SECOND YEAR: ELECTRICAL & ELECTRONICS ENGINEERING

SCHEME OF INSTRUCTION AND EXAMINATION REVISED COURSE 2019-2020

SEMESTER - III

Subject Code	Name of the Subject	Scheme of Instruction Hrs/Week				Scheme of Examination							Credit
		L	T	P	H	Th Duration (Hrs)	Marks						
							Th	S	TW	P	O	Total	
EE310	Mathematics-III	3	1	0	4	3	100	25	25	0	0	**150**	**4**
EE320	Electromagnetic Fields	3	0	0	3	3	100	25	0	0	0	**125**	**3**
EE330	Digital Electronics	4	0	0	4	3	100	25	0	0	0	**125**	**4**
EE340	Electrical Machines - I	4	0	0	4	3	100	25	0	0	0	**125**	**4**
EE350	Electrical Circuit Analysis	3	1	0	4	3	100	25	25	0	0	**150**	**4**
EE360	Digital Electronics Lab	0	0	2	2	-	0	0	25	50	0	**75**	**1**
EE370	Electrical Machines-I Lab	0	0	2	2	-	0	0	25	50	0	**75**	**1**
HM001	Technical Communication	2	0	0	2	-	0	0	75	0	0	**75**	**2**
AC390	Mathematics-I & II (Bridge Course)*	2	0	0	2	-	0	0	0	0	0	**0**	**0**
TOTAL		**21**	**2**	**4**	**27**	**--**	**500**	**125**	**175**	**100**	**0**	**900**	**23**

- Applicable to direct second year /lateral entry students

SECOND YEAR: ELECTRICAL & ELECTRONICS ENGINEERING

SCHEME OF INSTRUCTION AND EXAMINATION REVISED COURSE 2019-2020

SEMESTER – IV

Subject Code	Name of the Subject	Scheme of Instruction Hrs/Week				Scheme of Examination							Credit
		L	T	P	H	Th Duration (Hrs)	Marks						
							Th	S	TW	P	O	Total	
EE410	Numerical Methods	3	1	0	**4**	3	100	25	25	0	0	**150**	**4**
EE420	Electrical Machines - II	4	0	0	**4**	3	100	25	0	0	0	**125**	**4**
EE430	Analog Electronics	4	0	0	**4**	3	100	25	0	0	0	**125**	**4**
EE440	Fundamentals of Signal Processing	3	1	0	**4**	3	100	25	25	0	0	**150**	**4**
EE450	Renewable Energy	3	0	0	**3**	3	100	25	0	0	0	**125**	**3**
EE460	Electrical Machines - II Lab	0	0	2	**2**	-	0	0	25	50	0	**75**	**1**
EE470	Analog Electronics Lab	0	0	2	**2**	-	0	0	25	50	0	**75**	**1**
HM003	Economics for Engineers	3	0	0	**3**	-	100	25	0	0	0	**125**	**3**
TOTAL		**20**	**2**	**4**	**26**	**--**	**600**	**150**	**100**	**100**	**0**	**950**	**24**

THIRD YEAR: ELECTRICAL & ELECTRONICS ENGINEERING

SCHEME OF INSTRUCTION AND EXAMINATION REVISED COURSE 2019-2020

SEMESTER – V

Subject Code	Name of the Subject	Scheme of Instruction Hrs/Week				Scheme of Examination							Credit
		L	T	P	H	Th Duration (Hrs)	Marks						
							Th	S	TW*	P	O	Total	
EE510	Control Systems	3	1	0	**4**	3	100	25	0	0	0	**125**	**4**
EE520	Microprocessors &Microcontroller	4	0	0	**4**	3	100	25	0	0	0	**125**	**4**
EE531	Digital Signal Processing	3	0	0	**3**	3	100	25	0	0	0	**125**	**3**
EE532	Illumination Engineering												
EE533	Electrical Machines Design												
EE534	Electric Drives												
EE541	Testing & Maintenance of Electrical Machines	3	0	0	**3**	3	100	25	0	0	0	**125**	**3**
EE542	Analog and Digital Communication												
EE543	Bio-Medical Instrumentation												
EE544	Operation Research												
EE550	Control Systems Lab	0	0	2	**2**	-	0	0	25	50	0	**75**	**1**
EE560	Microprocessor & Microcontroller Lab	0	0	2	**2**	-	0	0	25	50	0	**75**	**1**
**	**Open Elective**	3	0	0	**3**	3	100	25	0	0	0	**125**	**3**
HM004	Entrepreneurship & Intellectual Property	3	0	0	**3**	3	100	25	0	0	0	**125**	**3**
TOTAL		**19**	**1**	**4**	**24**	**--**	**600**	**150**	**50**	**100**	**0**	**900**	**22**

Students to select ANY ONE subject from EE531, EE532, EE533 and EE534 as Professional elective I and ANY ONE subject from EE541, EE542, EE543 and EE544 as Professional elective II . *Term Work marks are to be awarded through continuous evaluation.

THIRD YEAR: ELECTRICAL & ELECTRONICS ENGINEERING

SCHEME OF INSTRUCTION AND EXAMINATION REVISED COURSE 2019-2020

SEMESTER - VI

Subject Code	Name of the Subject	Scheme of Instruction Hrs/Week				Scheme of Examination							Credit
							Marks						
		L	**T**	**P**	**H**	**Th Duration (Hrs)**	**Th**	**S**	**TW***	**P**	**O**	**Total**	
EE610	Power System – I	3	1	0	**4**	3	100	25	25	0	0	**150**	**4**
EE620	Power Electronics	4	0	0	**4**	3	100	25	0	0	0	**125**	**4**
EE631	Distributed Generation and Microgrid	3	0	0	**3**	3	100	25	0	0	0	**125**	**3**
EE632	Power Quality												
EE633	Digital Control System												
EE634	Artificial Neural Network & Fuzzy Logic												
EE641	Power System Protection	3	0	0	**3**	3	100	25	0	0	0	**125**	**3**
EE642	VLSI Circuit Design												
EE643	Hybrid Vehicles												
EE644	Electrical Energy Conservation & Auditing												
EE650	Electrical and Electronics engineering laboratory	0	0	2	**2**	-	0	0	25	0	25	**50**	**1**
EE660	Power Electronics Lab	0	0	2	**2**	-	0	0	25	50	0	**75**	**1**
**	Open Elective	3	0	0	**3**	3	100	25	0	0	0	**125**	**3**
HM005	Management & Organizational Behavior	3	0	0	**3**	3	100	25	0	0	0	**125**	**3**
TOTAL		**19**	**1**	**4**	**24**	- -	**600**	**150**	**75**	**50**	**25**	**900**	**22**

Students to select ANY ONE subject from EE631, EE632, EE633 and EE634 as Professional elective III and ANY ONE subject from EE641, EE642, EE643 and EE644 as Professional elective IV* Term Work marks are to be awarded through continuous evaluation

FOURTH YEAR: ELECTRICAL & ELECTRONICS ENGINEERING

SCHEME OF INSTRUCTION AND EXAMINATION REVISED COURSE 2019-2020

SEMESTER - VII

Subject Code	Name of the Subject	Scheme of Instruction Hrs/Week				Scheme of Examination							Credit
							Marks						
		L	T	P	H	Th Duration(Hrs)	Th	S	TW*	P	O	Total	
EE710	Power Systems - II	3	1	0	**4**	3	100	25	25	0	0	**150**	**4**
EE721	Flexible AC Transmission System	3	0	0	**3**	3	100	25	0	0	0	**125**	**3**
EE722	Image Processing												
EE723	Smart Grid												
EE724	PLC & Its Applications												
EE730	Power System Lab	0	0	2	**2**	--	0	0	25	0	25	**50**	**1**
**	Open Elective	3	0	0	**3**	3	100	25	0	0	0	**125**	**3**
EE740	Internship	0	0	6	**6**	--	0	0	50	0	50	**100**	**3**
EE750	Project Work - Phase I	0	0	6	**6**	--	0	0	50	0	75	**125**	**3**
TOTAL		**9**	**1**	**14**	**24**	**--**	**300**	**75**	**150**	**0**	**150**	**675**	**17**

Students to select ANY ONE subject from EE721, EE722, EE723 and EE724 as Professional elective V
*Term Work marks are to be awarded through continuous evaluation

FOURTH YEAR: ELECTRICAL & ELECTRONICS ENGINEERING

SCHEME OF INSTRUCTION AND EXAMINATIONREVISED COURSE 2019-2020

SEMESTER – VIII

Subject Code	Name of the Subject	Scheme of Instruction Hrs/Week				Scheme of Examination							Credit
		L	T	P	H	ThDuration(Hrs)	Marks Th	S	TW*	P	O	Total	
EE810	High Voltage Engineering	3	0	0	**3**	3	100	25	0	0	0	**125**	3
EE821	Embedded Systems	3	0	0	**3**	3	100	25	0	0	0	**125**	3
EE822	Power System Operation & Control												
EE823	Reliability of electrical system												
EE824	PV & Its Applications												
EE830	Elective - NPTEL / MOOC / SWAYAM	0	0	0	**3**	--	0	0	50	0	50	**100**	3
EE840	Project Work - Phase II	0	0	18	**18**	--	0	0	200	0	200	**400**	9
TOTAL		**6**	**0**	**18**	**24**	**--**	**200**	**50**	**250**	**0**	**250**	**750**	**18**

Students to select ANY ONE subject from EE821, EE822, EE823 and EE824 as Professional elective VI

*Term Work marks are to be awarded through continuous evaluation

BASICS OF ELECTRICAL & ELECTRONICS ENGINEERING					
Course Code	**FE 130**		**Credits**	**3**	
Scheme of Instruction Hours/ Week	**L**	**T**	**P**	**TOTAL**	
	3	**0**	**0**	**39 hrs/sem**	
Scheme of Examination TOTAL = 125 marks	**IA**	**TW**	**TH**	**P**	**O**
	25	**0**	**100**	**0**	**0**

Course Outcomes:

The student will be able to:

CO1	understand circuit laws, magnetic circuit quantities, single phase and three phase circuits, diode applications, principles of single-phase transformer, Bipolar junction transistor, MOSFET and IGBT.
CO2	Describe the concept of Power generation, magnetic circuits, voltage-currentphasor relationships in three phase circuits, working of single phase transformer, Bipolar junction transistor, MOSFET and IGBT
CO3	Use circuit laws to compute electrical quantities in DC, single phase and three phase circuits, rectifier circuits, voltage regulator circuits and transistor biasing circuits.
CO4	Develop phasor diagrams of single phase, three phase ac circuits and single phase transformer and analyse the performance of voltage regulator circuits using Zener diode and phase angle control circuits using SCR.

UNIT -1	
Introduction to Energy sources, DC Circuit Analysis: Kirchoff's laws, Thevenin's theorem, Norton's theorem, Superposition theorem, Maximum Power transfer theorem. Batteries, series and parallel connection of Batteries, Battery specifications. Magnetism: Related terms, B-H curve, Faraday's Laws, Lenz's Law, Analogy between Electrical and magnetic circuits, Solenoid	**10 Hours**
UNIT -2	
A.C Fundamentals: Analysis of R, L, C, R-L, R-C, RLC circuits, Concept of active power, reactive power, apparent power. Three phase systems. Star and Delta connection, current voltage and power relationship. Single phase transformer: Construction, principle of operation, efficiency, voltage regulation	**9 Hours**
UNIT -3	
Diodes and Circuits: PN junction diode, V-I characteristics, Zener diode, breakdown mechanism in diodes, light emitting diode. Diode Applications: Half-wave, Full-wave and Bridge Rectifiers, PIV; DC and r.m.s voltages, Ripple Factor. Voltage regulation using Zener diodes. SCR: construction, V-I characteristics, operation and phase control applications	**10 Hours**
UNIT -4	
Bipolar Junction Transistor (BJT): Construction; Operation, Transistor Amplifying Action; Common-Emitter Configuration; Common-Collector Configuration; Limits of Operation.	**10 Hours**

DC Biasing: Operating Point, Fixed-Bias Circuit; Emitter-Stabilized Bias Circuit; Voltage-Divider Biasing. **Field Effect Transistors:** Construction and Characteristics of JFETs; Transfer Characteristics; Depletion-Type MOSFET; Enhancement- Type MOSFET, CMOS. IGBT-Construction and characteristics.	

ESSENTIAL READINGS	
1	Vincent Del Tero; Principles of Electrical Engineering by; PHI Publication.
2	Joseph Administer; Electrical Circuits; Schaum Series Publication.
3	Hayt, Kemmerly, Durbin ;Engineering Circuit Analysis; Tata McGraw Hill Publication.
ADVANCED READINGS	
1	Rajendra Prasad; Fundamentals of Electrical Engineering; PHI Publication.
2	Boylestad and L. Nashelsky; Electronic Devices and Circuits; PHI
3	A. Mottershead; Electronic Devices and Circuits; PHI.
4	N.N.Bhargava; Basic Electronics and Linear Circuits; Tata McGraw-Hill.
5	Vijay Baru, RajendraKaduskar, Sunil Gaikwad; Basic Electronics Engineering; Dreamtech Textbooks.

ELECTRICAL & ELECTRONICS LABORATORY					
Course Code	**FE 160**		**Credits**	**1**	
Scheme of Instruction Hours/ Week	**L**	**T**	**P**	**TOTAL**	
	0	**0**	**2**	**26 hrs/sem**	
Scheme of Examination TOTAL = 25 marks	**IA**	**TW**	**TM**	**P**	**O**
	0	**25**	**0**	**0**	**0**

Course Outcomes:

The student will be able to:

CO1	Understand working of regulators, rectifiers, characteristics of various electronics devices
CO2	Assemble and test different circuit theorems and characteristics
CO3	Analyse and verify power in electric circuit, testing of single phase transformer
CO4	Apply circuit concept in electrical wiring

SN	Experimental List
1	Voltage Regulator
2	Half, Full and Bridge Rectifiers
3	Verification of Kirchoff's Law
4	Zener Diode Characteristics
5	Open and Short Circuit Tests on Single Phase Transformer
6	Load Test on Single phase Transformer
7	Verification of Thevenin's theorem and Norton's theorem
8	Verification of Superposition theorem and Maximum power transfer theorem
9	Silicon-Controlled Rectifier (SCR) Characteristics
10	FET Characteristics
11	Transistor Common - Emitter Configuration Characteristics
12	Measurement of power in single phase circuit
13	Study of single phase domestic wiring system

RECOMMENDED READING BOOKS	
1	Rajendra Prasad; Fundamentals of Electrical Engineering; PHI Publication.
2	Boylestad and L. Nashelsky; Electronic Devices and Circuits; PHI
3	A. Mottershead; Electronic Devices and Circuits; PHI.
4	N.N.Bhargava; Basic Electronics and Linear Circuits; Tata McGraw-Hill.
5	Vijay Baru, Rajendra Kaduskar, Sunil Gaikwad; Basic Electronics Engineering; Dreamtech Textbooks.

SECOND YEAR: ELECTRICAL & ELECTRONICS ENGINEERING

SCHEME OF INSTRUCTION AND EXAMINATION REVISED COURSE 2019-2020

SEMESTER - III

Subject Code	Name of the Subject	Scheme of Instruction Hrs/Week				Scheme of Examination							Credit
		L	T	P	H	Th Duration (Hrs)	Marks						
							Th	S	TW	P	O	Total	
EE310	Mathematics-III	3	1	0	4	3	100	25	25	0	0	**150**	**4**
EE320	Electromagnetic Fields	3	0	0	3	3	100	25	0	0	0	**125**	**3**
EE330	Digital Electronics	4	0	0	4	3	100	25	0	0	0	**125**	**4**
EE340	Electrical Machines - I	4	0	0	4	3	100	25	0	0	0	**125**	**4**
EE350	Electrical Circuit Analysis	3	1	0	4	3	100	25	25	0	0	**150**	**4**
EE360	Digital Electronics Lab	0	0	2	2	-	0	0	25	50	0	**75**	**1**
EE370	Electrical Machines-I Lab	0	0	2	2	-	0	0	25	50	0	**75**	**1**
HM001	Technical Communication	2	0	0	2	-	0	0	75	0	0	**75**	**2**
AC390	Mathematics-I & II (Bridge Course)*	2	0	0	2	-	0	0	0	0	0	**0**	**0**
TOTAL		**21**	**2**	**4**	**27**	**--**	**500**	**125**	**175**	**100**	**0**	**900**	**23**

- Applicable to direct second year /lateral entry students

MATHEMATICS-III					
Course Code	**EE310**		**Credits**	**4**	
Scheme of Instruction	**L**	**T**	**P**	**TOTAL**	
Hours/ Week	**3**	**1**	**0**	**42 hrs/sem**	
Scheme of Examination	**IA**	**TW**	**TH**	**P**	**O**
TOTAL = 150 marks	**25**	**25**	**100**	**0**	**0**

Course Objectives:
The objective of the course is to make students understand fundamentals of Mathematics necessary to formulate, solve and analyze engineering problems

Course Outcomes:
The student will be able to:

CO1	Understand the mathematics of matrices, various transforms used in engineering and basic concepts of partial differential equations
CO2	Compute the rank, eigen values, eigen vectors of a given matrix, transforms of continuous and discrete functions, Fourier series of periodic functions and partial differential equations
CO3	Solve differential equations, integral equations, and difference equations using the various transforms and analyze the consistency of a linear system of equations
CO4	Model real life problems with matrices, formulate and solve one dimensional wave and heat flow partial differential equations. Propose a value to be substituted in a Fourier series to obtain the given real number series.

UNIT -1	
Matrices: Types of matrices, Determinant, inverse of matrix, Elementary transformations, Elementary matrices, Rank of matrix, Reduction to normal form, Canonical form, Rank using elementary transformation, Linear independence and dependence of vectors, System of the form AX = 0, and AX = B, and their solutions, Eigen values, Eigen vectors with properties, Cayley-Hamilton theorem with its applications, minimal polynomial, Diagonalization	**11 Hours**
UNIT -2	
Laplace Transforms: Definition. Existence conditions, properties, inverse Laplace transforms. Laplace transform of periodic functions, Convolution theorem, Laplace transform of Dirac-Delta function, Application of Laplace transforms in solving linear differential equations with initial conditions and system of linear simultaneous differential equations	**10 Hours**
UNIT -3	
Fourier Series : Periodic functions, Trigonometric series, Euler's formulae, Dirichlet's condition, Even and odd functions, Half range series, Parseval's identity. **Fourier Transforms**: Fourier transforms, Inverse Fourier transforms,Fourier Sine and cosine transforms, convolution and application.	**10 Hours**
UNIT -4	

Partial Differential Equations: Derivation of equations governing transverse vibration of an elastic string (one dimension). Solution of one-dimensional wave equation using separation of variable method. Derivationof heat flow equation in one dimension and solution using separation of variable method. **Z-Transform**: Definition, region of convergence, properties, Z-transform on impulse function, Convolution theorem, application to difference equations.	**11 Hours**

ESSENTIAL READINGS	
1	B. S. Grewal; Higher Engineering Mathematics; Khanna Publications, New Delhi.
2	Veerarajan; Engineering Mathematics; Tata McGraw Hill Publications.
3	Erwin Kreyzing; Advanced Engineering Mathematic; New International Limited.
ADVANCED READINGS	
1	P. Kandasamy; Engineering Mathematics; Chand & Co., New Delhi.
2	Srimanta Pal, Subodh C. Bhunia; Engineering Mathematics; Oxford University Press
3	D. S. Chandrasekhraiah; Engineering Mathematics- Part III ; Prism Books Pvt. Ltd.
4	Montgomery, D. C., Probability and Statistics for Engineers; Prentice Hall of India.

ELECTROMAGNETIC FIELDS					
Course Code	**EE320**		**Credits**	**3**	
Scheme of Instruction	**L**	**T**	**P**	**TOTAL**	
Hours/ Week	**3**	**0**	**0**	**42 hrs/sem**	
Scheme of Examination	**IA**	**TW**	**TH**	**P**	**O**
TOTAL = 125 marks	**25**	**0**	**100**	**0**	**0**

Course Objectives:

The objective of the course is to make students understand concept and applications of electric and magnetic field

Course Outcomes:

The student will be able to:

CO1	Explain the concept of Electric field, magnetic field and potential
CO2	Compute the electric and magnetic fields charge configurations and relate itto potential.
CO3	Determine behavior of dielectric kept in Electric field and Boundary conditions
CO4	Analyse Maxwell's Equations and apply them for solving electromagnetic problems.

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	**3**	**3**	**2**	**2**	**2**	**2**	**1**	**1**	**1**	**1**	**1**	**2**
CO2	**3**	**2**	**2**	**2**	**2**	**2**	**1**	**0**	**1**	**1**	**0**	**2**
CO3	**3**	**2**	**2**	**2**	**2**	**1**	**1**	**0**	**1**	**1**	**0**	**2**
CO4	**3**	**2**	**2**	**2**	**2**	**1**	**1**	**0**	**1**	**1**	**1**	**2**

UNIT -1	
Vector Calculus: Vector Algebra-addition, subtraction, components of vectors, dot and cross product, triple Products. Representation of vector in three orthogonal coordinate systems (rectangular, cylindrical and spherical). Vector inter-conversion in three co-ordinate systems. Vector operator del, gradient, divergence, curl and their significance. **Static Electric Field:** Coulomb's law, Electric field intensity, Electrical field due to point charges. Line, Surface and Volume charge distributions. Gauss law and its applications. Absolute Electric potential, potential difference, Calculation of potential differences for different configurations. Electric dipole, Electrostatic Energy and Energy density	**11 Hours**
UNIT -2	
Dielectric material properties, Boundary conditions of perfect dielectric materials. Permittivity of dielectric materials, Polarization of dielectric. Capacitance, Capacitance of a two-wire line. Poisson's equation, Laplace's equation, solution of Laplace's and Poisson's equations and their applications.	**10 Hours**

UNIT -3	
Static Magnetic Fields: Biot-Savart Law Magnetic flux and magnetic flux density. Magnetic field density due to long current elements and coils. Magnetic field due to solenoid. Current and current density, Ohms Law in Point form, Continuity of current, Magnetic potentials. Ampere Law. Magnetic Forces, Materials and Inductance. Force on a moving charge, Force on a differential current element kept in magnetic field, Force between differential current elements, Nature of magnetic materials, Magnetization and permeability, Magnetic boundary conditions, Magnetic circuits, inductances and mutual inductances.	**10 Hours**
UNIT -4	
Time Varying Fields and Maxwell's Equations: Faraday's law for Electromagnetic induction, Displacement current, Point form of Maxwell's equation, Integral form of Maxwell's equations, Motional Electromotive forces Electromagnetic Waves, TEM Wave Equation, waves in free space and in a homogenous material. Skin effect. Poynting theorem.	**11 Hours**

ESSENTIAL READINGS	
1	W. Hayt, "Engineering Electromagnetics", McGraw Hill Education, 2012.
2	M. N. O. Sadiku, "Elements of Electromagnetics", Oxford University Publication, 2014.
3	A. Pramanik, "Electromagnetism - Theory and applications", PHI Learning Pvt. Ltd, New Delhi,2009.
ADVANCED READINGS	
1	G.W. Carter, "The electromagnetic field in its engineering aspects", Longmans, 1954.
2	W.J. Duffin, "Electricity and Magnetism", McGraw Hill Publication, 1980.
3	W.J. Duffin, "Advanced Electricity and Magnetism", McGraw Hill, 1968.
4	E.G. Cullwick, "The Fundamentals of Electromagnetism", Cambridge University Press, 1966

DIGITAL ELECTRONICS					
Course Code	**EE330**		**Credits**	**4**	
Scheme of Instruction	**L**	**T**	**P**	**TOTAL**	
Hours/ Week	**4**	**0**	**0**	**56 hrs/sem**	
Scheme of Examination	**IA**	**TW**	**TH**	**P**	**O**
TOTAL = 125 marks	**25**	**0**	**100**	**0**	**0**

Course Objectives:

The objective of the course is understanding the behaviour of digital logic circuits, Analog to Digital converters, Digital to Analog converters, semiconductor memories and programmable logic devices. Knowledge on optimized design of various digital circuits will also be impartedto the students.

