers. **Prerequisite:** Measurement and Instrumentation			
Subject Code: EE3P002	**Name: Control Systems Laboratory**	**L-T-P: 0-0-3**	**Credits: 2**
Transfer function evaluation of a DC motor; Study of an AC servomotor; Study of digital control systems; DC servo motor position control; Closed loop speed control of DC motor; Study of temperature control systems; Feedback control of magnetic levitation system; PID stabilization of an inverted cart-pendulum			

system; Study of coupled tank system; PID stabilization of a twin rotor MIMO system; PID control of two link flexible manipulator.

Prerequisite: Control Systems

Subject Code: EC3P002	**Name: Digital Signal Processing Laboratory**	**L-T-P: 0-0-3**	**Credits: 2**

Fourier transform; Z-transform; Discrete Fourier transform (DFT); Fast Fourier transform (FFT); Infinite impulse response (IIR), Finite impulse response (FIR) filter designs and power spectrum estimation.

Prerequisite: Digital Signal Processing

Subject Code: EE3P006	**Name: Power Systems Laboratory**	**L-T-P: 0-0-3**	**Credits: 2**

Performance of Transmission line (regulation and efficiency), parameter calculation (ABCD parameter), characteristics with and without compensation (voltage profile, Ferranti effect), fault transient studies (transient, sub-transient conditions, symmetrical and un-symmetrical faults), protection relay characteristics (over current, distance, differential relays), insulator testing (string efficiency), dielectric strength of insulation, underground cable parameter calculation, earth insulation resistance test.

Prerequisite: Electrical Power Transmission and Distribution

Subject Code: EE4P002	**Name: Renewable Energy Systems Laboratory**	**L-T-P: 0-0-3**	**Credits: 2**

Experiments on characteristics and control aspects of various renewable energy systems such as wind energy conversion system, photovoltaic systems, wave energy systems and hybrid systems etc. will be performed. Both isolated and grid-connected systems will be used in the experiments

Prerequisite: Renewable Energy Systems

Subject Code: EE6P051	**Name: Power Electronics System Simulation Laboratory**	**L-T-P: 0-0-3**	**Credits: 2**

Introduction to schematic design, Design of power PCB, Design of sandwiched Bus-bar, Introduction to DSP/FPGA programming for power application, PWM generation exercise, Simulation of DC-DC converter, Grid connected Inverter, Loss estimation techniques, Power Quality improvement studies, Input Filter design and noise reduction.

Subject Code: EE6P052	**Name: Switched Mode Power Conversion Laboratory**	**L-T-P: 0-0-3**	**Credits: 2**

Constant current Load, 15V Voltage regulator with current limit, Constant current-constant voltage regulator, Non-isolated Boost converter, Non-isolated Fly-back converter, Non -isolated Forward converter, Current mode control of Boost Converter, Current mode control of Forward Converter, soft-switched converter.

Subject Code: EE6P053	**Name: Power Converter and Electric Drives Laboratory**	**L-T-P: 0-0-3**	**Credits: 2**

Active Power Factor control, Parameterization of Industrial Drive, Converter Drive with Universal motors, Self-Commutated Four quadrant converter, Slip control of asynchronous motor, Frequency converter with three phase asynchronous motor, Electronically commutated Synchronous machine, Smooth starting of Three phase machine, PLC controlled Drive system