MANIPUR UNIVERSITY
CANCHIPUR, IMPHAL

CURRICULUM & SYLLABUS

FOR

BACHELOR OF ENGINEERING

IN

ELECTRICAL ENGINEERING

(2nd Year to 4th Year programme)

(Effective from the Academic Session 2021-2022)

C O N T E N T S

1. About the Department

Department of Electrical Engineering was opened in the year 2019. At present, it has four years degree course in Electrical Engineering with the total seat of 45 numbers. As of now, there are only two batches.

2. Vision of the Department

To impart knowledge, develop skills and prepare students in achieving global excellence in Electrical Engineering education, research and industry.

3. Mission of the Department

M1: To strengthen academic infrastructure leading to quality professionals through modern technology in the field of Electrical Engineering.
M2: To impart technical education with industry and society for developing competent Electrical Engineer.
M3: To create a passion for learning and promote innovation.

4. Programme Specific Outcomes (PSOs)

PSO 1: Apply the fundamentals of mathematics, science and engineering knowledge to identify, formulate, design and investigate complex engineering problems of electric circuits, analog and digital electronics circuits, control systems, electrical machines and Power system.
PSO 2: Apply the appropriate techniques and modern engineering hardware and software tools in electrical engineering to engage in life-long learning and to successfully adapt in multi-disciplinary environments.
PSO 3: Aware of the impact of professional engineering solutions in societal, environmental context, professional ethics and be able to communicate effectively.

5. Programme Educational Objectives (PEOs)

PEO1. To impart a programme oriented knowledge in mathematical, scientific and engineering fundamentals required to solve electrical engineering problems.

PEO2: To prepare students with engineering attitude so as to comprehend, analyze, design, and create novel products and solutions for the real life problems.

PEO3: To prepare students to involve in research, higher studies and to become entrepreneurship in long run.

PEO4: To inculcate professional and ethical attitude, communication and team work skills.

6. Program outcomes (POs)

PO 1: **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals and engineering specialization to solve complex engineering problems.
PO 2: **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO 3: **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO 4: **Conduct investigations of complex problems**: Use research-based knowledge and

research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO 5: **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO 6: **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO 7: **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO 8: **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO 9: **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO 10: **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO 11: **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO 12: **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

7. Structure of B.E. in Electrical Engineering

Semester	Credits
I	**17.5**
II	**21.0**
III	**22.0**
IV	**21.0**
V	**22.0**
VI	**20.5**
VII	**21.0**
VIII	**18.0**
Total	**163.0**

CURRICULUMS

THIRD SEMESTER

Sl. No.	Course No.	Subject	Hours/Week			Marks				
			L	T	P	Theory	Sess.	Pract	Total	Credit
1	MA 231	Engineering Mathematics–III	3	1	0	70	30	-	100	4
2	ME 231	Engineering Mechanics	3	1	0	70	30	-	100	4
3	EE 231	Electrical Circuit Analysis	3	1	0	70	30	-	100	3
4	EE 232	Analog Electronics	3	1	0	70	30	-	100	3
5	EE 233	Electrical Machines – I	3	1	0	70	30		100	3
6	HU 231	Economics for Engineers	2	0	0	35	15	-	50	2
		Sub-Total	**17**	**5**	**0**				**550**	**19**
		PRACTICAL								
7	EE 232P	Analog Electronics Laboratory	0	0	2	-	30	70	100	1
8	EE 233P	Electrical Machines Laboratory - I	0	0	2		30	70	100	1
9	EE234P	Internship-I	-	-	-	-	100	-	100	1
		Sub-Total	**0**	**0**	**4**	**-**			**300**	**3**
		TOTAL	**17**	**5**	**4**				**850**	**22**

FOURTH SEMESTER

Sl. No.	Course No.	Subject	Hours/Week			Marks				
			L	T	P	Theory	Sess.	Pract.	Total	Credit
1	MA 241	Numerical Methods and Computation	3	0	0	70	30	-	100	3
2	EE 241	Digital Electronics	3	0	0	70	30	-	100	3
3	EE 242	Electrical Machines – II	3	0	0	70	30	-	100	3
4	EE 243	Power Systems – I	3	0	0	70	30	-	100	3
5	EE 244	Signals and Systems	3	0	0	70	30	-	100	3
6	HU 241	Universal Human Values-II	2	1	0	70	30	-	100	3
		Sub-Total	**17**	**1**	**0**				**600**	**18**
		PRACTICAL								
7	EE 241P	Digital Electronics Laboratory	0	0	2	-	30	70	100	1
8	EE 242P	Electrical Machines Laboratory – II	0	0	2	-	30	70	100	1
9	EE 243P	Power Systems Lab– I	0	0	2		30	70	100	1
		Sub-Total	**0**	**0**	**6**				**300**	**3**
		MANDATORY COURSE								
10	*NC 241*	Organizational Behavior	*3*	*0*	*0*	-	50*	-	**-**	
		TOTAL	**20**	**1**	**6**				**900**	**21**