Course Outcomes:

The student will be able to:

CO1	Understand the behaviour of logic gates, combinational and sequential logic circuits, Analog to Digital converters, Digital to Analog converters, semiconductor memories and programmable logic devices
CO2	Apply the knowledge to implement logic circuits and interpret the output of digital logic circuits
CO3	Compare between different implementations and arrive at the most optimum implementation and experiment with the working.
CO4	Design, Assemble and Test various combinational and sequential logic circuits

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	2	1	2	0	1	0	1	1	1	1
CO2	2	3	2	1	2	1	1	0	1	1	1	1
CO3	2	3	2	2	2	3	1	1	2	3	2	2
CO4	2	2	3	3	3	1	1	2	3	1	2	2

UNIT -1	
Fundamentals of Digital Systems and logic families Digital signals, digital circuits, AND, OR, NOT, NAND, NOR and Exclusive-OR operations, Boolean algebra, examples of IC gates, number systems-binary, signed binary, octal hexadecimal number, binary arithmetic, one's and two's complements arithmetic, codes, error detecting and correcting codes, characteristics of digital ICs, digital logic families, TTL, Schottky TTL and CMOS logic, interfacing CMOS and TTL, Tri-state logic.	**14 Hours**
UNIT -2	
Combinational Digital Circuits Standard representation for logic functions, K-map representation, and simplification of logic functions using K-map, minimization of logical functions. Don't care conditions, Multiplexer, De-Multiplexer/Decoders,	**14 Hours**

Adders, Subtractors, BCD arithmetic, carry look ahead adder, serial adder, ALU, elementary ALU design, popular MSI chips, digital comparator, parity checker/generator, code converters, priority encoders, decoders/drivers for display devices, Q-M method of function realization.	
UNIT -3	
Sequential circuits and systems A 1-bit memory, the circuit properties of bistable latch, the clocked SR flip flop, J- K-T and D types flip flops, applications of flip flops, shift registers, applications of shift registers, serial to parallel converter, parallel to serial converter, ring counter, sequence generator, ripple (Asynchronous) counters, synchronous counters, counters design using flip flops, special counter ICs, asynchronous sequential counters, applications of counters.	**14 Hours**
UNIT -4	
D/A Converters Weighted resistor D/A converter, R-2R Ladder D/A converter, specifications for D/A converters, examples of D/A converter ICs, **A/D Converters** Sample and hold circuit, quantization and encoding, A/D converter types, specifications of A/D converters, example of A/D Converter ICs **Semiconductor memories and Programmable logic devices** Memory organization and operation, expanding memory size, classificationand characteristics of memories, sequential memory, read only memory (ROM), read and write memory(RAM), content addressable memory (CAM), charge coupled device memory (CCD), commonly used memory chips, ROM as a PLD, Programmable logic array, Programmable array logic, complex Programmable logic devices (CPLDS), Field Programmable Gate Array (FPGA).	**14 Hours**

ESSENTIAL READINGS	
1.	Donald P. Leach/ Albert Paul Malvino, "Digital principles and Applications ", Tata McGraw
2.	M. M. Mano, "Digital logic and Computer design", Pearson Education India, 2016.
3.	Robert L Morris / John R. Miller, "Designing with TTL integrated Circuits ", McGraw Hill international
4.	Sung mo Kang, "CMOS digital Integrated circuits Analysis and Design", Tata McGraw
ADVANCED READINGS	
1.	R. P. Jain, " Modern Digital Electronics ", McGraw Hill Education, 2009.
2.	A. Kumar, "Fundamentals of Digital Circuits", Prentice Hall India, 2016.

ELECTRICAL MACHINES-I					
Course Code	**EE340**		**Credits**	**4**	
Scheme of Instruction	**L**	**T**	**P**	**TOTAL**	
Hours/ Week	**4**	**0**	**0**	**56 hrs/sem**	
Scheme of Examination	**IA**	**TW**	**TH**	**P**	**O**
TOTAL = 125 marks	**25**	**0**	**100**	**0**	**0**

Course Objectives:

The objective of this course is to understand the basic principle, construction, characteristics and operating modes of dc machines, performance analysis and applications of dc machines. Students will also learn basic principle, construction, performance analysis and applications of single phase and three phase transformers

Course Outcomes:

The student will be able to:

CO1	Recall electromagnetic laws, magnetic circuits, electromechanical energy conversion principle, draw the characteristics of dc motors, dc generators, draw and write three equivalent circuit of single phase and three phase transformers
CO2	Explain the construction and working of dc machines, single phase and three phase transformers
CO3	Determine the performance of dc machines and transformers by conducting suitable tests
CO4	Analyze, evaluate performance parameters of dc machines, transformers. Calculate force/torque produced in an electromechanical system and obtain load shared by transformers operating in parallel

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	2	1	1	0	1	1	1	0	1	1
CO2	2	2	2	2	3	3	1	1	1	3	3	1
CO3	2	3	3	3	3	1	3	0	2	0	0	3
CO4	2	3	2	2	2	1	0	3	3	3	2	0

UNIT -1	
Electromechanical Energy Conversion: Review of magnetic circuits - MMF, flux, reluctance, inductance, concept of leakage flux. Review of Amperes circuital law and Lenz's law. Flow of Energy in Electromechanical Devices, Energy in magnetic systems- concepts of field energy, co-energy and mechanical force, Torque equation, singly and multiply excited systems, Energy stored in Magnetic field, Dynamic equation of Electromechanical systems. Elementary machines, generated emf in Machines, Distribution factor, Pitch factor. MMF produced by distributed Windings, MMF of a coil, MMF waveform of commutator machines, and torque in round rotor machines	**14 Hours**

UNIT -2	
DC Machines Basic construction of a DC machine, magnetic structure - stator yoke, stator poles, pole-faces or shoes, air gap and armature core, excitation with armature winding open, air gap flux density distribution, flux per pole, induced EMF in an armature coil. Armature winding and commutation – Elementary armature coil and commutator, lap and wave windings, construction of commutator, linear commutation. Derivation of back EMF equation, derivation of torque equation, armature reaction, air gap flux density distribution with armature reaction. Armature circuit equation for motoring and generation, Types of field excitations – separately excited, shunt and series. Open circuit characteristic of separately excited DC generator, Voltage build-up in a shunt generator, critical field resistance and critical speed. V-I characteristics and torque-speed characteristics of separately excited, shunt and series motors. Speed control through armature voltage. Losses, load testing and back-to-back testing of DC machines.	**14 Hours**
UNIT -3	
Single Phase Transformers Principle, construction and operation of single-phase transformers, equivalent circuit, phasor diagram, voltage regulation, losses and efficiency Testing - open circuit and short circuit tests, polarity test, back-to-back test, separation of hysteresis and eddy current losses, per unit representation. Autotransformers - construction, principle, applications and comparison with two winding transformers	**14 Hours**
UNIT -4	
Three Phase Transformers Three-phase transformer - construction, types of connection and their comparative features, magnetizing current, effect of nonlinear B-H curve of magnetic core material, harmonics in magnetization current, Phase conversion - Scott connection, three-phase to six-phase conversion, Tap-changing transformers - No-load and on-load tap-changing of transformers, Three-winding transformers. Cooling of transformers, Transformer Accessories.	**14 Hours**

ESSENTIAL READINGS	
1.	P. S. Bimbhra, “Electrical Machinery”, Khanna Publishers, 2011
2.	I. J. Nagrath and D. P. Kothari, “Electric Machines”, McGraw Hill Education, 2010
ADVANCED READINGS	
1.	M. G. Say, “Performance and design of AC machines”, CBS Publishers, 2002.
2.	A. E. Fitzgerald and C. Kingsley, "Electric Machinery”, McGraw Hill Education, 2013.

ELECTRICAL CIRCUIT ANALYSIS					
Course Code	**EE350**		**Credits**	**4**	
Scheme of Instruction	**L**	**T**	**P**	**TOTAL**	
Hours/ Week	**3**	**1**	**0**	**42 hrs/sem**	
Scheme of Examination	**IA**	**TW**	**TH**	**P**	**O**
TOTAL = 150 marks	**25**	**25**	**100**	**0**	**0**

Course Objectives:

The objective of this course is to understand the basic principle, construction, characteristics and operating modes of dc machines, performance analysis and applications of dc machines. Students will also learn basic principle, construction, performance analysis and applications of single phase and three phase transformers

Course Outcomes:

The student will be able to:

CO1	Understand various network theorems and various types of electrical circuits and analysis tools.
CO2	Analyse various electrical circuits and their steady state and transient state response for DC and AC excitations
CO3	Demonstrate use of various mathematical tools in evaluating electrical circuits
CO4	Apply network theorems for the analysis of electrical circuits

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	2	1	2	0	1	0	1	1	1	1
CO2	2	3	2	1	2	1	1	0	1	1	1	1
CO3	2	3	2	2	2	3	1	1	2	3	2	2
CO4	2	2	3	3	3	1	1	2	3	1	2	2

UNIT -1	
Network Theorems: Superposition theorem, Thevenin theorem, Norton theorem, Maximum power transfer theorem, Reciprocity theorem, Compensation theorem. Analysis with dependent current and voltage sources. Node and Mesh Analysis. Concept of duality and dual networks.	**11 Hours**
UNIT -2	
Solution of First and Second order networks: Solution of first and second order differential equations for Series and parallel R-L, R-C, R-L-C circuits, initial and final conditions in network elements, forced and free response, time constants, steady state and transient stateresponse	**10 Hours**
UNIT -3	
Sinusoidal steady state analysis: Representation of sine function as rotating phasor, phasor diagrams, impedances and admittances, AC	**10 Hours**

circuit analysis, effective or RMS values, average power and complex power. Three-phase circuits. Mutual coupled circuits, Dot Conventionin coupled circuits, Ideal Transformer. Review of Laplace Transform, Analysis of electrical circuits using Laplace Transform for standard inputs, convolution integral, inverse Laplace transform, transformednetwork with initial conditions	
UNIT -4	
Electrical Circuit Analysis Using Laplace Transforms: Transfer function representation. Poles and Zeros. Frequency response (magnitude and phase plots), series and parallel resonances, Two Port Network and Network Functions: Two Port Networks, terminal pairs, relationship oftwo port variables, impedance parameters, admittance parameters, transmission parameters and hybrid parameters, interconnections of two port networks.	**11 Hours**

ESSENTIAL READINGS	
1.	M. E. Van Valkenburg, "Network Analysis", Prentice Hall, 2006.
2.	D. Roy Choudhury, "Networks and Systems", New Age International Publications, 1998.
ADVANCED READINGS	
1.	W. H. Hayt and J. E. Kemmerly, "Engineering Circuit Analysis", McGraw Hill Education, 2013.
2.	C. K. Alexander and M. N. O. Sadiku, "Electric Circuits", McGraw Hill Education, 2004.
3.	K. V. V. Murthy and M. S. Kamath, "Basic Circuit Analysis", Jaico Publishers, 1999.

DIGITAL ELECTRONICS LABORATORY					
Course Code	**EE 360**		**Credits**	**1**	
Scheme of Instruction	**L**	**T**	**P**	**TOTAL**	
Hours/ Week	**0**	**0**	**2**	**28 hrs/sem**	
Scheme of Examination	**IA**	**TW**	**TH**	**P**	**O**
TOTAL = 75 marks	**0**	**25**	**0**	**50**	**0**

Course Objectives:

The objective of the course is to provide practical experience in assembling and testing various digital electronic circuits.

Course Outcomes:

The student will be able to:

CO1	Understand the behaviour of logic gates, combinational and sequential logic circuits
CO2	Apply the knowledge to implement logic circuits and interpret and verify the output of digital logic circuits.
CO3	Compare between different implementations practically and experiment with the working
CO4	Design, assemble and test various combinational and sequential logic circuits

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	2	1	2	0	1	0	1	1	1	1
CO2	2	3	2	1	2	1	1	0	1	1	1	1
CO3	2	3	2	2	2	3	1	1	2	3	2	2
CO4	3	3	3	2	3	1	1	3	3	2	2	3

SN	**Experimental List**
1	Verification of De-Morgan's Theorems.
2	Logic Gates.
3	Design and Verification of Adder Circuits.
4	Design and Verification of Subtractor Circuits.
5	Design and Verification of 2's Complement Converter.
6	Design and Verification of Parity Generator and Checkers.
7	Design and Verification of Code Converters.
8	Verification of Encoders.
9	Verification of Seven Segment Decoder.
10	Design and Verification of 4digit Multiplexed seven segment display
11	Study of Multiplexers &Demultiplexers.
12	Design using Multiplexer
13	Design using Decoder
14	Verification of Flip-Flops.
15	Verification of Binary Ripple Counter.
16	Verification of Shift Registers.

RECOMMENDED READING BOOKS	
1	Donald P. Leach/ Albert Paul Malvino, "Digital principles and Applications ", Tata McGraw
2	M. M. Mano, "Digital logic and Computer design", Pearson Education India, 2016.
3	Robert L Morris / John R. Miller, "Designing with TTL integrated Circuits ", McGraw Hill international
4	Sung mo Kang, "CMOS digital Integrated circuits Analysis and Design", Tata McGraw
5	R. P. Jain, " Modern Digital Electronics ", McGraw Hill Education, 2009.

ELECTRICAL MACHINES-I LABORATORY					
Course Code	**EE 370**		**Credits**	**1**	
Scheme of Instruction Hours/ Week	**L**	**T**	**P**	**TOTAL**	
	0	**0**	**2**	**28 hrs/sem**	
Scheme of Examination TOTAL = 75 marks	**IA**	**TW**	**TH**	**P**	**O**
	0	**25**	**0**	**50**	**0**

Course Objectives:

The objective of the course is to allow students to perform various tests on electrical machines to analyse their performance.

Course Outcomes:

The student will be able to:

CO1	Understand the practical operation of DC generator. Motor and transformer
CO2	Assemble, Test and verify the performance of DC machines and transformers
CO3	Analyse the experimental results
CO4	Design the testing circuit to evaluate the performance of these machines

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	2	1	1	0	1	1	1	0	1	1
CO2	2	2	2	2	3	3	1	1	1	3	3	1
CO3	2	3	3	3	3	1	3	0	2	0	0	3
CO4	2	3	2	2	2	1	0	3	3	3	2	0

SN	**Experimental List**
1	OCC of separately excited DC generator.
2	Performance characteristics of DC machine
3	Speed Control of DC motors
4	Hopkinson's test
5	Load test on DC series motor
6	Speed-Torque characteristics of DC Shunt Motor
7	OC and SC test on single phase transformer
8	Load test on single phase transformer
9	Sumpner's Test
10	Parallel operation of Single phase transformers
11	Study of vector group and vector group test of three phase transformers
12	Load Test on Three Phase Transformers
13	Simulation on DC Machines
14	Simulation on Transformer

ESSENTIAL READINGS	
1	P. S. Bimbhra, “Electrical Machinery”, Khanna Publishers, 2011
2	I. J. Nagrath and D. P. Kothari, “Electric Machines”, McGraw Hill Education, 2010
3	M. G. Say, “Performance and design of AC machines”, CBS Publishers, 2002.
4	A. E. Fitzgerald and C. Kingsley, "Electric Machinery”, McGraw Hill Education, 2013.

TECHNICAL COMMUNICATION					
Course Code	**HM001**		**Credits**	**2**	
Scheme of Instruction	**L**	**T**	**P**	**TOTAL**	
Hours/ Week	**2**	**0**	**0**	**28 hrs/sem**	
Scheme of Examination	**IA**	**TW**	**TH**	**P**	**O**
TOTAL = 75 marks	**0**	**75**	**0**	**0**	**0**

Course Objectives: To make students aware and conversant with oral, written communication and work on their personality and career development.

Course Outcomes:

The student will be able to:

CO1	Demonstrate precise language skills with suitable vocabulary and apt style.
CO2	Develop life skills/interpersonal skills to progress professionally.
CO3	Apply traits of suitable candidature for a job/higher education.
CO4	Deliver formal presentations and effectively implementing the verbal and non-verbal skills.

UNIT -1	
Communication **Oral Communication:** Listening, Speaking, Reading, Writing (LSRW), Conversational Dialogues, Role Play, Barriers to Oral Communication, Effective Oral Communication,Principles of Communication, Dos and Don'ts of Group Discussion **Global Communication:** Social media, People Analytics, Models of Culture, Cross-Cultural Communication, Compare Cultures of the World, Impact of Cultural Differences on Managerial Communication, Effective Communicator in a Cross-Cultural setting	**7 Hours**
UNIT -2	
Personality Development Social Etiquette, Email Etiquette, Table Etiquette, Telephone Etiquette, SWOC Analysis, Life Coaching, Emotional Intelligence, Leadership, Time Management, Motivation, Goal Setting, Team Work and Collaboration, Critical Thinking and Problem Solving, Professional Attitude, Persuasion, Anxiety and Stress Management, Social Responsibility	**7 Hours**
UNIT -3	
Career Development: Resume Building, Interviewing Skills, Job Search, Personal Networking andBranding, Personal Finance, Build Professional Portfolio	**7 Hours**

UNIT -4	
Public Speaking Methods to overcome anxiety, Build Confidence, Use of Media Aids, Craft an Impactful Speech, Design Impactful Presentations, Effective Presentation Delivery	**7 Hours**

ESSENTIAL READINGS	
1	Meenakshi Raman and Sangeeta Sharma; Technical Communication: Principles and Practice, 3rd ed; Oxford University Press
2	Meenakshi Raman, Prakash Singh; Business Communication; 2nd ed.; Oxford University Press
3	Dr. K. Alex; Soft Skills: Know Yourself and Know the World; 3rd ed; S. Chand Publishing
ADVANCED READINGS	
1	Nicky Stanton; Mastering Communication; 5th ed.; Palgrave Master Series; Red Globe Press
2	Ghosh, B. N.; Managing Soft Skills for Personality Development; Tata McGraw Hill; 2012
3	Wallace and Masters; Personal Development for Life and Work;10thedition; Thomson Learning
4	Lehman, Dufrene, Sinha; BCOM : A South-Asian Perspective with Course Mate; 2ndedition; Cengage Learning
5	Ashraf Rizvi; Effective Technical Communication; Tata McGraw-Hill; 2005
6	Molefi Kete Asante, William B. Gudykunst, Bella Mody; Handbook of Internationaland Intercultural Communication; 2nd ed.; Sage Publications

MATHEMATICS-I& II (BRIDGE COURSE)					
Course Code	**AC390**		**Credits**	**0**	
Scheme of Instruction	**L**	**T**	**P**	**TOTAL**	
Hours/ Week	**2**	**0**	**0**	**28 hrs/sem**	
Scheme of Examination	**IA**	**TW**	**TH**	**P**	**O**
TOTAL = 0 marks	**0**	**0**	**0**	**0**	**0**

Course Outline:

This is an audit course.

This course is compulsory to direct second year/lateral entry students. It is introduced to reduce the knowledge gap in the students.

The syllabus is selected topics from FE110 Mathematics I and FE120 Mathematics II.

The Text books and References are same as shown in FE110 Mathematics I and FE120 Mathematics II.

SECOND YEAR: ELECTRICAL & ELECTRONICS ENGINEERING

SCHEME OF INSTRUCTION AND EXAMINATION REVISED COURSE 2019-2020

SEMESTER – IV

Subject Code	Name of the Subject	Scheme of Instruction Hrs/Week				Scheme of Examination							Credit
		L	T	P	H	Th Duration (Hrs)	Marks						
							Th	S	TW	P	O	Total	
EE410	Numerical Methods	3	1	0	**4**	3	100	25	25	0	0	**150**	**4**
EE420	Electrical Machines - II	4	0	0	**4**	3	100	25	0	0	0	**125**	**4**
EE430	Analog Electronics	4	0	0	**4**	3	100	25	0	0	0	**125**	**4**
EE440	Fundamentals of Signal Processing	3	1	0	**4**	3	100	25	25	0	0	**150**	**4**
EE450	Renewable Energy	3	0	0	**3**	3	100	25	0	0	0	**125**	**3**
EE460	Electrical Machines - II Lab	0	0	2	**2**	-	0	0	25	50	0	**75**	**1**
EE470	Analog Electronics Lab	0	0	2	**2**	-	0	0	25	50	0	**75**	**1**
HM003	Economics for Engineers	3	0	0	**3**	-	100	25	0	0	0	**125**	**3**
TOTAL		**20**	**2**	**4**	**26**	**--**	**600**	**150**	**100**	**100**	**0**	**950**	**24**

NUMERICAL METHODS					
Course Code	**EE410**		**Credits**	**4**	
Scheme of Instruction	**L**	**T**	**P**	**TOTAL**	
Hours/ Week	**3**	**1**	**0**	**42 hrs/sem**	
Scheme of Examination	**IA**	**TW**	**TH**	**P**	**O**
TOTAL = 150 marks	**25**	**25**	**100**	**0**	**0**

Course Objectives:

The objective of the course is to impart adequate knowledge of numerical methods in order to be able to implement them whenever required in their engineering course. Also to adequate knowledge of probability theory so as to enable them to comprehend its application in their engineering studies.

Course Outcomes:

The student will be able to:

CO1	Understand the mathematics of polynomial interpolation, numerical solutions of algebraic equations and linear systems of equations, numerical solutions of differential equations, numerical integration and basic concept of probability
CO2	Compute the interpolating polynomial; for a given data set., compute numerically an integral and calculate probabilities.
CO3	Solve an algebraic equation and system of equations and analyze the solution, numerical solve differential equations to the desired accuracy
CO4	Modern real-life problems and estimate using interpolation, numerical integration

UNIT -1	
Finite Difference and Interpolation: Operators: Forward Difference operator-, backward difference operator-, Taylor's operator-D, shift operator-E, averaging operator –μ, Central Difference operator-δ Differences: Forward and backward difference, Central differences, Divided differences, Difference tables, Interpolating polynomials, factorial polynomials, Newton Forward & Backward difference interpolation formula. Newton's Divided difference interpolation formulae: Lagrange's interpolation formula: Derivation, Central Difference interpolation formula: Stirling's and Bessel's interpolation Formula.	**11 Hours**
UNIT -2	
Solutions of Equations: Solutions of non-linear equations of single variables using Bisection method, Regula- Falsi method, Secant method and Newton- Raphson method. Order of convergence of these methods, comparison of these methods. **Solution of Linear Algebraic Equations:** Direct methods: Gauss Elimination method, Partial & Complete pivoting, Gauss- Jordan method. Iterative methods: Jacobi's method, Gauss-Siedel method. Condition for convergence of above methods, Ill conditioned & well-conditioned systems.	**10 Hours**

UNIT -3	
Numerical Integration: Newton-Cotes formula, Trapezoidal rule, Simpson's 1/3 rule, Simpson's 3/8 rule, Weddle's rule, Romberg's integration Richardson extrapolation), Truncation errors for these rules. **Numerical Solution of Differential Equations**: Picard's method & Taylor series method, Euler's method & Modified Euler's method, Second order Runge- Kutta method, Fourth order Runge- Kutta method, Milne's Predictor-Corrector method.	**10 Hours**
UNIT -4	
Probability: Definition, properties, Axioms of probability, conditional probability, theorem on total probability, Baye's theorem; Random variables-discrete & continuous; Expectation, Variance, Standard deviation, Moment Generating Function & properties, Standard distributions: discrete-Binomial, Geometric & Poisson; continuous- Uniform, Normal, exponential, Gamma, Chi-square.	**11 Hours**

ESSENTIAL READINGS	
1	B. S. Grewal ;Numerical Methods; Khanna Publications.
2	Douglas C. Montgomery, George C. Runger; Applies Statistics & Probability for Engineers; Wiley
ADVANCED READINGS	
1	P. Kandasamy ; Numerical Methods ; S. Chand & Co., New Delhi.
2	E. Balagurusamy ; Numerical Methods ; Tata McGraw, PHI.
3	Srimanta Pal, Subodh C. Bhunia; Engineering Mathematics; Oxford University Press

ELECTRICAL MACHINES-II					
Course Code	**EE420**		**Credits**	**4**	
Scheme of Instruction	**L**	**T**	**P**	**TOTAL**	
Hours/ Week	**4**	**0**	**0**	**56 hrs/sem**	
Scheme of Examination	**IA**	**TW**	**TH**	**P**	**O**
TOTAL = 125 marks	**25**	**0**	**100**	**0**	**0**

Course Objectives:

The objective of this course is to understand the basic principle, construction, characteristics and operating modes of induction machines, construction, operation and performance of synchronous machines performance analysis and applications of dc machines.

Course Outcomes:

The student will be able to:

CO1	Recall magnetic field concepts, Understanding the working of three phase and single-phase induction motors, synchronous generator and motors and do draw the phasor diagram of these machines
CO2	Explain and predetermine the performance of induction motors using equivalent circuit and circle diagrams and voltage regulation of alternator. Explain working principle of PMSM, BLDC, SRM and PMDC motor
CO3	Determine the different starting methods, braking methods and speed control techniques of induction motors. Determine performance characteristics of Special motors.
CO4	Analyze operation of synchronous machine on infinite bus and interpret and analyze the dynamic behavior of machines.

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	2	1	1	0	1	1	1	0	1	1
CO2	2	2	2	2	3	3	1	1	1	3	3	1
CO3	2	3	3	3	3	1	3	0	2	0	0	3
CO4	2	3	2	2	2	1	0	3	3	3	2	0

UNIT -1	
Fundamentals of AC machines Physical arrangement of windings in stator and cylindrical rotor; slots for windings; single turn coil - active portion and overhang; full-pitch coils, concentrated winding, distributed winding, Air-gap MMF distribution with fixed current through winding, Constant magnetic field, pulsating magnetic field - alternating current in windings with spatial displacement, Magnetic field produced by a single winding - fixed current and alternating current. Pulsating fields produced by spatially displaced windings, Windings spatially shifted by 90 degrees, Addition of pulsating magnetic fields, Three windings spatially shifted by 120 degrees (carrying three-phase balanced currents), revolving magnetic field	**14 Hours**

UNIT -2	
Induction Machines Construction, Types (squirrel cage and slip-ring), Torque slip characteristics, Starting and maximum torque. Equivalent circuit, Phasor Diagram, Losses and Efficiency. Effect of parameter variation on torque speed characteristics (variation of rotor and stator resistances, stator voltage, frequency). Methods of starting, braking and speed control for induction motors. Generator operation, Self-excitation, Doubly-Fed Induction Machines.	**14 Hours**
UNIT -3	
Single Phase Machines Constructional features double revolving field theory, equivalent circuit, and determination of parameters. Split-phase starting methods and applications. Constructional features, EMF, Torque equation and Torque speed characteristics of PMDC motor, BLDC motor, Switched reluctance motor and Permanent magnet synchronous motor	**14 Hours**
UNIT -4	
Synchronous Machines Constructional features, cylindrical rotor and salient pole synchronous machine - generated EMF, equivalent circuit and phasor diagram, armature reaction, synchronous impedance, voltage regulation. Operating characteristics of synchronous machines, Excitation characteristics of synchronous machines (Alternator and Synchronous motor), Concept of two reaction theory, analysis of phasor diagram, Reactive power capability, power angle characteristics. Parallel operation of alternators, synchronization and load division.	**14 Hours**

ESSENTIAL READINGS	
1.	P. S. Bimbhra, “Electrical Machinery”, Khanna Publishers, 2011.
2.	I. J. Nagrath and D. P. Kothari, “Electric Machines”, McGraw Hill Education, 2010.
ADVANCED READINGS	
1.	M. G. Say, “Performance and design of AC machines”, CBS Publishers, 2002.
2.	A. E. Fitzgerald and C. Kingsley, "Electric Machinery”, McGraw Hill Education, 2013.

ANALOG ELECTRONICS					
Course Code	**EE430**		**Credits**	**4**	
Scheme of Instruction	**L**	**T**	**P**	**TOTAL**	
Hours/ Week	**4**	**0**	**0**	**56 hrs/sem**	
Scheme of Examination	**IA**	**TW**	**TH**	**P**	**O**
TOTAL = 125 marks	**25**	**0**	**100**	**0**	**0**

Course Objectives: To familiarize the students with a thorough understanding of various electronic devices and its application circuits.

Course Outcomes:
The student will be able to:

CO1	Acquire the basic knowledge of working and characteristics of Diode, transistor, MOSFET and building blocks of an Operational Amplifier.
CO2	Develop the ability to analyze the behavior of BJT, MOSFET as an amplifier circuit using small signal equivalent circuit, Determine gain, frequency response of Op amp.
CO3	Design, construct and test the circuit as an amplifier, rectifier, oscillator, multivibrator and interpret their results.
CO4	Realize the applications of semiconductor devices to build nonl inear applications such as log/antilog opamp, Special application as ADC/DAC and Phase locked loop.

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	2	1	1	0	0	0	0	0	1	1	0	2
CO2	3	3	2	1	2	0	0	0	2	2	0	2
CO3	3	3	3	3	3	2	1	2	3	3	2	3
CO4	2	2	2	1	2	1	0	2	2	2	2	2

UNIT -1	
Diode circuits: P-N junction diode, I-V characteristics of a diode; review of half-wave and full-wave rectifiers, Zener diodes, clamping and clipping circuits. **BJT circuits:** Structure and I-V characteristics of a BJT; BJT as a switch. BJT as an amplifier: small-signal model, biasing circuits, current mirror; common-emitter, common-base and common collector amplifiers; Small signal equivalent circuits, high-frequency equivalent circuits.	**14 Hours**
UNIT -2	
MOSFET structure and I-V characteristics: MOSFET as a switch. MOSFET as an amplifier: small-signal model and biasing circuits, common-source, common-gate and common-drain amplifiers; small signal equivalent circuits - gain, input and output impedances, transconductance, high frequency equivalent circuit. Transistor AC Equivalent Circuits: H-parameter model, r-e model, ac equivalent circuit of small signal BJT and FET amplifiers. Design of a single stage voltage amplifier using BJT and FET. Different types of coupling (RC, transformer and direct) and their frequency response. Lag-Lead networks	**14 Hours**

UNIT -3	
Differential, multi-stage and operational amplifiers: Differential amplifier; power amplifier; direct coupled multi-stage amplifier; internal structure of an operational amplifier, ideal op-amp, non-idealities in an op-amp (Output offset voltage, input bias current, input offset current, slew rate, gain bandwidth product) **Linear Applications**:- Amplifier circuit, Summing and Subtracting amplifier, Differentiator, Integrator, Instrumentation amplifier, V-I and I-V converters, voltage follower and inverter.	**14 Hours**
UNIT -4	
Filter and Oscillator circuits : active filter, P, PI and PID controllers and lead/lag compensator using an op-amp, voltage regulator, oscillators (Wein bridge and phase shift). Analog to Digital Conversion. **Nonlinear applications of op-amp** : Hysteretic Comparator, Zero Crossing Detector, Square-wave and triangular-wave generators. Precision rectifier, peak detector. **Multivibrators:** Astable and Monostable Multivibrators using 555 Timer and its applications. Phased Locked Loop: Operating principle, applications of LM565.	**14 Hours**

ESSENTIAL READINGS	
1.	Donald A Neaman; Semiconductor Physics and Devices; Third Edition, Tata Mc Graw Hill Inc.; 2007.
2.	Khetan and Goyal; A Monograph of Electronic Design Principles; Khanna Publicatio
3.	Robert Boylestad and Louis Nashelsky; Electron Devices and Circuit Theory; Pearson Prentice Hall; 10th edition; July 2008.
ADVANCED READINGS	
1.	S. Salivahanan; Electronic devices & circuits; Vikas Publication
2.	Ramakant Gayakwad ; Operational amplifier and Linear Integrated Circuits; Pearson
3.	K R Botkar; Integrated Circuits; Khanna Publishers

FUNDAMENTALS OF SIGNAL PROCESSING					
Course Code	**EE440**		**Credits**	**4**	
Scheme of Instruction	**L**	**T**	**P**	**TOTAL**	
Hours/ Week	**3**	**1**	**0**	**42 hrs/sem**	
Scheme of Examination	**IA**	**TW**	**TH**	**P**	**O**
TOTAL = 150 marks	**25**	**25**	**100**	**0**	**0**

Course Objectives:

The objective of the course is to provide knowledge of time-domain representation, analysisof signals and systems and fundamentals of sampling. It will also enable them to perform frequency-domain representation and analysis using Fourier tools, Laplace transform and Z transforms.

Course Outcomes:

The student will be able to:

CO1	Understand the fundamental concepts of signals and system, Behaviour of continuous and discrete LTI systems, sampling, reconstruction, and representation of system in state space, Fourier tools, Laplace transforms and Z-transforms.
CO2	Apply the mathematical relations to determine signal and system properties, impulse response and state response, state space properties, Fourier,Laplace and Z-transform properties.
CO3	Analyze the systems in time domain and frequency domain.
CO4	Compute the convolution, correlation, solution to differential equation using Fourier, Laplace, Z transforms.

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO 8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	1	0	1	0	1	0	1	2	0	1
CO2	3	2	2	1	1	0	1	0	2	2	0	1
CO3	3	3	2	2	3	1	2	2	2	2	1	1
CO4	3	3	2	3	3	1	2	2	2	2	2	1

UNIT-1	
Introduction to Signals and Systems Signals and systems as seen in everyday life, and in various branchesof engineering and science. Signal properties: periodicity, absolute integrability, determinism and stochastic character. Some special signals of importance: the unit step, the unit impulse, the sinusoid, the complex exponential, some special time-limited signals; continuous and discrete time signals, continuous and discrete amplitude signals. System properties: linearity: additivity and homogeneity, shift-invariance, causality, stability, realizability. Examples. **Behavior of continuous and discrete-time LTI systems:** Impulse response and step response, convolution, input-output behavior with aperiodic convergent inputs, cascade interconnections. Characterization of causality and stability of LTI systems. System representation through differential equations and difference equations.	**11 Hours**

UNIT-2	
State Space Representation and Fourier Series State-space Representation of systems. State-Space Analysis, Multi- input, multi-output representation. State Transition Matrix and its Role. Periodic inputs to an LTI system, the notion of a frequency response and its relation to the impulse response. Fourier series representation of periodic signals, Waveform Symmetries, Calculation of Fourier Coefficients. Fourier Transform, convolution/multiplication and their effect in the frequency domain, magnitude and phase response, Fourier domain duality.	**10 Hours**
UNIT-3	
Fourier, Laplace and z- Transforms The Discrete-Time Fourier Transform (DTFT) and the Discrete Fourier Transform (DFT). Parseval's Theorem. Review of the Laplace Transform for continuous time signals and systems, system functions, poles and zeros of system functions and signals, Laplace domain analysis, solution to differential equations and system behavior. The z-Transform for discrete time signals and systems, system functions, poles and zeros of systems and sequences, z-domain analysis.	**10 Hours**
UNIT-4	
Sampling and Reconstruction The Sampling Theorem and its implications. Spectra of sampled signals. Reconstruction: ideal interpolator, zero-order hold, first- order hold. Aliasing and its effects. Relation between continuous and discrete time systems. Introduction to the applications of signal and system theory: modulation for communication, filtering, feedback control systems.	**11 Hours**

ESSENTIAL READINGS	
1	A. V. Oppenheim, A. S. Willsky and S. H. Nawab, "Signals and systems", Prentice Hall India, 1997.
2	A. V. Oppenheim and R. W. Schafer, "Discrete-Time Signal Processing", Prentice Hall, 2009.
3	S. Haykin and B. V. Veen, "Signals and Systems", John Wiley and Sons, 2007.
ADVANCED READINGS	
1	J. G. Proakis and D. G. Manolakis, "Digital Signal Processing: Principles, Algorithms, and Applications", Pearson, 2006.
2	H. P. Hsu, "Signals and systems", Schaum's series, McGraw Hill Education, 2010.
3	M. J. Robert "Fundamentals of Signals and Systems", McGraw Hill Education, 2007.
4	B. P. Lathi, "Linear Systems and Signals", Oxford University Press, 2009.

RENEWABLE ENERGY					
Course Code	**EE450**		**Credits**	**3**	
Scheme of Instruction	**L**	**T**	**P**	**TOTAL**	
Hours/ Week	**3**	**0**	**0**	**42 hrs/sem**	
Scheme of Examination	**IA**	**TW**	**TH**	**P**	**O**
TOTAL = 125 marks	**25**	**0**	**100**	**0**	**0**

Course Objectives:

The objective of the course is to understand types and applications of various forms of renewable energy and its environmental impacts. It will assist students to identify the new methodologies / technologies for effective utilization of renewable energy sources and analyze environmental and cost economics of using renewable energy sources compared to fossil fuels.

Course Outcomes:

The student will be able to:

CO1	understand different forms of Renewable Energy sources
CO2	Analyze environmental, economic assessment of the resources used.
CO3	identify the new methodologies / technologies for effective utilization of renewable energy sources.
CO4	design the renewable energy systems for power generation and otherenergy uses for domestic and industrial applications

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	1	1	0	0	1	0	1	1	1	3
CO2	2	2	1	2	1	1	3	0	0	3	3	1
CO3	2	3	3	0	1	3	1	1	1	1	0	1
CO4	2	1	2	3	3	1	1	3	3	0	1	0

UNIT-1	
Introduction: World energy use, reserves of energy resources, environmental aspects of energy utilization, concepts of non-conventional energy sources, criteria for assessing the potential of NCES, renewable energy scenario in India and around the world, potentials, achievements / applications, classification of NCES, solar, wind, geothermal, biomass, ocean, tidal, wave energy sources, comparison of these energy sources, economics of renewable energysystems, comparative analysis of renewable and non-renewable energy sources, limitations of renewable energy systems.	**11 Hours**
UNIT-2	
Solar Energy: Energy available from sun, solar radiation data, solarradiation on tilted surface, instruments for measuring solar radiation, solar energy conversion into heat, flat plate and concentrating collectors, principle of natural and forced convection, orientation and thermal analysis of solar collectors.	**10 Hours**

PhotoVoltaics: P-N junctions. solar cells, PV systems, calculation of energy through photovoltaic power generation. Standalone and grid connected solar PV systems. Photovoltaic applications: Battery charger, domestic lighting, street lighting, water pumping and power generation schemes.	
UNIT-3	
Wind Energy: Energy available from wind, general formula, lift and drag. Basics of wind energy conversion, effect of density, frequency variances, angle of attack, wind speed estimation, Betz limit. Horizontal axis and vertical axis rotors, aerodynamics of wind turbine rotor, determination of torque coefficient, site selection, wind resource assessment. **Wind Turbine Generators:** Induction, synchronous machines, constant V & F and variable V & F generations, reactive power compensation, integration of wind energy converters into grid, working principle of wind power plant.	**10 Hours**
UNIT-4	
Other Types of Energy resources: Fuel cell :- Principle of working, various types , construction and applications. Mini and Microhydel Power (MHP) Generation: Classification of hydel plants, concept of micro hydel, merits. MHP plants: Components, design and layout, turbines, efficiency, integrated energy systems and their cost benefit analysis. Principles of ocean and tidal energy conversion. Biomass resources and their classification, biomass conversion processes, thermo chemical conversion, direct combustion, gasification, pyrolysis and liquefaction.	**11 Hours**

ESSENTIAL READINGS	
1	G. D. Rai; Non-Conventional Energy Sources; Khanna Publishers.
2	J. W. Twidell and A. Weir; Renewable Energy Sources; Taylor & Francis, CRC press.
ADVANCED READINGS	
1	S. P. Sukhatme; Solar energy; Tata McGraw Hill Publishing Company Ltd, PHI Learning Private Limited.
2	Chetan Singh Solanki; Solar Photovoltaics Fundamentals, Technologies and Applications; Prentice hall India ltd.
3	D. P. Kothari & K. C. Singhal; Renewable energy sources and emerging technologies; Prentice hall India ltd.

ELECTRICAL MACHINES-II LABORATORY					
Course Code	**EE 450**		**Credits**	**1**	
Scheme of Instruction Hours/ Week	**L**	**T**	**P**	**TOTAL**	
	0	**0**	**2**	**28 hrs/sem**	
Scheme of Examination TOTAL = 75 marks	**IA**	**TW**	**TH**	**P**	**O**
	0	**25**	**0**	**50**	**0**

Course Objectives:

The objective of the course is to impart hand on knowledge of Electrical machines.

Course Outcomes:

The student will be able to:

CO1	Understand the practical operation of AC generators and Motors
CO2	Assemble, Test and verify the performance of single phase and three phase AC machines.
CO3	Analyze the experimental results
CO4	Design the testing circuit to evaluate the performance of these machines

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	2	1	1	0	1	1	1	0	1	1
CO2	2	2	2	2	3	3	1	1	1	3	3	1
CO3	2	3	3	3	3	1	3	0	2	0	0	3
CO4	2	3	2	2	2	1	0	3	3	3	2	0

SN	**Experimental List**
1	No load and Blocked rotor Test on Three Phase Induction Machine.
2	Performance characteristics of Induction machine
3	Speed Control of Induction motor
4	Direct load test on three phase Induction Motor
5	No Load and blocked rotor test on single phase Induction motor
6	Load Test on single phase Induction motor
7	OC and SC test on three phase alternator
8	Load test on three phase alternator
9	Slip test on three phase alternator
10	Parallel operation of three phase alternator
11	To determine V curves of synchronous motor
12	Performance characteristics of PMDC/ BLDC motor
13	Simulation experiment on Induction Motor
14	Simulation experiment on Synchronous Machine

ESSENTIAL READINGS	
1	P. S. Bimbhra, “Electrical Machinery”, Khanna Publishers, 2011.
2	I. J. Nagrath and D. P. Kothari, “Electric Machines”, McGraw Hill Education, 2010.
3	M. G. Say, “Performance and design of AC machines”, CBS Publishers, 2002.
4	A. E. Fitzgerald and C. Kingsley, "Electric Machinery”, McGraw Hill Education, 2013.

ANALOG ELECTRONICS LABORATORY					
Course Code	**EE 460**		**Credits**	**1**	
Scheme of Instruction	**L**	**T**	**P**	**TOTAL**	
Hours/ Week	**0**	**0**	**2**	**28 hrs/sem**	
Scheme of Examination	**IA**	**TW**	**TH**	**P**	**O**
TOTAL = 75 marks	**0**	**25**	**0**	**50**	**0**

Course Objectives:

The objective of the course is to provide hands on working experience on various electronics devices and analog circuits.

Course Outcomes:

The student will be able to:

CO1	Measure and understand the input and output characteristics of transistor, zener diode, MOSFET, operation amplifier.
CO2	Realize half wave, full wave rectifier circuits, zener diode as regulator
CO3	Design filters, oscillators, astable and monostable multivibrators as per the specifications
CO4	Evaluate the performance of circuits using simulation software

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	1	3	1	0	0	0	1	2	0	2
CO2	3	3	2	2	2	0	0	2	3	2	0	2
CO3	3	3	3	3	3	2	2	2	3	3	2	3
CO4	3	2	2	1	3	2	2	2	2	3	2	3

SN	**Experimental List**
1	Design of Half Wave Rectifier.
2	Design of Full Wave Rectifier
3	Input-Output characteristics of transistor biasing circuits.
4	MOSFET Characteristics.
5	Zener diode Characteristics & Regulator using Zener diode.
6	UJT relaxation oscillator.
7	RC coupled amplifier
8	Operational Amplifiers (IC741)-D.C and A.C Characteristics.
9	Opamp as differentiator and Integrator
10	Design of Active filters: Low and High pass Filter
11	Waveform generation using IC741: Square wave and Triangular wave, Sawtooth wave.
12	Design of Schmitt Trigger and Zero crossing Detector
13	Wein bridge oscillators
14	IC voltage regulators

ESSENTIAL READINGS	
1	Donald A Neaman; Semiconductor Physics and Devices; Third Edition, Tata Mc Graw Hill Inc.; 2007.
2	Khetan and Goyal; A Monograph of Electronic Design Principles; Khanna Publications
3	Robert Boylestad and Louis Nashelsky; Electron Devices and Circuit Theory; Pearson Prentice Hall; 10th edition; July 2008.
4	S. Salivahanan; Electronic devices & circuits; Vikas Publication
5	Ramakant Gayakwad ; Operational amplifier and Linear Integrated Circuits; Pearson

ECONOMICS FOR ENGINEERS					
Course Code	**EE 470**		**Credits**	**3**	
Scheme of Instruction	**L**	**T**	**P**	**TOTAL**	
Hours/ Week	**3**	**0**	**0**	**42 hrs/sem**	
Scheme of Examination	**IA**	**TW**	**TH**	**P**	**O**
TOTAL = 125 marks	**25**	**0**	**100**	**0**	**0**

Course Objectives:

The course objective is to expose students to basic economic concepts and apply economic reasoning to real world problems of business. The students will be able to apply the concepts learned in their profession.

Course Outcomes:

After the successful completion of the course, the student will be able to:

CO1	Understand the basic principles of economics, micro behaviour of consumer & firms in different market structures, various macroeconomic policies, aspects of financial market & measures of Economic Growth and Development.
CO2	Apply the basics of economics, costs concepts in decision making. Calculate the National Income terms to analyze the progress of the economy.
CO3	Analyze the macroeconomic concepts & their relation to microeconomic concept & how they affect the business and economy. Assess the measures of Economic Growth and Development.
CO4	Evaluate economic theories, principles of economics, cost concepts, market structures, measures of National Income and assess its impact on economic growth and development. Make economically sound decision.

UNIT 1	
Central concepts of Economics- Definitions of Economics, Scarcity and Efficiency, Nature of Economics: Positive and normative economics, Microeconomics and Macroeconomics Basic Elements of Supply and Demand- The Demand Schedule, The Demand Curve, Market Demand , Forces behind the Demand Curve, Shifts in Demand. The Supply Schedule The Supply Curve, Forces behind the Supply Curve , Shifts in Supply. Equilibrium of Supply and Demand, Effect of a Shift in Supply or Demand. Supply and Demand: Elasticity and Applications to major economic issues **Estimation/Forecasting of Demand:** Meaning, importance, methods – trend, exponential smoothing, regression analysis	**11 Hours**
UNIT 2	
Microeconomics: Demand & Consumer Behaviour- Choice & Utility Theory. Production and Business Organization, Theory of Production and Marginal Products Basic Concepts, The Nature of the Firm, Big, Small, and Infinitesimal Businesses. Economic Analysis of Costs, Total Cost: Fixed and Variable. Production, Cost Theory, and Decisions of the Firm. Market structures. Perfect and imperfect competition, oligopoly, monopoly.	**10 Hours**

UNIT 3	
Macroeconomics: Key Concepts of Macroeconomics. Objectives and Instruments of Macroeconomics. Aggregate Supply and Demand. **National Income Terms:** -Gross Domestic Product: The Yardstick of an Economy's Performance. Real vs. Nominal GDP. Net Domestic Product, GNP, National Income, Per capita income, Disposable Income, Price Index, Inflation. Consumption and Investment- Consumption, Income, and Saving, Investment. Determinants of Investment. Monetary Policy and the Economy. Government Control of the Economy- The Tools of Government Policy	**10 Hours**
UNIT 4	
Economic Growth and Development: Economic Growth- The Long-Term Significance of Growth, The Four Wheels of Growth. Economic Development- meaning, criteria, measures of development- Per Capita Income, Index of Human Development . Financial markets- Structure, Participants, functions. Capital market- Instruments, Players, trading - Primary and secondary market - Role of stock exchanges and stock indices. Money market	**11 Hours**

ESSENTIAL READINGS	
1	P.A. Samuelson & W.D. Nordhaus, Economics, 19th Edition McGraw Hill, New York, 1995.
2	A. Koutsoyiannis, Modern Microeconomics, Macmillan, 1975.
3	O.P. Khanna , Economics for Engineers,VK Global Publications Private Limited.
ADVANCED READINGS	
1	Chandra P., Fundamentals of Financial Management, Tata McGraw Hill Education Private Limited, New Delhi

THIRD YEAR: ELECTRICAL & ELECTRONICS ENGINEERING

SCHEME OF INSTRUCTION AND EXAMINATION REVISED COURSE 2019-2020

SEMESTER – V

Subject Code	Name of the Subject	Scheme of Instruction Hrs/Week				Scheme of Examination							Credit
		L	T	P	H	Th Duration (Hrs)	Marks						
							Th	S	TW*	P	O	Total	
EE510	Control Systems	3	1	0	**4**	3	100	25	0	0	0	**125**	**4**
EE520	Microprocessors &Microcontroller	4	0	0	**4**	3	100	25	0	0	0	**125**	**4**
EE531	Digital Signal Processing	3	0	0	**3**	3	100	25	0	0	0	**125**	**3**
EE532	Illumination Engineering												
EE533	Electrical Machines Design												
EE534	Electric Drives												
EE541	Testing & Maintenance of Electrical Machines	3	0	0	**3**	3	100	25	0	0	0	**125**	**3**
EE542	Analog and Digital Communication												
EE543	Bio-Medical Instrumentation												
EE544	Operation Research												
EE550	Control Systems Lab	0	0	2	**2**	-	0	0	25	50	0	**75**	**1**
EE560	Microprocessor & Microcontroller Lab	0	0	2	**2**	-	0	0	25	50	0	**75**	**1**
**	**Open Elective**	3	0	0	**3**	3	100	25	0	0	0	**125**	**3**
HM004	Entrepreneurship & Intellectual Property	3	0	0	**3**	3	100	25	0	0	0	**125**	**3**
TOTAL		**19**	**1**	**4**	**24**	**--**	**600**	**150**	**50**	**100**	**0**	**900**	**22**

Students to select ANY ONE subject from EE531, EE532, EE533 and EE534 as Professional elective I and ANY ONE subject from EE541, EE542, EE543 and EE544 as Professional elective II . *Term Work marks are to be awarded through continuous evaluation.

CONTROL SYSTEMS					
Course Code	**EE510**		**Credits**	**4**	
Scheme of Instruction	**L**	**T**	**P**	**TOTAL**	
Hours/ Week	**3**	**1**	**0**	**52 hrs/sem**	
Scheme of Examination	**IA**	**TW**	**TH**	**P**	**O**
TOTAL = 125 marks	**25**	**0**	**100**	**0**	**0**

Course Objectives:

The objective of this course is to familiarize the students with the basic elements of control systems and their characteristics. They should be able to understand the input output relation and analyse control systems in frequency and time domain.

Course Outcomes:

The student will be able to:

CO1	Understand the different components and types of control system, concept of time domain and frequency domain response of the system.
CO2	Apply knowledge of electrical circuits to solve control system applications.
CO3	Analyze control system concept using time domain and frequency domain analysis.
CO4	Design various types of controllers and compensators for various applications using stability criteria.

UNIT -1	
Introduction to control problem Industrial Control examples. Mathematical models of physical systems. Control hardware and their models. Transfer function models of linear time-invariant systems. Feedback Control: Open-Loop and Closed-loop systems. Benefits of Feedback. Block diagram algebra. Signal Flow graph. Masons gain formula.	**10 Hours**
UNIT -2	
Time Response Analysis Standard test signals. Time response of first and second order systems for standard test inputs. Application of initial and final value theorem. Design specifications for second-order systems based on the time-response. Concept of Stability. Routh-Hurwitz Criteria. Relative Stability analysis. Root-Locus technique. Construction of Root-loci.	**10 Hours**
UNIT 3	
Frequency-response analysis Relationship between time and frequency response, Polar plots, Bode plots. Nyquist stability criterion. Relative stability using Nyquist criterion – gain and phase margin. Closed-loop frequency response.	**10 Hours**
UNIT -4	
Introduction to Controller Design Stability, steady-state accuracy, transient accuracy, disturbance rejection, insensitivity and robustness of control systems. Root-loci method of feedback controller design. Design specifications in frequency-domain. Frequency-domain methods of design. Application of Proportional, Integral and Derivative Controllers, Lead and Lag compensation in designs.	**9 Hours**

ESSENTIAL READINGS	
1.	K. Ogata, “Modern Control Engineering”, Prentice Hall, 1991.
2.	I. J. Nagrath and M. Gopal, “Control Systems Engineering”, New Age International,2009
3.	M. Gopal, “Control Systems: Principles and Design”, McGraw Hill Education, 1997.
ADVANCED READINGS	
1.	B. C. Kuo, “Automatic Control System”, Prentice Hall, 1995.
2.	Norman Nise; Control System Engineering; Wiley Edition

MICROPROCESSOR & MICROCONTROLLERS					
Course Code	**EE 520**		**Credits**	**4**	
Scheme of Instruction	**L**	**T**	**P**	**TOTAL**	
Hours/ Week	**4**	**0**	**0**	**52 hrs/sem**	
Scheme of Examination	**IA**	**TW**	**TH**	**P**	**O**
TOTAL = 125 marks	**25**	**0**	**100**	**0**	**0**

Course Objectives: To familiarize the students with a thorough understanding of architecture of a Microprocessor and Microcontroller, instruction sets, and programming using assembly language.

Course Outcomes:

The student will be able to:

CO1	Understand the basics of Microprocessor and Microcontroller Architecture
CO2	Analyze addressing modes, Instruction categories, memory mapping
CO3	Develop assembly programs using Microprocessor and Microcontroller
CO4	Build a system to interface devices to microcontroller, Develop an assembly/C program to handle the given task.

UNIT -1	
Fundamentals of Microprocessors: Fundamentals of Microprocessor Architecture. 8-bit Microprocessor 8085, Architecture of 8085, Assembly programs using basic 8085 Instruction sets (Arithmetic, Logical, Branching, data transfer Instruction). **Microcontroller** 8-bit Microcontroller, Address bus, data bus. Comparison of 8-bit microcontrollers, 16-bit and 32-bit microcontrollers. Definition of embedded system and its characteristics, Role of microcontrollers in embedded Systems. Overview of the 8051 family.	**13 Hours**
UNIT -2	
The 8051 Architecture: Working registers, SFRs, Clock and RESET circuits, Stack and Stack Pointer, Program Counter, I/O ports. **Memory Structures** Data and Program Memory, Timing diagrams and Execution Cycles. Addressing modes: Instruction syntax, Data types, Subroutines Immediate addressing, Register addressing, Direct addressing, Indirect addressing, Relative addressing, Indexed addressing, Bit inherent addressing, bit direct addressing. 8051 Interrupts, Power saving mode operation.	**13 Hours**
UNIT -3	
8051 Instruction set Instruction timings. Data transfer instructions, Arithmetic instructions, Logical instructions, Branch instructions, Subroutine instructions, Bit manipulation instruction. **Assembly Program** Assembly language programs, C language programs. Assemblers and compilers. Programming and debugging tools.	**13 Hours**

UNIT -4	
8051 Interfacing Devices Interfacing peripheral devices such as General Purpose I/O, ADC, DAC, timers, counters, memory devices. LED, LCD and keyboard interfacing. Stepper motor interfacing, DC Motor interfacing, **External Communication Interface** Synchronous and Asynchronous Communication. RS232, SPI, I2C. Introduction and interfacing to protocols like Blue-tooth and Zig-bee	**13 Hours**

ESSENTIAL READINGS	
1	R. S. Gaonkar, " Microprocessor Architecture: Programming and Applications with the 8085", Penram International Publishing, 1996
2	K. J. Ayala, "8051 Microcontroller", Delmar Cengage Learning, 2004
3	M. A.Mazidi, J. G. Mazidi and R. D. McKinlay, "The8051Microcontroller and Embedded Systems: Using Assembly and C", Pearson Education, 2007.
ADVANCED READINGS	
1	D. A. Patterson and J. H. Hennessy, "Computer Organization and Design: The Hardware/Software interface", Morgan Kaufman Publishers, 2013.
2	R. Kamal, "Embedded System", McGraw Hill Education,2009.

DIGITAL SIGNAL PROCESSING					
Course Code	**EE531**		**Credits**	**3**	
Scheme of Instruction	**L**	**T**	**P**	**TOTAL**	
Hours/ Week	**3**	**0**	**0**	**39 hrs/sem**	
Scheme of Examination	**IA**	**TW**	**TH**	**P**	**O**
TOTAL = 125marks	**25**	**0**	**100**	**0**	**0**

Course Objectives:

The objective of this course is to familiarize the students with the discrete time signal systems, Z transforms, Discrete Fourier Transforms and algorithms. They should be able to design filters and understand multirate signal processing.

Course Outcomes:

The student will be able to:

CO1	Understand the basics of discrete time signals and systems, sampling, reconstruction, Z transform ROC, Discrete Fourier transforms, filters and multirate signal processing.
CO2	Apply Z transforms properties, properties of DFT and FFT, structures for filters, methods for parametric and non-parametric estimation.
CO3	Analyze Z transforms, Discrete Fourier transforms for LTI systems, FFT algorithms, Filter structures, Methods for filter design and methods of parametric and non-parametric estimation.
CO4	Compute stability using Z transforms, convolution and correlation using FFT , spectral estimation and design FIR and IIR Filters.

UNIT -1	
Discrete-time signals and systems Discrete time signals and systems: Sequences, representation of discrete systems using difference equations, Sampling and reconstruction of signals - aliasing; Sampling theorem and Nyquist rate. **Z-transform** z-Transform, Region of Convergence, Analysis of Linear Shift Invariant systems using z transform, Properties of z-transform for causal signals, Interpretation of stability in z-domain, Inverse z-transforms.	**9 Hours**
UNIT -2	
Discrete Fourier Transform Frequency Domain Analysis, Discrete Fourier Transform (DFT), Properties of DFT, Convolution of signals, Fast Fourier Transform Algorithm: Decimation in time , decimation in frequency FFT: radix 2 and mixed radix algorithms, applications of FFT in linear filtering and correlation. Parseval's Identity, Implementation of Discrete Time Systems.	**10 Hours**
UNIT 3	
Filters: Structures for FIR and IIR systems- Direct, parallel and cascade. Design of FIR Digital filters: Window method, Park-McClellan's method. Design of IIR Digital Filters: Butterworth, Chebyshev and Elliptic Approximations; Low-pass, Band-pass, Bandstop and High-pass filters.	**10 Hours**

UNIT -4	
Effect of finite register length in FIR filter design. Parametric and non-parametric spectral estimation. Introduction to multi-rate signal processing. **Applications of Digital Signal Processing** Correlation Functions and Power Spectra, Stationary Processes, Optimal filtering using ARMA Model, Linear Mean-Square Estimation, Wiener Filter.	**10 Hours**

ESSENTIAL READINGS	
1.	John G Proakis, Dimitris Manolakis; Digital Signal Processing; Prentice Hall of India
2.	A.V. Oppenheim and R. W. Schafer, "Discrete Time Signal Processing", Prentice Hall, 1989.
3.	S. K. Mitra, "Digital Signal Processing: A computer-based approach", McGraw Hill, 2011
4.	S Salivahanan, A Vallavaraj, C Gnanapriya; Digital Signal Processing; McGraw Hill
ADVANCED READINGS	
1.	L. R. Rabiner and B. Gold, "Theory and Application of Digital Signal Processing", Prentice Hall, 1992.
2.	J. R. Johnson, "Introduction to Digital Signal Processing", Prentice Hall, 1992.
3.	Vinay K.Ingle, John G.Proakis; Digital Signal Processing-A MATLAB based approach
4.	Oppenheim and Willskay, Hamid Nawab; Signals and Systems; Prentice Hall of India

ILLUMINATION ENGINEERING					
Course Code	**EE 532**		**Credits**	**3**	
Scheme of Instruction Hours/ Week	**L**	**T**	**P**	**TOTAL**	
	3	**0**	**0**	**39 hrs/sem**	
Scheme of Examination TOTAL = 125 marks	**IA**	**TW**	**TH**	**P**	**O**
	25	**0**	**100**	**0**	**0**

Course Objectives:

By learning this course, a student will be able to understand different characteristics & qualities of light / lighting sources, types of lighting, as well as measurement of different lighting parameters. It will also enable a student to apply right type of lighting system for the right application, get familiarized with different laws of illumination as well as understand the design of interior & exterior lighting.

Course Outcomes: After successful completion of this course the student will be able to

CO1	Understand different factors affecting good lighting , qualities of good lighting as well as identify parameters involved in lighting system design
CO2	Analyse qualities of luminaires &their functions
CO3	Design indoor & outdoor lighting systems
CO4	Compute the polar curves& other photometric diagrams in calculation of light output ratio of Luminaires

UNIT -1	
Introduction to light: Natural light , artificial light & supplementary light Radiations their wavelength &colour - colour characteristics - Colour temperature,coloursensitivity,vision&theirtypes-scotopic&photopicvision. Qualities of good lighting Factors affecting good lighting , different types of glares, glare index, ways of their minimization, types of shadows & their types, ways of minimization of hard shadows, different contrast levels between visual task, working plane, surrounding & field of vision, colour rendering effect & CRI, reflection& its types, stroboscopic effect & its ways of minimization. Types of lighting sources and their comparison w.r.t. their characteristics, Method of artificial lighting, Types of Lighting systems and lighting schemes and the application of each. Types of luminaires- their functional aspects &applications.	**10 Hours**
UNIT -2	
Measurement of light: Terms related to lighting, types of candle powers- M.S.C.P, M.H.C.P, and their measurements, efficacy of lamp, Polar curves- its significance & types, procedure for drawing polar curves. Laws of Illumination and their applications, Illumination from point, line & flat source. Photometry& spectrometry, procedure for photometry, photometer & its types. Photo cells, Illuminance meter. Determination of luminance & illuminance for round source, flat source, tubular source/ diffuser. Photometric diagrams, efficacy of lamp, DLOR, ULOR, LFF, UFF, LFU. UFU &COU.	**11 Hours**

UNIT -3	
Design of interior lighting: Illumination required for various work plane. Terms related to interior lighting. Standard practice for illumination required in different areas. Different factors related to interior lighting design, their selection and range of their nominal values. Room index, cavity index, mounting height, suspension height, Space to mounting height ratio- their nominal values & factors affecting them. Factors affecting C.O.U. **Selection of lamps & luminaires**, their methods of mounting, Methods used in interior lighting design, Layout of luminaires Design of lighting for industries, residential areas, office, indoor stadium, theatre& hospital, Auditorium lighting & spot lighting.	**10 Hours**
UNIT -4	
Design of exterior lighting: Terms related & standard practice for illumination level. Design of street lighting & flood lighting- types of luminaires used, their merits & demerits & their selection, arrangement of luminaires, different factors involved & the range of their nominal values. Aiming of flood light projectors. Aviation lighting. Lighting for display & signaling, surveillance lighting, **Advanced trends in lighting:** LED luminaire design, intelligent LED fixtures, Organic lighting system, Laser its characteristics, features & applications, optical fibres as lighting guide	**8 Hours**

ESSENTIAL READINGS	
1	D.C. Prichard; Lighting; Published by Routledge
2	Cayless& Marsden; Lamps & lightings; Published by Hodder Arnold, United Kingdom.
3	J. Lindsay; Applied Illumination Engineering Published by Fairmont Press
ADVANCED READINGS	
1.	Dr. Warren G. Julian; Principles of lighting published by Indian society of lighting Engineers
2.	Anil Walia, Design With Light, Lighting Handbook(Lighting System 2002)

ELECTRICAL MACHINE DESIGN					
Course Code	**EE 533**		**Credits**	**3**	
Scheme of Instruction	**L**	**T**	**P**	**TOTAL**	
Hours/ Week	**3**	**0**	**0**	**39 hrs/sem**	
Scheme of Examination	**IA**	**TW**	**TH**	**P**	**O**
TOTAL = 125 marks	**25**	**0**	**100**	**0**	**0**

Course Objectives:

The objective of this course is to focus on properties of electrical materials used for designing electrical machines, calculating mmf and thermal ratings of electrical machines. Course covers designofstatorandrotorofInductionmachineandSynchronousmachine.Italsocoversdesign of core, windings and cooling system of transformer.

Course Outcomes:

The student will be able to:

CO1	Understand the design concept of Transformer, Induction motor and Synchronous motor.
CO2	Explain the considerations used for design of electrical machines, operating characteristics of transformer, Induction motors and necessity of CAD.
CO3	Analyze effect of temperature, raw material, cooling medium and insulating materials on design of electrical machines.
CO4	Compute mmf, flux densities, temperature rise calculations, number of stator and rotor slots and ratings for various electrical machines.

UNIT -1	
Introduction: Major considerations in electrical machine design, electrical engineering materials, space factor, choice of specific electrical and magnetic loadings, thermal considerations, heat flow, temperature rise, rating of machines.	**10 Hours**
UNIT -2	
Transformers: Sizing of a transformer, main dimensions, kVA output for single- and three-phase transformers, window space factor, overall dimensions, operating characteristics, regulation, no load current, temperature rise in transformers, design of cooling tank, methods for cooling of transformers.	**10 Hours**
UNIT 3	
Induction Motors: Sizing of an induction motor, main dimension, length of air gap, rules for selecting rotor slots of squirrel cage machines, design of rotor bars & slots, design of end rings, design of wound rotor, leakage reactance of polyphase machines, magnetising current, short circuit current, operating characteristics.	**10 Hours**
UNIT -4	
Synchronous Machines: Sizing of a synchronous machine, main dimensions, design of salient pole machines, short circuit ratio, shape of pole face, armature design, armature parameters, estimation of air gap length, design of rotor, design of field winding. **Computer aided Design (CAD):** Limitations (assumptions) of traditional designs, need for CAD analysis, synthesis and hybrid methods, design optimization using computers.	**9 Hours**

ESSENTIAL READINGS	
1.	A. K. Sawhney, " A Course in Electrical Machine Design" , DhanpatRai and Sons, 1970.
ADVANCED READINGS	
1.	R.K.Agarwal, Principles of electrical machine Design, Esskay publication
2.	M.V.Deshpande, Design and Testing of electrical Machines, Wheeler Publications
3.	Ramamurthy M, Computer aided design of Electrical equipment, , East West Press

ELECTRICAL DRIVES					
Course Code	**EE 534**		**Credits**	**3**	
Scheme of Instruction	**L**	**T**	**P**	**TOTAL**	
Hours/ Week	**3**	**0**	**0**	**39 hrs/sem**	
Scheme of Examination	**IA**	**TW**	**TH**	**P**	**O**
TOTAL = 125 marks	**25**	**0**	**100**	**0**	**0**

Course Objectives:

The objective of this course is to make a student to:

1. Understand the concept of Electrical drives, its modes of operations &control.
2. Illustrate the steady state operation and transient dynamics of a motor load system
3. Analyze the operation of the converter, chopper fed DC drive
4. Familiarize with the starters and controllers for DC and AC drives
5. Understand the applications of electrical drives

Course Outcomes:

The student will be able to:

CO1	understand the basic concepts of electrical drives,
CO2	control of DC and AC drives
CO3	learn motor starters and controllers using various relay
CO4	study the industrial applications

UNIT -1	
General concept of Electric drives: Classification of electric drives, Advantages of electric drives, components of electric drives, choice of electric drives, Selection of motor power rating, Thermal model of motor for heating and cooling, calculation of motor rating for various types of duty cycles. Dynamics of Electric drives, fundamental torque equation, speed torque equation of DC and AC motors, speed torque conventions, Four quadrant operations, Joint speed – torque characteristics, Components of load torques, load equalization. **Types of braking**: Dynamic braking, counter current braking, Regenerative Braking of DC and AC motors. Classification of control schemes, manual control, semiautomatic control, automatic control.	**12 Hours**
UNIT -2	
Control of DC Drives: Basic parameters, operating modes, motoring modes, Braking modes, schemes for DC motor speed control, buck boost control, single phase, three phase fully controlled, half controlled DC drives, dual converter control, chopper-controlled DC drives **Control of AC Drives:** Basic parameters, speed control of induction motor drives, pole changing Induction motor drives, stator frequency variation. Speed control of slip ring induction motors, stator voltage variation, rotor resistance variation, slip power recovery, eddy current drives, variable voltage variable frequency (VVVF) control. Speed control of Synchronous motor, input frequency variation, starting of large synchronous motor.	**11 Hours**

UNIT 3	
Motor starters and controllers: DC motor starters, starters using voltage sensing relays, current sensing relays, time delay relays, starters using frequency relays. Methods used in interlocking operation, Sequential control using Time delay relay DOL starters with provision for speed reversal, Autotransformer starters, Rotor resistance starters, Master controller for wound rotor Induction motors, starting, plugging and speed reversal, starters for two speed pole changing induction motor. Starters for two winding two speed pole changing induction motor with provision for speed reversal (constant Torque), starter for single winding two speed pole changing Induction motor with provision for speed reversal, constant horse power operation.	**8 Hours**
UNIT -4	
Industrial applications: Layout of electric drives, Application of Synchronous motor, Induction motor (squirrel cage/ wound rotor), DC motor for electric drives, Suitable electric drives for Rolling mills, Textile mills, Lathe Machines, Drilling Machines **Electric traction**: Tractive effort, requirements of Electric traction, suitability of different types of motors, coefficient of Adhesion, supply systems, train movement, speed control, traction in metro systems	**8 Hours**

ESSENTIAL READINGS	
1.	Gopal K Dubey; Fundamentals of Electric Drives; Narosa publishing House.
2.	Nisit K De, Prashanta K Sen; Electric Drives; PHI publication.
3.	S.K.Pillai; A First course on Electrical Drives ;New Age International publishers
ADVANCED READINGS	
4.	V Subramanayam; Electric Drives-Concepts and applications; Tata McGraw Hill publication
5.	R. Krishnan; Electric motor drives-Modelling Analysis and Control; PHIIndia

TESTING AND MAINTENANCE OF ELECTRICAL MACHINES					
Course Code	**EE 541**		**Credits**	**3**	
Scheme of Instruction Hours/ Week	**L**	**T**	**P**	**TOTAL**	
	3	**0**	**0**	**39 hrs/sem**	
Scheme of Examination TOTAL = 125 marks	**IA**	**TW**	**TH**	**P**	**O**
	25	**0**	**100**	**0**	**0**

Course Objectives:

By learning this course, a student shall be able to understand different types of tests to be carried on Electrical machines right from the instant of its procurement till its commissioning as well as understand their merits & Limitations. It will also enable him to apply right type of test for right application & get familiarized with various techniques adopted for testing of machines.

Course Outcomes:

The student will be able to:

CO1	Understand different tests to be carried out from the instant of its procurement till their commissioning with respect to their scope for accuracy in measurement of various parameters
CO2	Apply different measuring & Testing techniques adopted
CO3	Analyze merits & demerits of each technique listed
CO4	Compute Right technique for right application with focus on Energy conservation

UNIT -1	
Classification of Test: Type Test, routine test, Acceptance test, pre commissioning test/ commissioning test, methods of measurements of Temperature rise of various parts of machines, concept of direct and indirect, Regenerative testing (Phantom loading). **DC Machines Testing:** Classification of various losses in DC Machines as per IS and separation of various losses, Calculation of mechanical, Electrical and overall efficiency, Determination of Efficiency by direct, Indirect and Regenerative methods. (Brake test, Swinburn test and Hopkinson test). Heat Run test	**10 Hours**
UNIT -2	
Transformers: Location and sites, selection and design of foundation details (like bolts size, their sequence number etc.) code of practice for terminal plates, polarity and phase sequence, oil tanks, drying of windings with and without oil, general inspection. **Commissioning Tests:** Following tests as per National and International standards, volts ratio test, earth resistance, oil strength, Bochlholz and other relays, tap changing gear, fan and pumps, insulation test, impulse test, polarizing index, load and temperature rise test. **Specific Tests:** Determination of performance curves like efficiency, regulation, etc, determination of mechanical stress under normal and abnormal conditions. Maintenance Schedule	**10 Hours**

UNIT -3	
Induction Motors: Specifications for different types of motors. Duties &protection. **Installation & Commissioning:** Location of the motors (including the foundation details) and its control apparatus, shaft and alignment for various couplings, fitting of pulleys and couplings, drying of windings. Mechanical test for alignment, air gap symmetry, tests for bearings, vibrations and balancing. **Performance Tests and Maintenance Schedule**: Insulation test, earth resistance, high voltage test, reduced voltage test, starting up, failure to speed up to take the load, type of test, routine test, factory tests and site tests (in accordance with ISI code). Performance and temperature rise tests, stray load losses, shaft elements, deratings and special duty capability. Maintenance Schedule. Ac machine testing and loss estimation.	**10 Hours**
UNIT -4	
Synchronous Machines: Installation and Commissioning Tests: Physical inspection, rating name plate details, foundation details, alignments, excitation systems, cooling and control gear, drying out. Insulation, resistance measurement of armature and field windings, waveform and telephone interference factors, line charging capacity. **Performance tests**: Various tests to estimate the performance for generator and motor operations, slip maximum lagging currents, maximum reluctance power tests, sudden short circuit tests, transient and sub transient parameters, measurements of sequence impedances, capacitive reactance, separation of losses, temperature rise tests, and retardation tests. Factory tests- Gap length, magnetic centrity balancing vibration, bearing performance.	**9 Hours**

ESSENTIAL READINGS	
1.	S . S Rao, Testing and Commissioning of Electrical Equipments. Khanna Publ,2006
2.	IS code Books on Testing of Electrical Machines
ADVANCED READINGS	
1.	Er. V.K.Jain , Bulk Distribution of Electrical Power, Galgotia Publication 1991

ANALOG AND DIGITAL COMMUNICATION					
Course Code	**EE542**		**Credits**	**3**	
Scheme of Instruction	**L**	**T**	**P**	**TOTAL**	
Hours/ Week	**3**	**0**	**0**	**39 hrs/sem**	
Scheme of Examination	**IA**	**TW**	**TH**	**P**	**O**
TOTAL = 125 marks	**25**	**0**	**100**	**0**	**0**

Course Objectives:
The objective of this course is to understand the information representation and processing, the fundamentals of communication engineering, the basics of classical communication systems, the hardware and software communication devices, modern communication systems.

Course Outcomes:
The student will be able to:

CO1	Understand the basic concept of Analog and digital communication
CO2	Apply the fundamental concepts for the operation of various communication system
CO3	Compare the different communication systems
CO4	Design various analog and digital communication system

UNIT -1	
Modulation: Need for modulation, Basic principles of amplitude modulation (AM), frequency spectrum of AM wave, Power and current relationships in AM, generation of AM wave using collector/emitter modulation, Detection of AM using Diode/Envelope detector. SSB techniques: Suppression of carrier using FET, Suppression of sideband using Phase shift method/Third Method. Basic theory of frequency Modulation and phase modulation, spectrum of FM, Generation and detection of FM. Comparison between AM, FM and PM.	**10 Hours**
UNIT -2	
Sampling Theory: Sampling theorem, recovery of signal from samples. Basic principles of PAM, PWM and PPM, their generation and detection circuits. Quantization, Quantization noise &companding principles of PCM transmission & Reception, Delta modulation and Adaptive delta modulation. (4 Hours) **Digital Modulation techniques:** ASK, FSK and PSK. Modulator/demodulator circuits of BPSK, QPSK and DPSK.	**9 Hours**
UNIT 3	
Data Communication: Components, basic concepts–line configuration point to point, multipoint Topologies - Mesh, star, tree, Bus, Ring, hybrid. Line Encoding and error detection and correction (LRC/CRC, Hamming and CRC codes). **Fiber Optic Communication**: Types of fiber such as step and graded index, Principle of Optical Transmission, Optical sources (LED's and ILD's only) optical detectors (PIN diode and APD) Applications in Telecommunication. **Satellite Communication:** Synchronous orbit, geostationary orbit, Satellite Subsystem (block diagram) Earth station (Block diagram), Telemetry tracking and command.	**10 Hours**

UNIT -4	
Wireless Transmission: Multiplexing, Cellular Systems. **Telecommunication System:** GSM, mobile services, system Architecture. **Wireless LAN:** Advantages & disadvantages of WLAN, Infrared vs. radio transmission, Infrastructure and ad hoc networks, IEEE 802.11 - System architecture, Protocol Architecture. **Bluetooth:** User scenarios, Physical layers, MAC layer, Networking, Security & link Management.	**10 Hours**

ESSENTIAL READINGS	
1.	George kennedy; Electronic communication System; Tata McGraw Hill
2.	W Tomasi; Electronics Communication Systems; PHI
ADVANCED READINGS	
1.	Thyagrajan Vishwanathan; Telecommunication Switching Systems and Networks; PHI
2.	D C Agarwal; Satellite Communication; Khanna Publishers
3.	Keiser; Optical fiber communication; McGraw Hill
4.	Jochen Schiller; Mobile Communication; Education Asia.

BIOMEDICAL INSTRUMENTAION					
Course Code	**EE 543**		**Credits**	**3**	
Scheme of Instruction	**L**	**T**	**P**	**TOTAL**	
Hours/ Week	**3**	**0**	**0**	**39 hours/sem**	
Scheme of Examination	**IA**	**TW**	**TH**	**P**	**O**
TOTAL = 125 marks	**25**	**0**	**100**	**0**	**0**

Course Objectives:
The objective of this course is to enable the student to have clear understanding of biomedical techniques used for measurement of different human body parameters, possibility of electric shock hazards from biomedical instruments & the safety measures to be adopted to prevent accidents.

Course Outcomes:
The student will be able to:

CO1	Understand the difficulties involved in measurement of various biological parameters as well as the different sources of bioelectric potential &electrodes,
CO2	Identify the different types of heart sounds & the application of right types of transducer used in biomedical applications
CO3	Analyze the different waveforms of ECG, EEG, ERG&EMG & their usefulness in diagnosis of different ailments of the subject
CO4	Practice & implement the rules related to patient safety & safety of medical equipment

UNIT -1	
Biomedical Instrumentation System: Block diagram and specification, problems encountered in the design of a living system, general constraint in the design of biomedical instrumentation system. **Sources Of Bioelectric Potential**: resting & action potential- propagation of action potential. biomedical electrodes- Skin surface, needle type, micro electrode & their application. Heart & cardio vascular system. Systolic & Diastolic heart sound. Transducers used in biomedical applications (physiological transducer) Measurement of blood pressure- methods used. Measurement of blood flow and cardiac output using magnetic blood flow meter- electromagnetic type, NMR type, ultrasonic type, indicator dilution method Electro cardiograph, -block diagram, ECG electrodes and leads, types of ECG recorder.	**12 Hours**
UNIT -2	
Plethismography- measurement of heart sounds-PCG, Anatomy of nervous system, nervous system measurement, neuronal communication, EPSP & IPSP. Neoronal receptors, neuronal firing measurements. Electroencephalograph (EEG)- block diagram, various rhythms, EEG in diagnostics. Electromyograph (EMG)- Block diagram, ophthalmology instruments- electroretinogram, electrocculogram, ophtalmoscope, tonometer for eye pressure measurement. Clinical laboratory instrument- blood cells- tests on blood cells, measurement of blood parameters, blood cell counters. Oximetry- invitro Oximetry, invivooximetry, Ear oximeter.	**10 Hours**

UNIT 3	
Therapeutic instrument- Cardiac pacemaker & their types, Cardiac defibrillator& their types. Artificial kidney, Dialysis Dialyser, hemodialysis, hemodialyser- types. Diathermy- short wave & microwave, Surgical diathermy –working principle of each. Biomedical telemetry- physiological parameters adaptable to biotelemetry- components of bio telemetrical system, implantable units.	**10 Hours**
UNIT -4	
Patient safety & electrical safety of medical equipment, physiological effects of electric current. Electrical shock hazards from medical equipment. Methods to prevent accidents. Patient care & monitoring system- bedside monitor & control specification Imaging system- Xray machine, basic principle, CT& MRI Scanner –ultrasound diagnostic.	**7 Hours**

ESSENTIAL READINGS	
1.	R.S. Khandpur; Hand book of biomedical instrumentation; Tata MC grawHill.
2.	Crombell, Weibell, Pfeitter; Biomedical instruments &measurements.
ADVANCED READINGS	
1.	John G. Webster; Medical Instrumentation Application & Design; John Wiley & Sons New York1998.
2.	Omkar Pandey & Rakesh Kumar; Biomedical Electronics & Instrumentation; S.K. kataria publication

OPERATION RESEARCH					
Course Code	**EE544**		**Credits**	**3**	
Scheme of Instruction	**L**	**T**	**P**	**TOTAL**	
Hours/ Week	**3**	**0**	**0**	**39 hrs/sem**	
Scheme of Examination	**IA**	**TW**	**TH**	**P**	**O**
TOTAL = 125 marks	**25**	**0**	**100**	**0**	**0**

Course Objectives:

1. To analyze real-life decision-making situations and develop the art of converting these situations into mathematical models
2. To understand the working principles of techniques to solve LPP models and solve differently styled LP problems
3. To study standard network analysis problems and apply solution techniques
4. To solve problems wherein the dynamic decisions are made in stages and consolidated to arrive at final decision
5. To solve problems related to queuing and inventory systems

Course Outcomes:

The student will be able to:

CO1	Understand the various techniques to solve a linear programming model
CO2	Identify the specially structured linear programming models and accordingly apply the technique
CO3	Analyse and solve various linear programming techniques
CO4	Formulate a real-life situation into a mathematical model and apply appropriate technique to solve a linear programming model

UNIT -1	
Introduction: Historical development of operations research, Models and principles of modeling, Techniques in operations research **Linear Programming**: Introduction, Formulation of linear programming problems (LPP), Graphical method to solve LPP, Special cases, Techniques to solve LPP: Simplex method, Analysis of special cases through simplex method, Big-M method, Two-phase method, Duality, Definition of a dual problem, Primal-Dual computation.	**10 Hours**
UNIT -2	
Specially structured linear Programmes: Transportation model, Definition and formulation, Transportation algorithm – finding initial basic feasible solution using Northwest corner rule, least cost cell and Vogel's approximation method. Optimizing using stepping stone method and MODI method Assignment model: Definition and formulation, Hungarian algorithm	**9 Hours**
UNIT 3	
Network Analysis: Introduction, scope, definitions, maximal-flow problems, Shortest Route problem, Minimal spanning tree problem, Project management– PERT/CPM networks **Game Theory**: Introduction, Two-person zero-sum game, saddle point, pure and mixed strategy, Dominance rule, graphical solution, formulation and solution as an LPP	**10 Hours**

UNIT -4	
Dynamic Programming: Introduction, characteristics of dynamic programming, dynamic programming approach to Capital allocation problem, Knap-sack problem, Travelling salesman problem **Queing Theory:** Introduction, general structure and performance measures of queuing system, Markovian model, Poisson-exponential single server queuing system, self-service system.	**10 Hours**

ESSENTIAL READINGS	
1.	Ravindran A., Philips, D., and Solberg, J. J.; *Operations Research: Principles and Practice*; 2nd edition, John Wiley & Sons Inc.; 2012.
2.	Paneer selvam R.; *Operations Research;*2nd edition, Prentice Hall of India Private Ltd.,; 2009.
3.	Sharma S. D.; *Operations Research: Theory, Methods and Applications*; Kedar Nath; 2012.
ADVANCED READINGS	
1.	Sharma J. K.; *Operations Research*; 3rd edition 2009, Laxmi Publications; 2009.
2.	Yadav S. R. and Malik A. K.; *Operations Research*; 1st edition, Oxford University Press; 2014.
3.	Gupta P. K. and Hira D. S. ; *Operations Research*; 5th edition, S Chand; 1976

CONTROL SYSTEMS LABORATORY					
Course Code	**EE 550**		**Credits**	**1**	
Scheme of Instruction	**L**	**T**	**P**	**TOTAL**	
Hours/ Week	**0**	**0**	**2**	**26 hrs/sem**	
Scheme of Examination	**IA**	**TW**	**TH**	**P**	**O**
TOTAL = 75 marks	**0**	**25**	**0**	**50**	**0**

Course Objectives:

The objective of the course is to provide practical experience in studying control system components and analyzing the systems for stability using simulation software.

Course Outcomes:

The student will be able to:

CO1	Understand the different components and types of control system.
CO2	Apply knowledge of electrical circuits to solve control system applications.
CO3	Analyse the control systems for stability using time and frequency domain methods and simulation software.
CO4	Design various types of controllers and compensators.

Sr.No	**Experimental List**
1	Speed Torque characteristics of AC servomotor.
2	Characteristics of DC servomotor.
3	Study of stepper motor.
4	Characteristics of Synchro transmitter, transmitter-receiver and error detector.
5	DC motor transfer function.
6	Effect of PD, PI and PID controller on second order system.
7	Determination of DC motor gain constants.
8	Transfer function of DC servomotor.
9	Study of control system components.
	Simulations on Matlab/Scilab
10	Modelling a DC servomotor with armature and field control.
11	Time domain response for various undamped frequencies (Wn) and damping factors(ξ)of a second order system
12	Time domain specification of a second order system.
13	Plotting Root locus of a given transfer function.
14	Plotting Bode plot of a given transfer function.
15	Plotting Nyquist plot of a given transfer function.
16	Plotting phase magnitude plot of a given transfer function
17	Design of Lead, Lag and Lead-Lag compensation circuit for a given transfer function. Analyze step response by simulation.

ESSENTIAL READINGS	
1	K. Ogata, “Modern Control Engineering”, Prentice Hall, 1991.
2	I. J. Nagrath and M. Gopal, “Control Systems Engineering”, New Age International,2009
3	M. Gopal, “Control Systems: Principles and Design”, McGraw Hill Education, 1997.
4	B. C. Kuo, “Automatic Control System”, Prentice Hall, 1995.
5	Norman Nise; Control System Engineering; Wiley Edition

*Note Minimum eight experiments should be completed at the end of semester.

MICROPROCESSOR & MICROCONTROLLER LABORATORY					
Course Code	**EE 560**		**Credits**	**1**	
Scheme of Instruction Hours/ Week	**L**	**T**	**P**	**TOTAL**	
	0	**0**	**2**	**26 hrs/sem**	
Scheme of Examination TOTAL = 75 marks	**IA**	**TW**	**TH**	**P**	**O**
	0	**25**	**0**	**50**	**0**

Course Objectives:

The objective of the course is to provide hands on programming on microprocessor (8085) and microcontroller (8051), also study the various Interfacing devices to 8051.

Course Outcomes:

The student will be able to:

CO1	Understand the Instruction sets of 8085 and 8051
CO2	Develop and execute assembly level programming
CO3	Design and interface peripheral devices to microcontroller.
CO4	Build the real time application projects

Sr.No	**Experimental List**
1	Summation of n given numbers: 8085
2	Largest and smallest of N given number:8085
3	Sorting of N numbers:8085
4	Square of a number using procedure.:8085
5	DAC interface to generate Triangular/ Square / Pulse Waveform
6	Alternate glowing of LEDs using 8051
7	Seven segment display interfacing to 8051
8	Stepper motor interfacing to 8051
9	DC motor interfacing to 8051
10	DAC interfacing to 8051
11	ADC Interfacing to 8051
12	LCD interfacing to 8051
13	Mini projects (with the use of Microcontroller)

- **Note Minimum eight experiments should be completed at the end of semester.**

ESSENTIAL READINGS	
1	R. S. Gaonkar, “, Microprocessor Architecture: Programming and Applications withthe 8085”, Penram International Publishing, 1996
2	Mazidi; The 8051 Microcontroller and embedded systems using assembly and C; PHI.
ADVANCED READINGS	
1	Ayala; 8051 Microcontroller Architecture and Programming; Penram International Publisher
2	B. Ram “Fundamentals of Microprocessors and Microcontrollers”,Dhanpat Rai Publications.

ENTREPRENEURSHIP & INTELLECTUAL PROPERTY					
Course Code	**HM004**		**Credits**	**3**	
Scheme of Instruction	**L**	**T**	**P**	**TOTAL**	
Hours/ Week	**3**	**0**	**0**	**39 hrs/sem**	
Scheme of Examination	**IA**	**TW**	**TH**	**P**	**O**
TOTAL = 125 marks	**25**	**0**	**100**	**0**	**0**

Course Objectives:

Students will study concepts of entrepreneurship and financial management. They will also understand the Intellectual Property Rights

Course Outcomes:

The student will be able to:

CO1	Explain the basic concepts in the area of entrepreneurship, financial management and Intellectual Property Rights.
CO2	Apply the concepts of financial management for project appraisal, principle of budgeting &finance and intellectual property rights for entrepreneurial success.
CO3	Analyze the business environment in order to identify business opportunity. Interpret & communicate the information contained in basic financial statements
CO4	Prepare project report, business plan, summarize & interpret the accounting data for managerial decision. Evaluate the different Intellectual Property strategy to protect inventions and innovations of new ventures.

UNIT -1	
Definition and clarification of concept of entrepreneurship: Qualities and skills required for entrepreneurship, Functions of an entrepreneur, Importance of entrepreneur in economic development. **Theories of Entrepreneurship**: Economic theory, Sociological theory, psychological theory. Types of entrepreneurs: Based on type of business, based on use of technology, based on motivation, based on stages of development, based on motive, Based on capital ownership, Danhof's classification. **Project identification**: External environment analysis, Meaning and characteristics of a project, Classification of projects, Project life-cycle, Sources and screening of project ideas. **Project formulation:** Meaning and significance, Feasibility analysis, Techno-economic analysis, Input analysis, financial analysis, social cost benefit analysis. Project feasibility. **Pre-feasibility study:** Project feasibility report - Meaning, Importance and Contents.	**10 Hours**
UNIT -2	
Project financing and institutional finance: Classification of capital – Fixed capital -Meaning, Factors governing fixed capital requirements, working capital–Meaning and concepts, Types, Factors determining working capital requirements. Sources of finance – Share capital, Debenture capital, Lease finance and term loans from commercial banks. Financial aspects: Break even analysis, Income statement, Balance sheet, Fund flow statement, Ratio analysis – Liquidity, leverage and profitability ratios. Capital budgeting – Need, Importance, Process, methods of project evaluation: Payback period, Net Present Value Index.	**10 Hours**

UNIT - 3	
Overview of Intellectual Property: Introduction and the need for intellectual property right (IPR) - Kinds of Intellectual Property Rights: Patent, Copyright, Trade Mark, Design, IPR in India: Genesis and development – IPR in abroad - Major International Instruments concerning Intellectual Property Rights: Paris Convention, 1883, the Berne Convention, 1886, the Universal Copyright Convention 1952, the WIPO Convention 1967, the Patent Co-operation Treaty 1970, the TRIPS Agreement,1994. **Patents -** Elements of Patentability: Novelty, Non-Obviousness (Inventive Steps), Industrial Application - Non - Patentable Subject Matter - Registration Procedure, Rights and Duties of Patentee, Assignment and license, Infringement, Remedies & Penalties - Patent office and Appellate Board. Patent Law in India.	**10 Hours**
UNIT – 4	
Copyright: Nature of Copyright - Subject matter of copyright: original literary, dramatic, musical, artistic works; cinematograph films and sound recordings - Registration Procedure, Term of protection, Ownership of copyright, Assignment and license of copyright-Infringement, Remedies& Penalties – Related Rights - Distinction between related rights and copyrights. **Trademarks:** Concept of Trademarks - Different kinds of marks (brand names, logos, signatures, symbols, well known marks, certification marks and service marks) – Non-Registrable Trademarks - Registration of Trademarks - Rights of holder and assignment and licensing of marks - Infringement, Remedies & Penalties - Trademarks registry and appellate board.	**09 Hours**

ESSENTIAL READINGS	
1.	C.B. Gupta and N.P. Srinivasan; Entrepreneurship; Sultan Chand and Sons; 1997,4/e.
2	Prassanna Chandra; Fundamentals of Financial Management; Tata McGraw Hill; 2001, 3/e.
3	Neeraj P., & Khusdeep, D. Intellectual Property Rights. India, IN: PHI learning Private Limited (2014).
4.	Nithyananda K V. Intellectual Property Rights: Protection and Management. India, IN: Cengage Learning India Private Limited (2019)
5.	Vivek Sood, Cyber Law Simplified, Tata McGraw-Hill, ISBN 0-07-043506-5.
ADVANCED READINGS	
1	Ahuja V K. Law relating to Intellectual Property Rights. India, IN: Lexis Nexis. (2017)
2	Pm buddha Ganguli, Intellectual property right - Unleasbing the knowledge economy, Tata MccrawHill Publishing Company Ltd
3	Patents, copyrights, trademarks and design by B L Wadhera
4	C.B. GuptaandS.S. Khanka;Entrepreneurship and Small Business Management; Sultan Chand and Sons; 1997,2/e.
5	Richard M. Lynch, Robert W. Williamson; Accounting for Management, Planning and Control; Third Edition, Tata McGraw-Hill, New Delhi.

THIRD YEAR: ELECTRICAL & ELECTRONICS ENGINEERING

SCHEME OF INSTRUCTION AND EXAMINATION REVISED COURSE 2019-2020

SEMESTER - VI

Subject Code	Name of the Subject	Scheme of Instruction Hrs/Week				Scheme of Examination							Credit
							Marks						
		L	**T**	**P**	**H**	**Th Duration (Hrs)**	**Th**	**S**	**TW***	**P**	**O**	**Total**	
EE610	Power System – I	3	1	0	**4**	3	100	25	25	0	0	**150**	**4**
EE620	Power Electronics	4	0	0	**4**	3	100	25	0	0	0	**125**	**4**
EE631	Distributed Generation and Microgrid	3	0	0	**3**	3	100	25	0	0	0	**125**	**3**
EE632	Power Quality												
EE633	Digital Control System												
EE634	Artificial Neural Network & Fuzzy Logic												
EE641	Power System Protection	3	0	0	**3**	3	100	25	0	0	0	**125**	**3**
EE642	VLSI Circuit Design												
EE643	Hybrid Vehicles												
EE644	Electrical Energy Conservation & Auditing												
EE650	Electrical and Electronics engineering laboratory	0	0	2	**2**	-	0	0	25	0	25	**50**	**1**
EE660	Power Electronics Lab	0	0	2	**2**	-	0	0	25	50	0	**75**	**1**
**	Open Elective	3	0	0	**3**	3	100	25	0	0	0	**125**	**3**
HM005	Management & Organizational Behavior	3	0	0	**3**	3	100	25	0	0	0	**125**	**3**
TOTAL		**19**	**1**	**4**	**24**	- -	**600**	**150**	**75**	**50**	**25**	**900**	**22**

Students to select ANY ONE subject from EE631, EE632, EE633 and EE634 as Professional elective III and ANY ONE subject from EE641, EE642, EE643 and EE644 as Professional elective IV* Term Work marks are to be awarded through continuous evaluation

POWER SYSTEMS-I					
Course Code	**EE610**		**Credits**	**4**	
Scheme of Instruction	**L**	**T**	**P**	**TOTAL**	
Hours/ Week	**3**	**1**	**0**	**52hrs/sem**	
Scheme of Examination	**IA**	**TW**	**TH**	**P**	**O**
TOTAL = 150 marks	**25**	**25**	**100**	**0**	**0**

Course Objectives:

The objective of this course is to understand the concepts of Power generation, power transmission, power distribution and power utilization

Course Outcomes:

The student will be able to:

CO1	Understand the conventional and non-conventional sources of energy and economic aspects of the same.
CO2	Describe the parameters related to power transmission and power distribution
CO3	Analyze substation design and along with its equipments.
CO4	Calculate the voltage regulation and efficiency of transmission line.

UNIT -1	
Generation: Introduction to Thermal, Hydel, Nuclear and Gas power plants, choice of sites for power plants, cogeneration system, and introduction to distributed generation systems. Economic Aspects: Capital cost, annual fixed and operating costs of plants, depreciation, diversity factor, load factor, plant capacity factor, plant utilization factor, load curves. Tariffs: Need, types, interconnection of power stations.	**10 Hours**
UNIT -2	
Transmission: Basic network of electric power system, Transmission line constants, Resistance, Inductance and Capacitance of single phase and three phase transmission lines, effect of earth, line transposition, steady state analysis of short, medium and long transmission lines, ABCD constants, calculation of regulation and efficiency, sending end/receiving end circle diagrams. Mechanical Design: Transmission line conductors, line supports, insulators, voltage distribution in insulator string, grading, string efficiency. Sag and tension calculations.	**10 Hours**
UNIT -3	
Distribution: Feeders and distributors, criterion for selection of cross section of conductors in distributors and feeders, different types of DC and AC distribution systems, voltage drop calculation, Kelvin's law. Constructional features of LT and HT cables, dielectric stress and grading, thermal characteristics. Substation: Layout, line diagrams, bus bar arrangement, current limiting reactors. Grounding Systems: Neutral and equipment earthing, lightning and its effects.	**10 Hours**

UNIT -4	
Utilization: Illumination: Introduction to lighting schemes, types of lamps, efficiency, principles of lighting calculations, design of indoor and outdoor lighting schemes. Electric Heating: Different methods Resistance, Induction and Dielectric. Operation of Arc furnace and induction furnace. Electric welding **Electric Traction:** Systems of electric traction, power supply system for track Electrification, comparison and application of different systems, traction methods.	**9 Hours**

ESSENTIAL READINGS	
1	V.K.Mehta, Rohit Mehta; Principles of Power System; S.Chand & Company Ltd.
2	B.R.Gupta; Course in Electrical Power; Kataria & Sons
3	C.L.Wadhwa; Electrical power systems; New Age International Ltd.
ADVANCED READINGS	
1	Dr.S.L.Uppal; Electrical Power; Khanna Publications
2	H Partab; Art and Science of Utilisation of Electrical Energy; Dhanpat Rai and Sons
3	H Cotton; Transmission and Distribution of Electric Energy; B.I Publishers

POWER ELECTRONICS					
Course Code	**EE620**		**Credits**	**4**	
Scheme of Instruction	**L**	**T**	**P**	**TOTAL**	
Hours/ Week	**4**	**0**	**0**	**52 hrs/sem**	
Scheme of Examination	**IA**	**TW**	**TH**	**P**	**O**
TOTAL = 125 marks	**25**	**0**	**100**	**0**	**0**

Course Objectives:
The objective of the course is to understand the behaviour of Power switching devices, AC regulators, AC-DC converters. Various DC-DC converters, single phase and three phase Inverters. Knowledge on applications of various power electronics converters circuits will also be imparted to the students.

Course Outcomes:
The student will be able to:

CO1	Understand the working and characteristics of Power switching devices, commutation circuits and various types of converters.
CO2	Analyse the various commutation circuits and all types of power electronics converters.
CO3	Apply Power switching devices and various types of converters in day today use
CO4	Design and implement different converter circuits

UNIT -1	
Power switching devices Thyristor, MOSFET, IGBT: I-V Characteristics; Firing circuit for thyristor; Voltage and current commutation of a thyristor; Gate drive circuits for MOSFET and IGBT. **AC Voltage Controllers:** Introduction, principle of operation of single-phase voltage controllers for R and R-L loads and its applications.	**13 Hours**
UNIT -2	
Thyristor rectifiers Single-phase half-wave and full-wave rectifiers, Single-phase full-bridge thyristor rectifier with R load and highly inductive load; Three-phase full-Bridge thyristor rectifier with R-load and highly inductive load; Input current wave shape and power factor.	**13 Hours**
UNIT -3	
DC-DC buck converter Elementary chopper with an active switch and diode, concepts of duty ratio and average voltage, power circuit of a buck converter, analysis and waveforms at steady state, duty ratio control of output voltage. **DC-DC boost converter**: Power circuit of a boost converter, analysis and waveforms at steady state, relation between duty ratio and average output voltage.	**13 Hours**

UNIT -4	
Single-phase voltage source inverter Power circuit of single-phase voltage source inverter, switch states and instantaneous output voltage, square wave operation of the inverter, concept of average voltage over a switching cycle, bipolar sinusoidal modulation and unipolar sinusoidal modulation, modulation index and output voltage **Three-phase voltage source inverter** Power circuit of a three-phase voltage source inverter, switch states, instantaneous output voltages, average output voltages over a sub-cycle, three- phase sinusoidal modulation.	**13 Hours**

ESSENTIAL READINGS	
1.	M. H. Rashid, "Power electronics: circuits, devices, and applications", Pearson Education India, 2009.
2.	M. D. Singh, K. B. Khanchandani, Power Electronics, Tata McGraw-Hill Publishing Company, second edition.
3.	P. S. Bimbhra; Power Electronics; Khanna Publishers, New Delhi.
4.	L. Umanand, "Power Electronics: Essentials and Applications", Wiley India, 2009
ADVANCED READINGS	
1.	N. Mohan and T. M. Undeland, "Power Electronics: Converters, Applications and Design", John Wiley & Sons, 2007.
2.	R. W. Erickson and D. Maksimovic, "Fundamentals of Power Electronics", Springer Science & Business Media, 2007.

DISTRIBUTED GENERATION & MICROGRIDS					
Course Code	**EE 631**		**Credits**	**3**	
Scheme of Instruction	**L**	**T**	**P**	**TOTAL**	
Hours/ Week	**3**	**0**	**0**	**39 hrs/sem**	
Scheme of Examination	**IA**	**TW**	**TH**	**P**	**O**
TOTAL = 125 marks	**25**	**0**	**100**	**0**	**0**

Course Objectives:

The objective of this course is that on its completion, the students will be able to understand and explain different aspects of Distributed generation and Microgrids. They will be able to access and analyze integration and implementation of different aspects of DG and Microgrids for integration with the conventional grid. Course will be useful for students to get insight into design, operation control, stability and integration aspects of Microgrid.

Course Outcomes:

The student will be able to:

CO1	Understand and assess different aspects of Distributed Generation &Microgrids
CO2	Identify the different Power electronic topologies for effective utilization of distributed generation and Microgrids
CO3	Evaluate and compare performance of different Distributed generation and Power electronic topologies for Microgrids
CO4	Design and model different modes of operation, stability & control of Microgrids

UNIT -1	
Distributed Generation: Concept of distributed generations, need of distributed generation, selection of sources, Renewable sources in distributed generation, Planning of DGs, siting and sizing of DGs, optimal placement of DG sources in distribution systems, regulatory standards/ framework, Standards for interconnecting Distributed resources to electric power systems. IEEE 1547 standard. Energy storage elements: Batteries, ultra-capacitors, flywheels. Different types of interfaces, Inverter based DGs and rotating machine-based interfaces.	**10 Hours**
UNIT -2	
Microgrids: Concept and definition of microgrid, microgrid drivers and benefits, review of sources of microgrids, Types of Microgrids, Autonomous and non-autonomous grids, typical structure and configuration of a microgrid. AC, DC and hybrid microgrids, Power Electronics interfaces in DC, AC and hybrid microgrids, communication infrastructure, sizing of microgrids.	**10 Hours**
UNIT 3	
Impact of Grid Integration: Requirements for grid interconnection, limits on operational parameters: voltage, frequency, THD, response to grid abnormal operating conditions, islanding issues. Impact of grid integration with NCE sources on existing power system: reliability, stability issues. IEEE standards to be followed for grid integration, Power quality aspects in microgrids	**10 Hours**

UNIT -4	
Modes of operation and control: Modes of operation and control of microgrid, Grid connected and islanded mode, Active and reactive power control, protection issues, anti-islanding schemes: passive, active and communication-based techniques, microgrid communication infrastructure. Modelling and Stability analysis of Microgrid, regulatory standards, Microgrid economics, Introduction to smart microgrids, Case study.	**9 Hours**

ESSENTIAL READINGS	
1.	Nikos Hatziargyriou, "Microgrids: Architectures & Control", Wiley press
2.	Ali Keyhani, Mohammad N. Marwali, Min Dai, "Integration of Green and Renewable Energy in Electric Power Systems", Wiley press
ADVANCED READINGS	
1.	Suleiman Sharkh, Mohammad Abusar, Babar Hussain, "Power Electronic converters for Microgrid", IEEE Wiley press
2.	AmirnaserYezdani, Reza Iravani, "Voltage Source Converters in Power Systems: Modelling, Control and Applications", IEEE John Wiley Publications

POWER QUALITY					
Course Code	**EE 632**		**Credits**	**3**	
Scheme of Instruction Hours/ Week	**L**	**T**	**P**	**TOTAL**	
	3	**0**	**0**	**39 hrs/sem**	
Scheme of Examination TOTAL = 125 marks	**IA**	**TW**	**TH**	**P**	**O**
	25	**0**	**100**	**0**	**0**

Course Objectives:

The student will be able to:

1. To understand various types of disturbances contributing to power quality (PQ)issues, evaluate PQ parameters and indices, and apply suitable mitigation strategies.
2. To be able to measure and analyze of power quality data and evaluate PQ indices.

Course Outcomes:

CO1	Understand various harmonic sources, types of PQ disturbances, PQ parameters and indices, and mitigation strategies.
CO2	Explain / Discuss the types and characteristics of PQ disturbances, types and operating principle of mitigation devices and various measurements
CO3	Analyze various components of a power signal under disturbance conditions, analyze single phase & three phase circuits for sinusoidal & and non sinusoidal voltage source, balanced, unbalanced loads, Linear and Nonlinear load
CO4	Calculate rating of mitigating devices

UNIT -1	
Introduction to Power Quality: Definition of Power Quality, Power Quality Terminology, Power Quality Issues, Susceptibility Criteria, Responsibilities of Power Suppliers and Users, Power Quality Standards- IEEE Standards519 and 1159. **Power Frequency Disturbance:** Introduction to Power Frequency Disturbance, Common Power Frequency Disturbances, Cures for Low Frequency Disturbances, Voltage Distortion, Voltage Sag, Voltage Swell, Impulsive Transient, Oscillatory Transient, Interruption, Notching, Voltage Fluctuations and Flicker, Voltage Imbalance, Voltage Tolerance Criteria- ITIC Graph. **Electrical Transients:** Introduction to Transients, Transient System Model, Examples of Transient Models and Their Response. Power System Transient Modeling, Types and Causes of Transients, Examples of Transient Waveforms.	**10 Hours**
UNIT -2	
Power & Power Factor: Analysis of single phase & three phase circuits for sinusoidal & non sinusoidal voltage source, balanced, unbalanced loads, Linear and Nonlinear loads. Apparent, Active and Reactive Power, Displacement and True Power Factor, Arithmetic & vector power factor. Power Factor correction: Methods and advantages of correction. **Harmonics:** Definition of Harmonics, Harmonic Number (h), Odd and Even Order Harmonics, Harmonic Phase Rotation and Phase Angle, Voltage and Current Harmonics, Individual and Total Harmonic Distortion, Harmonic	**10 Hours**

Signatures. Effect of Harmonics on Power System Devices, Guidelines for Harmonic Voltage and Current Limitation, Harmonic Current Mitigation. **Harmonic Current Sources:** Single and Three-Phase Rectifiers, High-Frequency Fluorescent Ballasts, Transformers, Switch Mode Power Supplies, LED lamps and other systems and loads that draw Harmonic Currents	
UNIT -3	
Mitigation: **Passive Filters:** Introduction, Practical Considerations in the design & use of Passive Filters. **Active series and shunt mitigation devices:** DSTATCOM and DVR - configuration and working principle. **Active Power Filters (APF):** Introduction, Types - Shunt, Series and Hybrid, Principle of operation, control and their applications, determination of APF Rating. **Power Quality Benchmark:** Introduction, benchmark process, power quality contract.	**10 Hours**
UNIT -4	
Measuring And Solving Power Quality Problems: Introduction to Power Quality Measurements, Power Quality Measurement Devices, Power Quality Measurements Test Locations, Test Duration, Instrument Setup, Instrument Guidelines, Assessing power quality data, data analysis. **Methods For Correction Of Power-Quality Problems**: Introduction, Various Correction Methods, Remedies from Customer side & Utility side. Power quality state estimation, including power quality in distribution planning. Distributed generation and quality.	**9 Hours**

ESSENTIAL READINGS	
1	Math H. Bollen, “Understanding power quality problems”, IEEE press.
2	Bhim Singh, Ambrish Chandra, Kamal Al-Haddad, “Power quality Problems and Mitigation Techniques”, Wiley publishers
3	A. Ghosh, G. Ledwich, “Power Quality Enhancement using custom power devices”, Kluwer Academic publications.
ADVANCED READINGS	
1	Roger C. Dugan et al., “Electrical Power System Quality”, Tata McGraw-Hill.
2	C. Sankaran, “Power Quality”, CRC Press.

DIGITAL CONTROL SYSTEM					
Course Code	**EE633**		**Credits**	**3**	
Scheme of Instruction	**L**	**T**	**P**	**TOTAL**	
Hours/ Week	**3**	**0**	**0**	**39hrs/sem**	
Scheme of Examination	**IA**	**TW**	**TH**	**P**	**O**
TOTAL = 125 marks	**25**	**0**	**100**	**0**	**0**

Course Objectives:

The objective of this course is to familiarize the students with the discrete time signal systems, Z transforms. They should be able to design discrete control system.

Course Outcomes:

The student will be able to:

CO1	Understand the fundamental concepts of digital control, discrete representation, sample and hold circuits, pulse transfer functions, state space models, discrete PID controller, discrete output feedback control
CO2	Apply the mathematical relations to determine sampling frequency, Z-transforms, inverse Z-Transforms, stability of a discrete time system, state space models, parameters of a PID controller, parameters for feedback control
CO3	Analyze the systems for time domain analysis, stability analysis, controllability, reconstructability and observability analysis, State feedback controller, periodic output feedback controller.
CO4	Compute the ZOH equivalent, time response of discrete time systems, stability and design the discrete PID controller, set point tracker, discrete compensator and discrete output feedback control.

UNIT -1	
Discrete Representation of Continuous Systems Basics of Digital Control Systems. Discrete representation of continuous systems. Sample and hold circuit. Mathematical Modelling of sample and hold circuit. Effects of Sampling and Quantization. Choice of sampling frequency. ZOH equivalent. **Discrete System Analysis** Z-Transform and Inverse Z Transform for analyzing discrete time systems. Pulse Transfer function. Pulse transfer function of closed loop systems. Mapping from s-plane to z plane. Solution of Discrete time systems. Time response of discrete time system.	**10 Hours**
UNIT -2	
Stability of Discrete Time System Stability analysis by Jury test. Stability analysis using bilinear transformation. Design of digital control system with dead beat response. Practical issues with dead beat response design. **State Space Approach for discrete time systems** State space models of discrete systems, State space analysis. Lyapunov Stability. Controllability, reach-ability, Reconstructibility and observability analysis. Effect of pole zero cancellation on the controllability &observability.	**10 Hours**

UNIT 3	
Design of Digital Control System Design of Discrete PID Controller, Design of discrete state feedback controller. Design of set point tracker. Design of Discrete Observer for LTI System. Design of Discrete compensator.	**10 Hours**
UNIT -4	
Discrete output feedback control Design of discrete output feedback control. Fast output sampling (FOS) and periodic output feedback controller design for discrete time systems.	**9 Hours**

ESSENTIAL READINGS	
1.	K. Ogata, "Digital Control Engineering", Prentice Hall, Englewood Cliffs, 1995.
2.	M. Gopal, "Digital Control Engineering", Wiley Eastern, 1988.
3.	G. F. Franklin, J. D. Powell and M. L. Workman, "Digital Control of Dynamic Systems", Addison-Wesley, 1998.
4.	B.C. Kuo, "Digital Control System", Holt, Rinehart and Winston, 1980
ADVANCED READINGS	
1.	Rolf Isermann,"Digital Control Systems" Springer
2.	Charles L. Phillips, H. Troy Nagle , "Digital control system analysis and design" Pearson

ARTIFICIAL NEURAL NETWORK AND FUZZY LOGIC					
Course Code	**EE 634**		**Credits**	**3**	
Scheme of Instruction	**L**	**T**	**P**	**TOTAL**	
Hours/ Week	**3**	**0**	**0**	**39 hrs/sem**	
Scheme of Examination	**IA**	**TW**	**TH**	**P**	**O**
TOTAL = 125 marks	**25**	**0**	**100**	**0**	**0**

Course Objectives: Students will get familiarized with the techniques used in the soft computing methods using fuzzy logic and neural network.

Course Outcome:

CO1	Understand the concept of soft computing methods of neural networks and fuzzy logic
CO2	Apply the neural network system and fuzzy logic system
CO3	Analyze soft computing methods in practical systems
CO4	Design various controllers using Fuzzy logic and Neural Networks

UNIT -1	
Soft computing Techniques: Introduction to of Neural Network, Fuzzy Logic. Advantages of using soft computational methods over conventional method. **Fuzzy Logic**: Fuzzy logic vs Crisp Logic, Fuzzy sets, Basic Fuzzy set operation, Properties of Fuzzy sets, Fuzzy relations. Membership functions. Applications of fuzzy sets in fuzzy reasoning and fuzzy clustering.	**10 Hours**
UNIT -2	
Fuzzy rule-based system. Introduction to fuzzification and defuzzification methods Fuzzy inference, Mamdani and Sugeno types, design parameters-linguistic hedges, developing membership functions. **Design of fuzzy controllers**- Speed control, Air conditioner Control, washing machine control and Industrial applications.	**9 Hours**
UNIT -3	
Introduction to Neural Network: Biological neurons and memory: Structure and function of a single neuron; Mathematical Model Artificial Neural Networks (ANN). Supervised Learning: Single-layer networks; Perceptron-Linear separability, Training algorithm, Limitations; Multi-layer networks-Architecture, Back Propagation Algorithm (BTA) and its applications. **Adaptive Multi-layer networks**-Architecture, training algorithms; Recurrent Networks; Feed-forward networks; Radial-Basis-Function (RBF), Support Vector machine.	**10 Hours**
UNIT -4	
Associated Models: Auto associative and Hetero associative memory models. Hopfield Networks, Bidirectional Memory network. **Unsupervised Learning**: Winner-takes-all networks; Hamming networks; Maxnet; Simple competitive learning; Vector- Quantization; Counter propagation networks; Adaptive Resonance Theory; Kohonen's Self-organizing Maps; Principal Component Analysis. Typical applications of ANN.	**10 Hours**

ESSENTIAL READINGS	
1.	Simon Haykin, Neural Networks - A Comprehensive Foundation, Macmillan Publishing Co., New York, 1994.
2.	Timothy J. Ross - Fuzzy Logic with Engineering Applications, Willey Publication.
3	Neural networks, Fuzzy logic, and Genetic algorithms : Synthesis and Applications S. RAJASEKARAN and G.A. VIJAYALAKSHMI PAI, PHI
ADVANCED READINGS	
1.	J. M. Zurada, Introduction to Artificial Neural Networks, (Indian edition) Jaico Publishers, Mumbai, 1997.
2.	K. Mehrotra, C.K. Mohan and Sanjay Ranka, Elements of Artificial Neural Networks, MIT Press, 1997 - [Indian Reprint Penram International Publishing (India), 1997]

POWER SYSTEM PROTECTION					
Course Code	**EE 641**		**Credits**	**3**	
Scheme of Instruction	**L**	**T**	**P**	**TOTAL**	
Hours/ Week	**3**	**0**	**0**	**39 hrs/sem**	
Scheme of Examination	**IA**	**TW**	**TH**	**P**	**O**
TOTAL = 125 marks	**25**	**0**	**100**	**0**	**0**

Course Objectives:

The objective of this course is to make a student

1. Understand the concept of protective relaying.
2. Study the different protection systems for alternator, transformer and motor.
3. Familiarize with the protection of transmission lines and bus bars and protection against lightning as well as different types of system earthing
4. To study the difference between fuses, circuit breakers and it's working.

Course Outcomes:

The student will be able to:

CO1	Understand the basic concepts of protective relaying.
CO2	Apply different protection for alternator, transformer, Induction motor, transmission lines, bus bars and protections against lightning.
CO3	Analyze different types of fuses, circuit breakers, their opening & closing mechanisms as well as methods used in arc extinction
CO4	Design numerical relays for protection of various components of power system

UNIT -1	
Protective system: Introduction, need of C.T& P.T., protective relay & circuit breaker, Main protection & back up protection, Zone of protection **Protective Relays:** Fundamental requirements of protective relaying, Electromagnetic Induction relay, its working principle. Different types of over current relays, IDMT relay. Directional relays, Classification of directional relays based on the method of connection. Need of directional relay & distance relay. Types of distance relays impedance relay, reactance relay, mho relay, differential relay, relay setting and operating time. Overview of digital protection. **Static and Digital relaying:** Overview of static relay, block diagram, operating principle, merits and demerits of static relay, introduction and functional block diagram of numerical relay, sampling theorem, anti-Aliasing filter. Surge protection &signal conditioning device, merits and demerits of Numerical relays.	**10 Hours**
UNIT -2	
Differential protection of alternator: Earth fault protection, restricted earth fault protection, stator sensitive earth fault protection, leakage to frame protection, protection against unbalanced loads. Numerical protection of generator. **Protection of transformers**: Differential protection, over current and earth fault protection, restricted earth fault protection, gas actuated devices used for	**10 Hours**

protection, thermal protection, overfluxing protection. Numerical protection of transformer **Protection of Induction motors:** Protection of 3 phase motors against over current, protection against single phasing and phase reversals, rotor protection against rotor faults. Numerical protection of Induction motor.	
UNIT 3	
Protection of transmission lines and bus bars: Time graded protection, current graded protection, distance protection, carrier assisted distance protection, carrier current protection. Realization of distance relays (impedance, reactance and mho relay) using numerical relaying algorithm (flowchart, block diagram), Numerical protection of busbar. WAP& WAM, Synchronous phasor measurements. **Network protection with renewable energy resources.** **Protection against over voltages:** causes of over voltages & their protections. Protection against lightning. Mechanism of lightning, insulation coordination, types of lightning arrestors, surge absorbers **Neutral earthing**-Types of neutral earthing, isolator earthing switch. Grounding transformer	**10 Hours**
UNIT -4	
Protection against short circuit & overloads Short circuit protection devices: Fuses, desirable characteristics of a fuse element, types of fuses and their constructional features, difference between fuse and circuit breakers. Selection of fuses. Overload protection devices such as contactors, MCB& MCCB **Theory of circuit breakers:** Fundamental of fault clearing, switching phenomena in circuit breakers, arc formation and arc extinction in circuit breakers, Criteria for selection of ratings of circuit breakers **Types of circuit breakers:** Construction and principle of arc extinction in SF6 gas circuit breakers, vacuum circuit breakers Their merits & demerits. Difference between MCB and MCCB, switch fuse unit and fuse switch unit. ELCB- its types & working principle	**09 Hours**

ESSENTIAL READINGS	
1.	Sunil S. Rao; Switchgear and Protection; Khanna Publisher
2.	Paithankar YG & Bhide SP; Fundamentals of Power System Protection; PHI
3.	S. Badriram; Power system Protection; TMH
ADVANCED READINGS	
1.	M V Deshpande; Switchgear and Protection; TMH
2.	Ravindranath and Chander; Power system protection; NewAge
3.	T. S. Rao; Power system Protection static Relays with microprocessor application; TMH

VLSI CIRCUIT DESIGN					
Course Code	**EE642**		**Credits**	**3**	
Scheme of Instruction	**L**	**T**	**P**	**TOTAL**	
Hours/ Week	**3**	**0**	**0**	**39 hrs/sem**	
Scheme of Examination	**IA**	**TW**	**TH**	**P**	**O**
TOTAL = 125 marks	**25**	**0**	**100**	**0**	**0**

Course Objectives:

The objective of this course is to make the students aware of MOS transistor, its modeling, scaling and effects of small device geometry. It will equip students with skills for designing and test various implementations of CMOS combinational and sequential Circuits They will also learn concepts of High-level VLSI design using HDL and FPGA.

Course Outcomes:

The student will be able to:

CO1	Understand MOS system, Scaling, Inverters, Design rules, CMOS fabrication, VLSI testing and VHDL basic language elements
CO2	Apply MOSFET characteristics, scaling, small geometry effects, CMOS Layout Inverter characteristics, Combinational and sequential Logic Circuits, fault models for testing, VHDL modelling styles.
CO3	Analyse MOS transistor modelling, stick diagrams for combinational and sequential circuits, testing, VHDL programming, simulation and synthesis.
CO4	Design MOS inverters, Combinational and sequential circuits, Fault models and digital systems using VHDL programming.

UNIT -1	
MOS transistor: Structure, MOS system under external bias, operating regions, threshold voltage, MOSFET I-V characteristics. **MOSFET Scaling and small geometry effects**: Full scaling, constant voltage scaling, short channel effects, narrow channel effects, MOSFET capacitances. **Spice Modeling**: Modeling of MOS transistor using SPICE Level1 model equations.	**10 Hours**
UNIT -2	
Inverters: Passive and Active load MOS inverters, CMOS Inverter - Design, DC characteristics, Noise Margin, Power and Area considerations. **CMOS Layout:** Design rules, stick diagrams. **Combinational MOS Logic circuits**: CMOS NOR, NAND Logic circuits, Complex logic circuits, Euler's path, Adder circuits, Transmission gates.	**10 Hours**
UNIT 3	
Sequential MOS Logic Circuits: Latches, flip-flops, registers. **CMOS technology:** Basic n-well and p-well CMOS process fabrication steps.	**10 Hours**

Validation and testing: Design for Testability (DFT), Scan – Based Test, Boundary Scan Design, Built in self test(BIST),Built in Logic Block Observer (BILBO), Linear Feedback Shift Register (LFSR), Automatic Test-Pattern generation (ATPG), fault models.	
UNIT -4	
VHDL: Introduction, Basic language elements - identifiers, data objects, data types, entity, architectures, signals and variables. **Modeling styles**: Behavioral modeling. Sequential processing statements. Dataflow modeling, on current signal assignment and conditional signal assignment statements. Structural modeling, Component declaration, instantiation. Generics, Attributes, Configuration, Packages, Libraries. **VHDL Simulation:** Simulation delta, transport and inertial delay models, test bench. VHDL Synthesis**.**	**9 Hours**

ESSENTIAL READINGS	
1.	Sung-Mo Kang Yusuf Leblebici," CMOS Digital Integrated Circuits Analysis and design" Tata McGraw Hill Publication.
2.	Douglas Pucknell, Kamran Eshraghian, "Basic VLSI Design"
3.	Jan M. Rabaey ,"Digital Integrated Circuits " Prentice Hall India
4.	J. Bhaskar, "VHDL Primer"
ADVANCED READINGS	
1.	Douglas Perry ,"VHDL Programming by Example " Tata McGraw Hill Publication
2.	DebaprasadDas ," VLSI Design "Oxford University Press.

HYBRID VEHICLES					
Course Code	**EE 643**		**Credits**	**3**	
Scheme of Instruction Hours/ Week	**L**	**T**	**P**	**TOTAL**	
	3	**0**	**0**	**39 hrs/sem**	
Scheme of Examination TOTAL = 125 marks	**IA**	**TW**	**TH**	**P**	**O**
	25	**0**	**100**	**0**	**0**

Course Objectives:

The objective of this course is that on its completion, the students will be able to assess and explain different aspects of Hybrid vehicles. They will be able to do assessment of the various electric drive trains and storage systems that can be used in Hybrid vehicles. Course will be useful for students to get insight in to sizing, modelling, operation and control aspects of Hybrid Electric Vehicles.

Course Outcomes:

The student will be able to:

CO1	Assess and analyze various aspects of Hybrid vehicles
CO2	Identify the various methodologies / technologies for integrating electric drive train topologies for Hybrid vehicles
CO3	Compare and size the different storage systems for Hybrid vehicles
CO4	Design, evaluate and do modelling of Hybrid electric vehicles subsystems

UNIT -1	
Introduction to Hybrid Electric Vehicles: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies. Conventional Vehicles: Basics of vehicle performance, vehicle power source characterization, transmission characteristics, mathematical models to describe vehicle performance **Electric Drive-trains**: Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis	**10 Hours**
UNIT -2	
Hybrid Electric Drive-trains: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive- train topologies, fuel efficiency analysis. **Electric Propulsion unit:** Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency.	**9 Hours**

UNIT 3	
Energy Storage: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Super Capacitor based energy storage and its analysis, Flywheel based energy storage and its analysis, Hybridization of different energy storage devices **Sizing the drive system**: Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, Communications, supporting subsystems.	**10 Hours**
UNIT -4	
Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies. **Model-based development of HEV**: Modelling of a HEV and its subsystems, HEV performance measurements and system analysis, design and sizing Case Studies: Design of a Hybrid Electric Vehicle(HEV),Design of a Battery Electric Vehicle(BEV)	**10 Hours**

ESSENTIAL READINGS	
1.	Iqbal Hussein, “Electric and Hybrid Vehicles: Design Fundamentals”, CRC press
2.	James Larminie, John Lowry, “Electric Vehicle Technology Explained”, Wiley press
ADVANCED READINGS	
1.	Lino Guzella, Antonio Sciarretta, “Vehicle Propulsion Systems :- Introduction to Modelling and Optimization”, Wileypress
2.	Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, “Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design”, CRC press

ELECTRICAL ENERGY CONSERVATION & AUDITING					
Course Code	**EE 644**		**Credits**	**3**	
Scheme of Instruction	**L**	**T**	**P**	**TOTAL**	
Hours/ Week	**3**	**0**	**0**	**39hrs/sem**	
Scheme of Examination	**IA**	**TW**	**TH**	**P**	**O**
TOTAL = 125 marks	**25**	**0**	**100**	**0**	**0**

Course Objectives:

The objective of this course is that on its completion, the students will be able to understand different aspects of Energy auditing and management. They will be able to do environmental, economic assessment of the various energy resources used in Industry. Course will be useful to undertake the audit of various equipment's and suggest suitable energy conservation and efficiency measures for domestic as well as Industrial applications.

Course Outcomes:

The student will be able to:

CO1	Understand various aspects of energy use, energy conservation measures, energy audits and environmental impacts
CO2	Apply the various methodologies / technologies for effective utilization of energy sources and promotion of energy efficiency
CO3	Analyze the Plan and carry out practical energy audit of various sectors
CO4	Compute the analysis of the environmental and cost economics of using energy in various sectors

UNIT -1	
General aspects of energy management: Classification of energy, Primary & secondary Energy, Commercial and non-commercial Energy, Renewable and non- renewable Energy, Energy scenario, Energy pricing, Energy sector reforms, Energy Security. Energy Conservation and its importance, EC act 2001, Schemes of Bureau of Energy Efficiency (BEE) including designated consumers, state designated agencies, Definition and objectives of Energy Management, Energy Audit, Types and methodologies, Energy auditing report format, Energy Audit Instruments, Benchmarking and Energy performance, Energy Management centers and their importance, Energy and Environment	**10 Hours**
UNIT -2	
Energy efficiency in electrical utilities: Electrical system, Electric motors, Compressed air system, HVAC and refrigeration system, Pumps, pumping system. Lighting system, DG set system, Demand side Management, load control, Energy efficient technologies in Electrical system. Economics of power factor improvement. Power Quality issues related to energy efficient technologies.	**10 Hours**

UNIT 3	
Energy efficiency in thermal utilities: Fuels and combustion, Boiler systems, Boiler types and classification, performance evaluation of Boilers, Boiler Blowdown, energy conservation opportunities. Steam system, Furnaces, Insulation, Refractories, Cogeneration, Waste heat recovery Systems.	**09 Hours**
UNIT -4	
Economics and Finance: Project management, steps in project management, project planning techniques Case studies of energy audit projects. Energy performance contracts and role of Energy Service Companies. Financial management, investment need, Appraisal and criteria for Energy management projects, financial analysis techniques, Sensitivity and risk analysis, financing options, costing techniques, life cycle/levelized cost.	**10 Hours**

ESSENTIAL READINGS	
1.	Amlan Chakrabarti, "Energy engineering and management", Prentice Hall India
2.	Wayne C. Turner, Steve Doty, "Energy Management Handbook", Lulu press
ADVANCED READINGS	
1.	W.R .Murphy, G. McKay, "Energy Management", Butterworths Publisher
2.	Bureau of Energy Efficiency, "Study material for Energy Managers and Auditors Examination Paper I to IV", BEE /NPC publications

ELECTRICAL & ELECTRONICS ENGINEERING LABORATORY					
Course Code	**EE 650**		**Credits**	**1**	
Scheme of Instruction	**L**	**T**	**P**	**TOTAL**	
Hours/ Week	**0**	**0**	**2**	**26 hrs/sem**	
Scheme of Examination	**IA**	**TW**	**TH**	**P**	**O**
TOTAL = 50 marks	**0**	**25**	**0**	**0**	**25**

Course Objectives:

Students will familiarize with the various measuring instruments and working of electrical drives. Also they will understand various electrical and electronics engineering related experiments

Course Outcomes:

The student will be able to:

CO1	Understand the working of various measuring instruments, and modes of operation of electrical drives
CO2	Apply right type of braking, calibration of instruments
CO3	Analyze performance of electrical drives and measuring instruments
CO4	Compute the various parameters of drives and measuring instruments.

SN	Experimental List
1	Dynamic braking in D.C. shunt motor
2	Plugging in D.C. shunt motor
3	Plugging in 3 ph induction motor
4	A.C /D.C Dynamic braking in induction motor
5	Dynamic braking of Synchronous motor
6	Extension of range of wattmeter by using C.T &P.T
7	Extension of range of 1ph & 3 ph energy meter by using C.T. & P.T
8	Use of CLIP ON METER (Tong tester) for current & voltage measurements, Frequency meter & p.f. meter
9	To study the calibration of Trivector meter
10	Measurement of reactive power
11	Measurement of low resistance by using Kelvin's Double Bridge
12	Measurement of earth resistance of a wiring system by using earth tester
13	Study of I-V ,P-V characteristics of Solar Panel.

14	Study of Numerical Relay. IDMT Relay
15	Study and Use of PQ Analyzer
16	Study the operating characteristics and parameters of different types of lighting sources.
17	Representation of Basic signals and their transformation.
18	Discrete Convolution and correlation
19	Design Fuzzy logic controller
20	Characteristics of nmos, pmos transistors

POWER ELECTRONICS LABORATORY					
Course Code	**EE 660**		**Credits**	**1**	
Scheme of Instruction	**L**	**T**	**P**	**TOTAL**	
Hours/ Week	**0**	**0**	**2**	**26 hrs/sem**	
Scheme of Examination	**IA**	**TW**	**TH**	**P**	**O**
TOTAL = 75 marks	**0**	**25**	**0**	**50**	**0**

Course Objectives:

The objective of the course is to provide practical experience in assembling and testing various power electronic circuits.

Course Outcomes:

The student will be able to:

CO1	Understand the behaviour of power electronics devices, commutation circuits and various converters.
CO2	Applytheknowledgetoimplementpowerelectroniccircuitsandinterpretandverify the output of various converter circuits.
CO3	Compare between different implementations practically and experiment with the working
CO4	Simulate, assemble and test various power electronics converter circuits

List of Experiments:

(At least 8 experiments should be conducted from the list of experiments.)

1	SCR characteristics
2	Power MOSFET and IGBT characteristics.
3	Commutation circuits (class A, B, C).
4	Single phase half-controlled converter.
5	Single phase Full controlled converter.
6	AC voltage converter using TRIAC
7	Parallel bridge inverter
8	Series inverter
9	DC Chopper
10	DC-DC buck boost converter
11	Simulation of single phase fully controlled converter with R-L-E load
12	Simulation of single-phase voltage source inverter with R and RL load
13	Single phase Dual converter

Mini Project

Each batch (15-20 students) to carry out a mini project on the topics listed below or any other topic offered.

1. Firing circuit for fully controlled converter
2. Firing circuit for a closed loop Buck Regulator
3. Firing circuit for a closed loop Boost Regulator
4. Firing circuit for a single-phase Inverter
5. Controller for closed loop Buck or Boost Regulator

MANAGEMENT & ORGANIZATIONAL BEHAVIOUR					
Course Code	**HM005**		**Credits**	**3**	
Scheme of Instruction Hours/ Week	**L**	**T**	**P**	**TOTAL**	
	3	**0**	**0**	**39 hrs/sem**	
Scheme of Examination TOTAL = 125 marks	**IA**	**TW**	**TH**	**P**	**O**
	25	**0**	**100**	**0**	**0**

Course objectives:

To help students understand the management of behavior in organizations and to know how organizational behavior affects performance and effectiveness. To understands the dynamics of individual and group behavior in organizations. To help students understand how perceptions, attitudes and values influence their work and professional relationships.

Course outcomes:

The students will be able to:

CO1	Explain why organizational behavior is important for managerial decision making and creating a functional organization.
CO2	To appreciate and accommodate differences in perceptions, attitudes and personality and use this to work effectively with diverse individuals and Heterogeneous groups.
CO3	To understand how emotions and stress impact the management of organizational functioning.
CO4	To understand organizational dilemmas from an individual and interpersonal lens.

UNIT 1	
Introduction to organizational behavior, to review the reasons for joining organizations. Understanding the importance of organizational behavior in organizations. Understanding the self–to be able to reflect, understand and observe patterns of being in self. Understanding the Johari Window Framework. **Perception:** Definitions and concept of perception, exploring the factors that influence perception, the perceptual processes that affect the communicator's perception of others. **Individual decision making**- the cognitive shortcuts and biases the individual has and how they affect decision making.	**10 Hours**
UNIT 2	
The role of individual in the organization: Attitudes and job satisfactions – nature of attitudes- type of work attitudes, job satisfaction, job involvement, organizational commitment, types of organizational commitment, developing organizational commitment, and job satisfaction and employee performance. **Personality and values:** Definition and concept of personality, factors that determine an individual's personality. The Big Five personality model – Personality traits relevant to organizational behavior. Linking an individual's personality and values to the workplace.	

Motivation – Theories of work motivations, contemporary approaches and applications- linking employee involvement programs and motivation theories. Employee recognition, employee involvement, variable pay and flexible benefits.	**10 Hours**
UNIT 3	
Interpersonal skills and group processes. Understanding teams – creating effective teams- turning individuals Into team players – evaluating team performance and understanding team diversity – the management and assimilation of cultural differences Team processes, team work, factors determining the success of a team, team work. Difference between group and team Stages of group development- group norms, group structure, group status Group cohesiveness and group performance Group decision making – groupthink, group shift- group decision making techniques The nature of interpersonal skills- how interpersonal relationships influence teams and what managers do. **Communication:** Functions of organizational communications- the communication process. Electronic communications, managing information, the grapevine Barriers to communications Managing leadership and communication Trait Theories. Behavioral Theories: The leadership construct and the need for creating leaders in the managerial world.	**10 Hours**
UNIT 4	
Organizational culture: Definition and concept of organizational culture What do culture do? – Creating and Sustaining cultures. Notion of ethics and spirituality inorganizations. **Power and politics:** Understanding the dynamics of power and politics- social influence, individual power, the tactics of power, organizational politics and factors contributing to political behavior Conflict management – views of conflict. Organizational change and stress management Defining stress and identifying its potential sources. Identifying the consequences of stress Individual and organization approach to stress.	**9 Hours**

ESSENTIAL READINGS	
1	Greenberg J. and Baron R. – Behavior in Organizations , 8thEdition, Pearson Prentice Hal
2	Newstrom, J. and Davis, K. (1989)- Organizational Behavior : readings and exercises : 8thedition , New York: Mcgraw Hill
ADVANCED READINGS	
1	Aswathappa K. (2012) Organizational Behavior : Texts, cases and games , 10thedition, Himalaya Publishing House
2	Robbins, Timothy Judge, NeharikaVohra , 14thedition Pearson – Organisational Behavior
3	K. Aswathappa , Human Resource Management : Text and cases , 7thedition , Mc Graw Hill Education 2015

FOURTH YEAR: ELECTRICAL & ELECTRONICS ENGINEERING

SCHEME OF INSTRUCTION AND EXAMINATION REVISED COURSE 2019-2020

SEMESTER - VII

Subject Code	Name of the Subject	Scheme of Instruction Hrs/Week				Scheme of Examination							Credit
							Marks						
		L	T	P	H	Th Duration(Hrs)	Th	S	TW*	P	O	Total	
EE710	Power Systems - II	3	1	0	**4**	3	100	25	25	0	0	**150**	**4**
EE721	Flexible AC Transmission System	3	0	0	**3**	3	100	25	0	0	0	**125**	**3**
EE722	Image Processing												
EE723	Smart Grid												
EE724	PLC & Its Applications												
EE730	Power System Lab	0	0	2	**2**	--	0	0	25	0	25	**50**	**1**
**	Open Elective	3	0	0	**3**	3	100	25	0	0	0	**125**	**3**
EE740	Internship	0	0	6	**6**	--	0	0	50	0	50	**100**	**3**
EE750	Project Work - Phase I	0	0	6	**6**	--	0	0	50	0	75	**125**	**3**
TOTAL		**9**	**1**	**14**	**24**	**--**	**300**	**75**	**150**	**0**	**150**	**675**	**17**

Students to select ANY ONE subject from EE721, EE722, EE723 and EE724 as Professional elective V

*Term Work marks are to be awarded through continuous evaluation

POWER SYSTEMS-II					
Course Code	**EE710**		**Credits**	**4**	
Scheme of Instruction	**L**	**T**	**P**	**TOTAL**	
Hours/ Week	**3**	**1**	**0**	**52 hrs/sem**	
Scheme of Examination	**IA**	**TW**	**TH**	**P**	**O**
TOTAL = 150 marks	**25**	**25**	**100**	**0**	**0**

Course Objectives:

The objective of this course is to understand the response of the power system under steady-state and transient conditions and to model and analyse the power system under steady-state and transient conditions.

Course Outcomes:

The student will be able to:

CO1	Understand the response of the power system under steady-state and transient conditions.
CO2	Describe the concept of power flow, faults, and stability.
CO3	Analyse power flow and stability performance for power systems
CO4	Model and analyse the Power system under steady-state and transient conditions.

UNIT -1	
Basic components of power system, their models, Single line diagram, impedance diagram, reactance diagram, Per unit system, equivalence of per unit impedance of transformer on LT and HT side, change of base. Symmetrical components, resolution of symmetrical components, Sequence networks, Determination of zero sequence network of transformers, Formation of sequence networks of power system, sequence voltages of Generator.	**10 Hours**
UNIT -2	
Fault analysis– Faults on power system, Analysis of symmetrical balanced three phase fault, short circuit MVA, computation of short circuit capacity and fault currents. Current limiting reactors – functions, selection and location in power system. Representation of unsymmetrical faults –Single line to ground fault, line to line fault and double line to ground fault. Their analysis using sequence networks. Control of voltage profile. Introduction to reactive power control.	**10 Hours**
UNIT -3	
Load flow analysis – Neccessity of load flow studies, Classification of Buses, Formation of YBUS by singular transformation. Static load flow equations, Gauss-Seidal method – with PV bus present and absent, Q-limit check for voltage controlled buses. Newton Raphson method– with PV bus present and absent, Q-limit check for voltage-controlled buses. Economic Load Dispatch – Neglecting losses and Generator limits, Neglecting losses and including generator limits. Transmission loss coefficients, penalty factor.	**10 Hours**

UNIT -4	
Power system stability analysis – Importance of stability studies, Classification of Power system stability- steady state stability, transient stability and Dynamic stability. Maximum steady state power transfer, Power angle equation, Power angle curve, Methods of improving steady state stability. Rotor dynamics, constants of rotor, swing equation, swing curve, synchronizing power coefficients. Equal area criterion, Critical clearing angle, Multimachine stability. Factors affecting transient stability and methods for its improvement.	**9 Hours**

ESSENTIAL READINGS	
1	I. J. Nagrath and D. P. Kothari; Modern Power System Analysis; Tata McGraw Hill.
2	Hadi Sadaat; Power System Analysis; Tata McGraw Hill.
3	Stevenson W.D. Jr and Grainger; Elements of Power System Analysis; Tata McGraw Hill.
4	B R Gupta; Electrical Power System; S. Chand and Company Ltd.
ADVANCED READINGS	
1	C. L. Wadhwa; Electrical Power Systems; New Age International.
2	B M Weedy; Electrical Power Systems; John Wiley and Sons.
3	M. A. Pai; Computer Techniques in power system; Tata McGraw Hill.
4	P Kundur; Power System Stability and Control; Tata McGraw Hill.

FLEXIBLE AC TRANSMISSION SYSTEM					
Course Code	**EE721**		**Credits**	**3**	
Scheme of Instruction	**L**	**T**	**P**	**TOTAL**	
Hours/ Week	**3**	**0**	**0**	**39hrs/sem**	
Scheme of Examination	**IA**	**TW**	**TH**	**P**	**O**
TOTAL = 125 marks	**25**	**0**	**100**	**0**	**0**

Course Objectives:

The objective of this course is to understand the Series and shunt compensation provided for the transmission system for improving the power transfer capability, transmission system stability and power flow control.

Course Outcomes:

The student will be able to:

CO1	Understand the fundamentals of FACTS Controllers, Importance of controllable parameters and types of FACTS controllers and their benefits.
CO2	Apply the concept of Shunt and Series compensation.
CO3	Analyze the control circuits of Series and Shunt Controllers SVC and STATCOM for various functions viz. Transient stability Enhancement, voltage instability prevention and power oscillation damping.
CO4	Compute Power and control circuits of Series Controllers, shunt controllers and UPFC

UNIT -1	
Power flow in an AC system, loading capability of transmission line, reactive power control, effect of reactive power on voltage, power flow and dynamic stability considerations in an interconnected system. Emergence of FACTS, FACTS control considerations, basic types and brief descriptions of FACTS controllers.	**10 Hours**
UNIT -2	
Objectives of shunt compensation, methods of controllable VAR generation. Static VAR compensators SVC and Synchronous Compensator (STATCOM), characteristics and Control.	**10 Hours**
UNIT -3	
Objectives of static series compensation, variable impedance type series compensators, GCSC, TCSC and TSSC. Switching converter type series compensators, Static Synchronous Series Compensator (SSSC).	**10 Hours**
UNIT -4	
Principles of operation-Steady state model and characteristics of a static voltage regulators and phase shifters- power circuit configurations. UPFC - Principles of operation and characteristics, independent active and reactive power flow control, comparison of UPFC with the controlled series compensators and phase shifters.	**9 Hours**

ESSENTIAL READINGS	
1	Narain G Hingorani and L. Gyugyi; Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems; Wiley India, 2011.
2	Y. H. Song and A. T. Johns; Flexible AC Transmission System; Institution of Engineering and Technology; 2009.
3	K. R Padiyar; FACTS Controllers in Power Transmission and Distribution; New Age International, 2007.
ADVANCED READINGS	
1	Mohan Mathur, R., Rajiv. K. Varma; Thyristor – Based Facts Controllers for Electrical Transmission Systems; IEEE press and John Wiley & Sons, Inc.
2	Zhang, Xiao-Ping, Rehtanz, Christian, Pal, Bikash; Flexible AC Transmission Systems: Modeling and Control; Springer

IMAGE PROCESSING					
Course Code	**EE 722**		**Credits**	**3**	
Scheme of Instruction Hours/ Week	**L**	**T**	**P**	**TOTAL**	
	3	**0**	**0**	**39 hrs/sem**	
Scheme of Examination TOTAL = 125 marks	**IA**	**TW**	**TH**	**P**	**O**
	25	**0**	**100**	**0**	**0**

Course Objectives:

The course aims at making students familiar with the concepts of image representation and fundamental blocks of an image processing system. The ultimate objective of the course is to equip the students with skills for performing various transformations such as image enhancement, spatial and frequency domain filtering, image restoration and image compression.

Course Outcomes:

The student will be able to:

CO1	Understand and review the fundamental concepts and transformations of a digital image processing system.
CO2	Apply various spatial and frequency domain filters to a given image
CO3	Analyse enhancement, segmentation, restoration and compression techniques and morphological transformation for the given image.
CO4	Evaluate the compression ratio using various compression techniques

UNIT -1	
Digital Image Fundamentals: Fundamental steps in digital image processing, components of digital image processing system, digital image representation, simple image model, Sampling and Quantization, spatial and gray level resolution, Image quality, Noises in the Image. Image geometry - translation, scaling, rotation, zooming. **Image transforms** - 2D DFT, DCT and Wavelet transform **Basic relationship between pixels**: Neighborhood, adjacency, distance measures **Data structure for Image analysis:** Levels of image data representation, Image data structure - Matrices, Chains, Topological data structure, Relational structure, pyramids, quadtrees.	**10 Hours**
UNIT -2	
Image Pre-processing: Gray Level transformations, piecewise linear transformation, Histogram processing, negative transformation, log transformation, power law transformation, geometrical transformation. **Image Enhancement in spatial domain:** Arithmetic and logical operations, Basics of spatial filtering, smoothing and sharpening filters, Use of first and second order derivatives in enhancement.	**10 Hours**

UNIT -3	
Image Enhancement in frequency domain: Correspondence between filtering in spatial and frequency domain, smoothing and sharpening frequency domain filters **Image segmentation:** Detection of discontinuity (point, line, edge), edge linking and boundary detection, Thresholding- Global and local, Edge based segmentation, Region oriented segmentation -region growing, splitting and merging	**10 Hours**
UNIT -4	
Image Compression: Fundamentals of Image Compression, Compression models, Variable length coding, Huffman coding, Arithmetic coding. error free compression, lossy compression. **Image restoration:** Model of Image Degradation/Restoration process, Restoration methods, Inverse Filtering Weiner filtering.	**9 Hours**

ESSENTIAL READINGS	
1	R.C. Gonzalez and R.E. Woods, "Digital Image Processing", Addision Wesley
2	Milan Sonka, Vaclav Hlavac, Roger Boyle," Image processing, analysis and Machine Vision", Vikas Publishing.
ADVANCED READINGS	
1.	S. Sridhar,"Digital Image Processing", Oxford University Press
2.	R.C. Gonzalez, R.E. Woods, Steven L. Eddins", Digital Image Processing using MATLAB", Pearson Education
3.	A.K.Jain, "Fundamentals of Digital Image Processing", PHI
4.	A Rosenfield and A.C.Kak, "Digital image processing ", Academic press

SMART GRID					
Course Code	**EE 723**		**Credits**	**3**	
Scheme of Instruction	**L**	**T**	**P**	**TOTAL**	
Hours/ Week	**3**	**0**	**0**	**39hrs/sem**	
Scheme of Examination	**IA**	**TW**	**TH**	**P**	**O**
TOTAL = 125 marks	**25**	**0**	**100**	**0**	**0**

Course Objectives:

The objective of this course is that on its completion, the students will be able to assess and explain different aspects of smart grids. They will be able to assess and analyze implementation of different technologies which can be adopted for smart grid deployment. Course will be useful to design the smart systems for domestic and industrial applications.

Course Outcomes:

The student will be able to:

CO1	Explain and assess different aspects of smartgrids
CO2	Apply different technologies for effective utilization of smart grids
CO3	Evaluate and compare performance of smart grid components and evaluate management of the smart grids
CO4	Design and model different components of smart grids for effective utilization of smart grid technology

UNIT -1	
Introduction to SmartGrid: Concept, Definitions and need for Smart Grid, Representative Architecture, Difference between conventional & Smart Grid ,Functions of Smart Grid Components, Smart grid drivers, Opportunities, challenges and benefits, Concept of Resilient & Self-Healing Grid, Present development & International policies in Smart Grid, Global Smart Grid initiatives, Role of smart grid standards, Cyber security, Smart grid regulations, National smart grid mission of India.	**10 Hours**
UNIT -2	
Smart Grid Technologies-I: Introduction to Smart Meters, Smart Appliances, Automatic Meter Reading (AMR), Advanced Metering Infrastructure, Outage Management System (OMS), Smart Sensors, Home& Building Automation, Smart substations, Distribution Automation, Transmission Automation, Modelling of storage devices Battery, SMES, Compressed Air Energy Storage, Smart Energy Resources, Electric Vehicles, Vehicle to grid and grid to vehicle technology.	**10 Hours**
UNIT 3	
Smart Grid Technologies-II: Communication Technologies, Microgrid operation and control, Fault Detection, Isolation and service restoration of grid, Intelligent Electronic Devices (IED) & their application for monitoring & Protection, Supervisory control and data acquisition (SCADA), Wide Area Measurement System (WAMS), Phase Measurement Unit (PMU), Digital Relays for smart grid protection, Islanding detection techniques, Active and passive, Smart grid protection schemes.	**9 Hours**

UNIT -4	
Demand Side and Power Quality Management of Smart Grid: Demand side management in Smart grids, Demand response analysis, and architecture for DR implementation, Demand Response mathematical formulation and solution, DR strategies for various load categories. Power quality monitoring, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Design of Smart grid and practical case study of smart grid. Smart grids and Power Market Scenario in India	**10 Hours**

ESSENTIAL READINGS	
1.	Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, "Smart Grid: Technology and Application", Wiley press
2.	James Momoh,"Smart Grid :Fundamentals of Design and Analysis", Wiley IEEE press
ADVANCED READINGS	
1.	Jean Claude Sabonnadière, Nouredine Hadjsaid, "Smart Grids", Wiley Blackwell
2.	Clark W. Gellings; "The Smart Grid: Enabling Energy Efficiency and Demand Response", CRC press

PLC & ITS APPLICATIONS					
Course Code	**EE 724**		**Credits**	**3**	
Scheme of Instruction	**L**	**T**	**P**	**TOTAL**	
Hours/ Week	**3**	**0**	**0**	**39hrs/sem**	
Scheme of Examination	**IA**	**TW**	**TH**	**P**	**O**
TOTAL = 125 marks	**25**	**0**	**100**	**0**	**0**

Course Objectives:

The objective of this course is to make a student

1. Understand knowledge levels needed for PLC programming and operating.
2. Know the devices to which PLC input and output modules are connected
3. Create ladder diagrams from process control descriptions.
4. Understand various types of PLC registers, PLC Timers and Counters for the control of industrial processes & PLC functions.

Course Outcomes:

The student will be able to:

CO1	Understand Programmable Logic Controllers, registers, timers, counters, input and output modules.
CO2	Apply PLC programming for basic modules.
CO3	Analyze ladder diagrams from process control descriptions.
CO4	Design the control of industrial processes using different types of PLC functions.

UNIT -1	
PLC Basics: PLC system, I/O modules and interfacing, CPU processor, programming equipment, programming formats, construction of PLC ladder diagrams, devices connected to I/O modules. **PLC Programming:** Input instructions, outputs, operational procedures, programming examples using contacts and coils, drill press operation. Digital logic gates, programming in the Boolean algebra system, conversion examples. Ladder diagrams for process control: Ladder diagrams and sequence listings, ladder diagram construction and flow chart for spray process system.	**12 Hours**
UNIT -2	
PLC Registers: Characteristics of Registers, module addressing, holding registers, input registers, output registers. **PLC Functions:** Timer functions and Industrial applications, counters, counter function industrial applications, Arithmetic functions, Number comparison functions, number conversion functions.	**10 Hours**
UNIT 3	
Data handling functions: SKIP, Master control Relay, Jump, Move, FIFO, FAL, ONS, CLR and Sweep functions and their applications. Bit Pattern and changing a bit shift register, sequence functions and applications, controlling of two axes and three axis Robots with PLC, Matrix functions.	**10 Hours**

Analog PLC operation: Analog modules and systems, Analog signal processing, multi bit data processing, analog output application examples.	
UNIT -4	
PID principles, position indicator with PID control, PID modules, PID tuning, PID functions.	**7 Hours**

ESSENTIAL READINGS	
1.	John W. Webb and Ronald A. Reiss; Programmable Logic Controllers – Principle and Applications; Fifth Edition,PHI
2.	JR. Hackworth and F.D Hackworth Jr; Programmable Logic Controllers – Programming Method and Applications; Pearson;2004.
ADVANCED READINGS	
1.	Gary Dunning; Introduction to Programmable Logic Controllers; Cengage Learning.
2.	W.Bolton; Programmable Logic Controllers; Elsevier publisher

POWER SYSTEMS LABORATORY					
Course Code	**EE 730**		**Credits**	**1**	
Scheme of Instruction	**L**	**T**	**P**	**TOTAL**	
Hours/ Week	**0**	**0**	**2**	**26hrs/sem**	
Scheme of Examination	**IA**	**TW**	**TH**	**P**	**O**
TOTAL = 50 marks	**0**	**25**	**0**	**0**	**25**

Course Objectives:

The objective of the course is to impart hand on knowledge of Electrical Power Systems.

Course Outcomes:

The student will be able to:

CO1	Understand the practical operation of power transmission system, Power dispatch and protection relays.
CO2	Assemble, Test and verify the performance of power transmission system and protection relays.
CO3	Analyse the experimental results of testing the relays and power transmission system
CO4	Design the power transmission system and protection system for generators, motors, transformers and transmission line.

SN	Experimental List
1	Determination of ABCD parameters of a Transmission line using transmission line model.
2	Ferranti effect in a long transmission line using Transmission line model.
3	Voltage profile of a long transmission line using Transmission line model.
4	Computation of Voltage, Current, Power factor, Regulation and Efficiency of a Transmission line when the voltage and power at the sending end are given.
5	Fault analysis on a 3-phase Transmission line model.
6	Determination of Bus admittance matrix for a Power system network by Inspection method using MATLAB
7	Determination of Bus admittance matrix for a Power system network by Singular transformation method using MATLAB
8	Determination of Bus power, line losses and line flows for a given power system using Gauss-Seidel method.
9	Determination of Bus voltages, line flows and line losses for a given power system using Newton-Raphson method.
10	Determination of economical operation for a given load demand, cost equation and loss coefficient of different units of a plant.
11	Study of IDMT over-current relay with different plug setting and Time setting Multiplier and plotting its Time-Current characteristics.
12	Determination of the operating characteristics of Biased Differential relays with different biasing.
13	Characteristics of Static relays for under voltage / Over voltage
14	Measurement of Earthing resistance of the Earth-pit

*Minimum 8 experiments to be conducted.

SUGGESTED READING BOOKS	
1	B.R.Gupta; Course in Electrical Power; Kataria & Sons
2	I. J. Nagrath and D. P. Kothari; Modern Power System Analysis; Tata McGraw Hill.
3	M. A. Pai; Computer Techniques in power system; Tata McGraw Hill.
4	S. Badriram; Power system Protection; TMH

INTERNSHIP

Course Code	CV740	Credits		3	
Scheme of Instruction Hours/ Week	L	T	P	TOTAL	
	0	0	06	84 Hrs/Sem	
Scheme of Examination TOTAL = 100 marks	IA	TW	TM	P	O
	0	50	0	0	50

Course Objectives:|

1. To undergo a practice-oriented and hands-on working experience in the real world or industry and to enhance the student‘s learning experience.
2. To provide opportunity to develop a right work attitude, self-confidence, interpersonal skills and ability to work as a team in a real organizational setting.
3. To develop and enhance operational, customer service and other life-long knowledge and skills in a real-world work environment.
4. To provide Pre-employment training opportunities and an opportunity for the company or organization to assess the performance of the student and to offer the student an employment opportunity after his/her graduation, if it deems fit.

Course Outcomes:

The student after undergoing this course will be able to:

CO1	Demonstrate the application of knowledge and skill sets acquired from the course and workplace in the assigned job function/s
CO2	Solve real life challenges in the workplace by analysing work environment and conditions, and select appropriate skill sets acquired from the course.
CO3	Articulate career options by considering opportunities in company, sector, industry, professional and educational advancement;
CO4	Communicate and collaborate effectively and appropriately with different professionals in the work environment through written and oral means and exhibit professional ethics by displaying positive disposition during internship.

GUIDELINES FOR INTERNSHIP

Guiding Principle behind internship/training would be improvement in knowledge/skills and employability of the students and emphasis would be on core companies and practical/field work on any project

1. Students would be allowed internships in research institutes if they indicate academics/research as their career choice
2. As far as possible Departments to follow internship guidelines issued by the regulatory bodies AICTE/UGC whichever is applicable
3. Students who undergo internship would in general be monitored through emails/telecalls/Skype/Video Conferencing
4. For non-core companies, each department would frame a policy by constituting a department level

committee chaired by the HOD. There would be no blanket ban on training/internship in non-core organizations and for each student choosing to go to such an organization, the department level committee would review the case on merit after receiving the views/justification from the student.

5. The concerned Department and TPO shall arrange for internship seats
6. They shall tie up with the companies and renowned academic institutes and also look for placing students for training purpose in various PSUs like PWD, Electricity Board, Irrigation, private consultancy companies etc. Paid internships may be allowed in renowned companies
7. If sufficient numbers of seats are not arranged at the institute level then the students on their own can arrange training as per the guidelines given under title –as per point 1 to 4‖ above. However, the same must be approved by the Department. The students who are arranging their own training should give the confirmation to department before the start of the training
8. The students going for internships are required to get themselves registered with the Department/TPO before leaving for training. This may be done latest by the date specified for the normal semester registration for course work.
9. At 7th Semester 8 weeks internship/training/ Research Assistantship-(in the month of September & October). If required additionally at 8th Sem (before start of semester or during vacation) 4 weeks of Internship/ Training/ Research Assistantship can be provided to deserving students to enhance their employability -(in the month of January)
10. The institute shall ask the companies to allocate mentors to the students so that they can interact with each other before joining the internship and do ground work to make it more effective
11. The institute shall maintain a database of all mentors. Departments shall send information of all the mentors with their complete details to the Training and Placement Office/faculty in charge in the prescribed format provided by the TPO
12. Students are to ensure that their Joining reports are received by the department within 15 days of joining
13. The visits of faculty coordinators to industries shall not be necessary. Email/Skype/facetime/ Video Conferencing interactions shall be done by the faculty with the students and mentors. In case the faculty is interested in visiting the companies/institutes, they can visit. They shall be required to interact with the management of the companies/institutes visited in addition to interacting with the student mentors. All visit / monitoring reports are to be submitted to the respective departments by the faculty
14. Faculty-Industry Interaction: In addition to making evaluations based on email/Skype/facetime/ Video Conferencing interactions with the students or based on visits to the industry, the faculty coordinator will contact the industry coordinator fortnightly via e-mail/phone, to keep a close watch on the students progress
15. Every student shall submit the Internship certificate issued by company after completion and prepare an internship report as per the specified guideline. The Faculty Coordinator shall collect the feedback from the industry.

16. Faculty coordinator and the industry coordinator will directly access and award marks for under the heading Term work (out of 50) based on their assessment of the work done by a student.
17. The final Evaluation by Department including Presentations/ Viva Voce will be made before faculty panel and efforts should be made to invite one external expert from industry or research institute for evaluations (out of 50 ORAL Marks).

GUIDELINES FOR REPORT

Contents of the Report

1. Cover page – on hard paper
2. Inner page – same as cover page but on the soft paper
3. Declaration
4. Acknowledgement (if any)
5. Content
    A. Summary
    B. Introduction
    C. Work
    D. Industry
    E. Review
    F. Details of the work including work programme carried out & results
    G. Conclusions and Future Scope of Work
    H. Impediments/difficulties faced during project semester on project work; Suggestions related to work/project semester
    I. References (if any)

A total of THREE copies may be prepared – one for the student, second for the faculty coordinator and third for the institute.

DECLARATION

I hereby declare that the project work entitled (-Title of the project‖) is an authentic record of my own work carried out at (Place of work) as requirements for the award of degree of B.E. (Relevant Engineering), of ---

---- Goa University, under the guidance of (Name of Industry coordinator) and (Name of Faculty coordinator), during_to_____, 20).

(Signature of student) Name of Student Student I D

Date: _____

Certified that the above statement made by the student is correct to the best of our knowledge and belief.

(Name & Designation) Faculty Coordinator	**(Name & Designation) Industry Coordinator**

INDUSTRY FEEDBACK FORM

Department of---------- Engineering

Industry Feedback Form for 7 th semester Internship

Internee's Information	
Name	
Student ID	
Date of Joining (Internship)	
Date of Completion (Internship)	

Evaluator's Information

Name	
Designation	
Company's/ Organization's Name	
Company Address	
Phone	
Mobile No.	
Email ID	
Fax. No.	

To be filled by the Evaluator

Please tick mark in the relevant box in the following grade chart for the Internee

Sr. No.	Parameters					
		Excellent	Very Good	Good	Satisfactory	Unsatisfactory
1	Intelligence/Learning aptitude					
2	Professional Skill/Knowledge					
3	Work Output/Performance					
4	Expression					
5	Initiative & Drive					
6	Punctuality/Regularity					
7	Honesty/Integrity					
8	Co-operation & Tact					
9	Discipline					
10	Interpersonal Skills					
11	Dedication towards work					
12	Overall performance					
13	Did the Intern meet your expectations?					Yes/No

14	Would you like to take PEC students again in next year?	Yes/No
15	Do you think that the Institute can interact with the Industry/ organization in some other way also? Please specify	Yes/No

A+=Excellent, A=Very Good, B= Good, C=Satisfactory & D=Unsatisfactory

Did you offer your intern any further employment?
If yes, Package & Joining Details_____
Any other suggestions/feedback: _____

Following parameters may be kept in mind while evaluating the student

i	JOB KNOWLEDGE (refers to knowledge clarity of fundamentals, and latest development	ix	ADAPTABILITY TO NEW ENVIRONMENT (refers to ability to acclimatize himself/herself to new work environment/culture.
ii	CREATIVITY (refers to the ability to generate new and practical ideas for improvement of systems and operations related to the	X	PROBLEM FORMULATION (refers to initiative shown in converging to project formulation)
iii	PLANNING SKILLS (refer to the ability to conceptualize all aspect of the project and to systematically plan the series of activities to achieve the goals)	xi	TECHNIQUES/TOOLS used at various stages
iv	ORGANISING SKILLS (refers to the ability to mobilize co-ordinate, integrate various activities/resources to achieve fast completion)	xii	EXECUTION OF THE PROJECT)(S) (refers to (a) Setting Time frames (b)Efforts put into complete the project. Maintenance of work diary.
v	APPLICATION SKILLS (refer to the ability to apply knowledge to real life situations)	xiii	PROJECT REPORT & DEFENCE
vi	JOB INVOLVEMENT (refers to the concern and diligence shown in execution of the project)	xiv	PRESENTATION (Refers to style and effectiveness)
vii	INTERPERSONAL RELATIONSHIP (refers to ability to work harmoniously with superiors and subordinates)	xv	Written Expression
viii	REGULARITY & PUNCTUALITY (refers to (i) Sanctioned authorized leave, absence without permission (ii) late coming & leaving work place early)	xvi	Oral Expression

PROJECT WORK - PHASE I					
Course Code	**EE 750**		**Credits**	**3**	
Scheme of Instruction	**L**	**T**	**P**	**TOTAL**	
Hours/ Week	**0**	**0**	**6**	**78 Hrs/sem**	
Scheme of Examination	**IA**	**TW**	**TH**	**P**	**O**
TOTAL = 125 marks	**0**	**50**	**0**	**0**	**75**

Guidelines for Project Work:

1. Project can be undertaken in-house or in an industry or in a research /service organization.
2. Generally, a Project batch consists of two to four students, limited to six.
3. The project groups and title be preferably decided by the end of VIth semester.
4. The Project Title/Synopsis should be submitted by the first fortnight of the term and approved by a designated departmental committee/Head of Department.
5. The topic of the project may be in the area related to Electrical & Electronics Engineering involving investigation/analytical study/experimental work/prototype fabrication/statistical study/simulation etc.
6. The project shall involve applications of concepts learnt during curriculum.
7. The project work should be appropriately planned for VII th and VIII th semester.
8. VIIth semester Project Report will preferably consist of Problem identification and Statement, Formulation of the objective and Scope of the study, Literature review, Methodology to be adopted, Part execution etc.
9. Students shall submit project report to the department at the end of Semester.
10. Students shall present their work in three progress reviews (beginning, mid sem and end-sem).

FOURTH YEAR: ELECTRICAL & ELECTRONICS ENGINEERING

SCHEME OF INSTRUCTION AND EXAMINATIONREVISED COURSE 2019-2020

SEMESTER – VIII

Subject Code	Name of the Subject	Scheme of Instruction Hrs/Week				Scheme of Examination							Credit
		L	T	P	H	ThDuration(Hrs)	Marks						
							Th	S	TW*	P	O	Total	
EE810	High Voltage Engineering	3	0	0	**3**	3	100	25	0	0	0	**125**	3
EE821	Embedded Systems	3	0	0	**3**	3	100	25	0	0	0	**125**	3
EE822	Power System Operation & Control												
EE823	Reliability of electrical system												
EE824	PV & Its Applications												
EE830	Elective - NPTEL / MOOC / SWAYAM	0	0	0	**3**	--	0	0	50	0	50	**100**	3
EE840	Project Work - Phase II	0	0	18	**18**	--	0	0	200	0	200	**400**	9
TOTAL		**6**	**0**	**18**	**24**	**--**	**200**	**50**	**250**	**0**	**250**	**750**	**18**

Students to select ANY ONE subject from EE821, EE822, EE823 and EE824 as Professional elective VI

*Term Work marks are to be awarded through continuous evaluation

HIGH VOLTAGE ENGINEERING					
Course Code	**EE 810**		**Credits**	**3**	
Scheme of Instruction	**L**	**T**	**P**	**TOTAL**	
Hours/ Week	**3**	**0**	**0**	**39hrs/sem**	
Scheme of Examination	**IA**	**TW**	**TH**	**P**	**O**
TOTAL = 125 marks	**25**	**0**	**100**	**0**	**0**

Course Objectives:
To analyses the advantages of HV technology for power transmission and insulation testing.

Course Outcomes: On completion of this course, the students will be able to

CO1	Understand the advantages of high voltage systems, applications and generation of high voltages.
CO2	Apply the concepts of high voltage generation and measurement circuits.
CO3	Analyse the breakdown processes in solid, liquid and gaseous insulations.
CO4	compute the Travelling wave phenomenon and aspects of HV power transmission & HV cables.

UNIT -1	
Introduction: Introduction to HV technology, advantages of transmitting electrical power at high voltages, need for generating high voltages in laboratory. Important applications of high voltages. **Generation: HVAC & DC:** HV transformer - working of transformer connected in cascade. Series resonant circuit. Tesla coil. Voltage Doubler Circuit, Van De Graaff generator **Generation of Impulse Voltage and Current:** Introduction to standard lightning and switching impulse voltages. Standard Impulse Waveforms: Standard Lightening and switching Impulse waveform and its characteristics and specification. Single stage impulse generator.	**10 Hours**
UNIT -2	
Measurement of High voltages: Electrostatic voltmeter, Sphere gap, Rod gap, Chubb-Fortescue method, Transformer ratio method, Resistive Potential divider method, Capacitive Potential divider method. Generating voltmeter- Principle of operation & construction. Series resistance microammeter.	**6 Hours**
UNIT -3	
HV Insulation: Classification, Properties and breakdown theories. 1)Gaseous insulation: Ionizations, primary and secondary ionization processes. Townsend's theory, Streamer's theory. Corona discharges. Expression for disruptive and visual critical voltages and corona power loss. Breakdown in electronegative gases. Paschen's law. Time lags of Breakdown.	**9 Hours**

2)Liquid insulation: Breakdown in liquids, Suspended particle theory, electronic, cavity/bubble's theory and electro convection breakdown of commercial liquids, breakdown due to gaseous inclusions, liquid globules and solid particles. 3) **Solid insulation material:** Intrinsic, avalanche, Electromechanical breakdown, Breakdown due to internal discharges, Surface breakdown, Thermal breakdown, Electrochemical breakdown, Chemical deterioration, Breakdown of composite insulation.	
UNIT -4	
High voltage transmission: Advantages of HV transmissions, types of transmission conductors, GMR, mechanical aspects of transmission lines. Traveling wave theory, surge impedance, Transmission line parameters, charging current, reflection and refraction on transmission line, power circle diagram, Bewley Lattice diagrams. **Surge protection of Transmission lines**: Overhead ground wire, Spark gaps, Expulsion type lightning arrester, Valve type Lightning arrester, Gapless Lightning arrester, switching over voltages, methods of reducing switching over voltages. **High voltage cables:** Constructional details and power loss. Transformers, cables and High voltage bushings.	**14 Hours**

ESSENTIAL READINGS	
1	M. S. Naidu ;High voltage Engineering ; Tata McGraw Hills
2	Kuffel and Zaengal, Pergam; High Voltage Engineering
3	R. Begamudre; High voltage Transmission; Tata McGraw Hills
ADVANCED READINGS	
1	Subir Ray; An introduction to High Voltage Engineering; Prentice hall of India.
2	C. L. Wadwa; High Voltage Engineering; New Age International

EMBEDDED SYSTEMS					
Course Code	**EE 821**		**Credits**	**3**	
Scheme of Instruction Hours/ Week	**L**	**T**	**P**	**TOTAL**	
	3	**0**	**0**	**39 hrs/sem**	
Scheme of Examination TOTAL = 125 marks	**IA**	**TW**	**TH**	**P**	**O**
	25	**0**	**100**	**0**	**0**

Course Objectives:

To conceptualize the basics of PIC and ARM microcontrollers, develop programs so as to be able to automate using embedded systems.

Course Outcomes:

The student will be able to:

CO1	Understand the architecture, instruction set and working of various sub components of PIC and ARM microcontrollers.
CO2	Explain / Discuss the characteristics, architecture, addressing /operating modes and memory organization of PIC and ARM microcontroller.
CO3	Analyze usage of various instructions with relevance to timings, word length and code size and write optimum programs for various peripheral interfacing applications.
CO4	Calculate the register values for configuring the Parallel ports, Timers / Counters and Serial port in various modes, enabling / disabling interrupts, Design and test embedded systems using microcontroller.

UNIT -1	
Introduction to PIC Microcontroller: Overview of PIC family and features, Internal Bus structure of PIC microcontroller, Clock frequency, machine cycle and instruction cycle. **PIC Programming Model and Instruction Set**: PIC microcontroller programming model, Bus architecture, Program memory and data memory organization, various registers, Internal Architecture, Instruction Set, simple programs.	**10 Hours**
UNIT -2	
PIC Microcontroller: Timers and interrupts, parallel ports and serial communication **Peripherals and interfacing:** Serial EEPROM, Analog to Digital Converter, UART, LCD and keyboard Interfacing, ADC, DAC, and Sensor Interfacing, stepper motor interfacing.	**10 Hours**
UNIT -3	
ARM 7 Architecture: Detailed architecture, Block diagram, AMBA Bus structure, various registers, operating modes, memory mapping **ARM Instruction set:** Data processing instructions, branching instructions, arithmetic and logical instructions, data transfer instructions, coprocessor data operations Addressing modes, simple programs.	**10 Hours**

UNIT -4	
ARM microcontroller: Exceptions and interrupts handling, Memory Protection unit **Interfacing:** LED interfacing, Seven segment interfacing, LCD interfacing, ADC and DAC interfacing, Stepper Motor and DC Motor Interfacing	**9 Hours**

ESSENTIAL READINGS	
1	Mazidi, M.A.,"PIC Microcontroller", Prentice Hall of India, 2007
2	Ramesh Gaonkar, "Fundamentals of Microcontrollers and Applications in Embedded Systems (with the PIC 18 Microcontroller Family)", Penram International publications (Ind) Pvt. Ltd.
3	David Seal, "ARM Architecture Reference Manual", Second Edition, Addison-Wesley.
4	William Hohl, "ARM Assembly Language", CRC Press, ISBN:978-81-89643-04-1
ADVANCED READINGS	
1	Peatman,J.B., "Design with PIC Micro Controllers", Pearson Education, 3rdEdition, 2004.
2	Han Way Huang, "PIC Microcontroller: An Introduction to Software and Hardware Interfacing", Cengage Learning
3	Steve Furber, "ARM System on chip Architecture", Pearson, second edition
4	Andrew N. Sloss, "ARM System Developer's guide", Elsevier Publications, ISBN 978-81-8147-646-3, 2016

POWER SYSTEM OPERATION AND CONTROL					
Course Code	**EE 822**		**Credits**	**3**	
Scheme of Instruction Hours/ Week	**L**	**T**	**P**	**TOTAL**	
	3	**0**	**0**	**39hrs./sem**	
Scheme of Examination TOTAL = 125 marks	**IA**	**TW**	**TH**	**P**	**O**
	25	**0**	**100**	**0**	**0**

Course Objectives:

To understand and analyze the problems in today's complex power system and operate it with reliability and control.

Course Outcomes:

The student will be able to:

CO1	To understand the problem of Power flow between various interconnected Grids.
CO2	To analyze & develop control strategy for the flow of power between the grids reliably and economically.
CO3	To evaluate and control strategy for the reactive power flow so as to avoid exigencies such as voltage collapse and blackouts
CO4	To develop& design the demand supply strategy for optimal control and operation of power grid.

UNIT -1	
Optimal dispatch of generation: Introduction, equality and inequality constraints, operating cost of thermal plant, economic dispatch neglecting losses and no generator limits, economic dispatch neglecting losses and including generator limits, economic dispatch including losses. Examples Unit Commitment: Statement of the problem, need and importance of unit commitment.	**10 Hours**
UNIT -2	
Power System Control: Basic generation control loops, Load frequency control(LFC) modeling, steady state frequency deviation, AGC in single area system and multi area system, tie line bias control. Examples to be solved with MATLAB and Simulink.	**9 Hours**
UNIT -3	
Reactive Power and Voltage Control: Automatic voltage control (AVR) modeling, steady state voltage response, excitation system, power flow through transmission line, relation between voltage, real power and reactive power, supplementary methods of voltage control, sub synchronous resonance, voltage stability, voltage collapse. Examples to be solved using MATLAB and Simulink	**10 Hours**

UNIT -4	
Control center operation of power systems: Introduction to SCADA, control center, digital computer configuration, automatic generation control, area control error, operation without central computers, parallel operation of generators, area lumped dynamic model, examples	**10 Hours**

ESSENTIAL READINGS	
1	G. L. Kusic; Computer Aided Power System Analysis; 2/e, Taylor & Francis; 2008.
2	Kotrhari, Nagrath; Power System Analysis; 2/e,TMH; 2008.
ADVANCED READINGS	
1	Hadi Saadat; Power system engineering; 2/eTMH ; 2002.
2	A. J. Wood & B. F. Woolemberg; Power generation, operation and control; 1/e, John Wileyand Sons; 1984.

RELIABILITY OF ELECTRICAL SYSTEMS					
Course Code	**EE823**		**Credits**	**3**	
Scheme of Instruction	**L**	**T**	**P**	**TOTAL**	
Hours/ Week	**3**	**0**	**0**	**39hrs/sem**	
Scheme of Examination	**IA**	**TW**	**TH**	**P**	**O**
TOTAL = 125 marks	**25**	**0**	**100**	**0**	**0**

Course Objectives:

The objective of this course is to understand the generation system reliability, transmission system reliability, distribution system reliability and the different reliability indices.

Course Outcomes:

The student will be able to:

CO1	Understand the loss of load and energy indices for generation systems model and the recursive relation for capacitive model building.
CO2	Apply the concept of merging generation and load model, equivalent transitional rates, cumulative probability and cumulative frequency.
CO3	Analyze various indices for distribution systems
CO4	Evaluate the risk, system and load point reliability indices.

UNIT -1	
Generating System Reliability Analysis–I: Generation system model, capacity outage probability tables, Recursive relation for capacitive model building, sequential addition method, unit removal, Evaluation of loss of load and energy indices.	**10 Hours**
UNIT -2	
Generating System Reliability Analysis – II: Frequency and Duration methods, Evaluation of equivalent transitional rates of identical and non-identical units, Evaluation of cumulative probability and cumulative frequency of non-identical generating units, 2-level daily load representation, merging generation and load models	**10 Hours**
UNIT -3	
Transmission Planning and Reliability: Introduction, Objectives of Transmission Planning, Network Reconfiguration, System and Load Point Indices, Data required for Composite System Reliability. Distribution System Reliability Analysis – I (Radial configuration): Basic Techniques, Radial networks, Evaluation of Basic reliability indices, performance indices, load point and system reliability indices, customer oriented, loss and energy-oriented indices.	**10 Hours**

UNIT -4	
Distribution System Reliability Analysis – II (Parallel Configuration): Basic techniques, inclusion of busbar failures, scheduled maintenance, temporary and transient failures, weather effects, common mode failures, Evaluation of various indices. Substations and Switching Stations: Effects of short-circuits, breaker operation, Open and Short-circuit failures, Active and Passive failures, switching after faults, circuit breaker model, preventive maintenance, exponential maintenance times.	**9 Hours**

ESSENTIAL READINGS	
1	Roy Billinton& Ronald N. Allan; Reliability Evaluation of Power System; Springer Publication.
2	R.L. Sullivan; Power System Planning; Tata McGraw Hill Publishing Company Ltd.
3	J. Endrenyi; Reliability Modeling in Electric Power Systems; John Wiley and Sons.
ADVANCED READINGS	
1	Miler & Freund's; Probability and Statistic for Engineers; Pearson Education.
2	Richard Johnson; Proceeding of workshop on energy systems planning & manufacturing CI.
3	Turan Gonen; Electric power distribution system Engineering; McGraw Hill.

PV & ITS APPLICATIONS					
Course Code	**EE824**		**Credits**	**3**	
Scheme of Instruction	**L**	**T**	**P**	**TOTAL**	
Hours/ Week	**3**	**0**	**0**	**39hrs/sem**	
Scheme of Examination	**IA**	**TW**	**TH**	**P**	**O**
TOTAL = 125 marks	**25**	**0**	**100**	**0**	**0**

Course Objectives:

The objective of this course is to focus on solar photovoltaic (PV) energy systems, which convert solar energy into a convenient electrical energy form. It mainly covers the types of electrical components and schemes used in PV systems. The course covers the characteristics of solar radiation, PV cells, modules and arrays, stand-alone PV schemes with battery energy storage and grid-connected PV schemes.

Course Outcomes:

The student will be able to:

CO1	Understand characteristics of PV cell, grid connected inverter, load characteristics, types of batteries as energy storage.
CO2	Explain the use of bypass diodes and blocking diodes, operation of power electronic converters in single phase PV systems, operation of grid connected system, design related issues.
CO3	Analyze the performance of various array configurations, transformer less inverter, standalone PV system, grid connected schemes with standby energy storage.
CO4	Compute the performance parameters of PV configuration, PV inverter, PV water pumping system and batteries.

UNIT -1	
PV cells and module: Photovoltaic cell and its simple model; effect of temperature and insolation, i-v and p-v characteristics; PV modules and array configurations-Series, Parallel, Series-Parallel; effect of shading, use of bypass and blocking diodes; specifications of PV cell , terms such as open circuit voltage, short circuit current, maximum power, maximum voltage, maximum current, fill factor, shading loss, mismatching loss, efficiency, numerical.	**10 Hours**
UNIT -2	
PV inverters: Grid-connected single phase PV inverter schemes and control; power processing schemes based on single string, multi-string and ac module technologies; types of grid interface; power electronic converters used in single phase PV systems and their operation; transformer less inverters, centralized grid-connected three-phase inverters for large PV installations.	**10 Hours**
UNIT -3	
PV systems**:** Introduction, current-voltage curves for loads, grid connected systems,Grid connected PV economics, stand-alone PV systems, PV powered water pumping system.	**9 Hours**

UNIT -4	
Batteries for energy storage – types, charging, battery sizing and turn-around efficiency; other types of energy storage for PV systems; grid connected schemes with standby energy storage. Design related issues; grounding, dc arcing and other safety related issues; islanding; harmonics; electro-magnetic interference.	**10 Hours**

ESSENTIAL READINGS	
1.	Gilbert M. Masters: Renewable and Efficient Electric Power Systems. John Wiley & Sons, 2004
ADVANCED READINGS	
1.	Roger A. Messenger & Jerry Ventre: Photovoltaic Systems Engineering. CRC Press, 2004, 2nd edition
2.	Solanki: Solar Photovoltaics: Fundamentals, Technologies and Applications. PHI Learning Pvt Ltd, 2009

PROJECT WORK - PHASE II					
Course Code	**EE840**		**Credits**	**9**	
Scheme of Instruction Hours/ Week	**L**	**T**	**P**	**TOTAL**	
	0	**0**	**18**	**208 Hrs/sem**	
Scheme of Examination TOTAL = 400 marks	**IA**	**TW**	**TH**	**P**	**O**
	0	**200**	**0**	**0**	**200**

Guidelines for Project:

1) Students should present their work in two progress reviews (mid-sem and end sem).
2) VIIIth semester Project work being the concluding part of the Project, should preferably have details such as Statement of problem, Objective and Scope of the study, Literature review, Methodology, Results and Discussions, Conclusions and Future Scope, References etc.
3) Students shall submit final project report to the department in the form of hard and soft copy at the end of the term.
4) Term Work in project is a separate Head of Passing. The project work conducted and its report will be assessed under this Head.