**** Non-credit mandatory course but compulsory to pass**

FIFTH SEMESTER

Sl. No.	Course No.	Subject	Hours/Week			Marks				
			L	T	P	Theory	Sess.	Pract.	Total	Credit
1	EE 351	Electrical Measurement and Measuring Instrument	3	1	0	70	30	-	100	3
2	EE 352	Control System-I	3	1	0	70	30	-	100	3
3	EE 353	Power System-II	3	1	0	70	30	-	100	3
4	EE 354	Microprocessor	3	1	0	70	30	-	100	3
5	EE 355	Program Elective-I	3	1	0	70	30	-	100	3
6	EE 356	Electromagnetic field	3	1	0	70	30	-	100	3
		Sub-Total	**18**	**6**	**0**				**600**	**18**
		PRACTICAL								
7	EE 351P	Electrical Measurement and Measuring Instrument Lab	0	0	2	-	15	35	50	1
8	EE 353P	Power System Lab	0	0	2	-	15	35	50	1
9	EE 354P	Microprocessor lab	0	0	2	-	15	35	50	1
10	EE 357P	Internship-II	-	-	-	-	100	-	100	1
		Sub-Total	**0**	**0**	**6**				**250**	**4**
		MANDATORY COURSE								
11	NC 351	Environmental Science	2	0	0		50*			
		TOTAL	**20**	**6**	**6**				**850**	**22**

SIXTH SEMESTER

Sl. No.	Course No.	Subject	Hours/Week			Marks				
			L	T	P	Theory	Sess.	Pract.	Total	Credit
1	EE 361	Control System-II	3	1	0	70	30	-	100	3
2	EE 362	Power Electronics	3	1	0	70	30	-	100	3
3	EE 363	Switchgear & Industrial Protection	3	1	0	70	30	-	100	3
4	EE 364	Program Elective-II	3	1	0	70	30	-	100	3
5	EE 365	Power System Protection	3	0	0	70	30	-	100	3
6	EE 366	Open Elective-I	3	1	0	70	30	-	100	3
		Sub-Total	**18**	**5**	**0**				**600**	**18**
		PRACTICAL								
7	EE 361P	Control system lab	0	0	3	-	30	70	100	1.5
8	EE 362P	Power Electronics lab	0	0	2	-	15	35	50	1
		Sub-Total	**0**	**0**	**5**				**150**	**2.5**
		MANDATORY COURSE								
9	NC 361	Constitution of India/Essence of Indian Traditional Knowledge	3	0	0		50*			
		TOTAL	**21**	**5**	**5**				**750**	**20.5**

SEVENTH SEMESTER

Sl. No.	Course No.	Subject	Hours/Week			Marks				
			L	T	P	Theory	Sess.	Pract.	Total	Credit
1	EE 471	Digital Signal Processing	3	1	0	70	30	-	100	3
2	EE 472	Electrical Drives	3	1	0	70	30	-	100	3
3	EE 473	Program Elective -III	3	1	0	70	30	-	100	3
4	EE 474	Program Elective -IV	3	1	0	70	30	-	100	3
5	EE 475	Open Elective -II	3	1	0	70	30	-	100	3
		Sub-Total	***15***	***5***	***0***				***500***	***15***
		PRACTICAL								
6	EE 476P	Internship-III	-	-	-	-	100	-	100	1
7	EE 477P	Project-I	0	0	10	-	100	200	300	5
		Sub-Total	***0***	***0***	***10***	***-***	***-***	***-***	***400***	***6***
		TOTAL	**15**	**5**	**10**				**900**	**21**

EIGHTH SEMESTER

Sl. No.	Course No.	Subject	Hours/Week			Marks				
			L	T	P	Theory	Sess.	Pract.	Total	Credit
1	EE 481	Analog & Digital Communications	3	1	0	70	30	-	100	3
2	EE 482	HVDC Transmission System	3	1	0	70	30	-	100	3
3	EE 483	Program Elective - V	3	1	0	70	30	-	100	3
4	EE 484	Open Elective- III	3	1	0	70	30	-	100	3
		Sub-Total	***12***	***4***	***0***				***400***	***12***
		PRACTICAL								
5	EE 485P	Project - II	0	0	12		100	200	300	6
		Sub-Total	***0***	***0***	***12***				***300***	***6***
		TOTAL	**12**	**4**	**12**				**700**	**18**

THIRD SEMESTER

MA 231	Engineering Mathematics-III	3L:1T:0P	4 credits

Module 1: Fourier Series (6 lectures)
Derichlet's condition-General Fourier series- odd and even functions, Half range-sine and cosine series-complex form of Fourier series, Practical Harmonic analysis.

Module 2: Boundary Value Problems (6 lectures)
Classification of second order quasi linear partial differential equations- solution of one dimensional wave equation, one dimensional heat equation- steady state solution of two dimensional heat equation(insulated edges exclude)-Solution by separation of variables.

Module 3: Complex Analysis (10 lectures)
Analytic function-properties, Cauchy-Riemann equations, construction of analytic function, determination of conjugate harmonic functions, application to two dimensional potential problems. Conformal transformations, Bilinear Transformation. Cauchy's Integral theorem and Cauchy's integral formula (statement only), Taylor's and Laurent's expansions, isolated singularities, residues-Cauchy's residues theorem (statement only), contour integration-over unit circle and semi- circle(excluding poles on real axis).

Module 4: Basic Probability (10 lectures)
Probability spaces, conditional probability, independence; Discrete random variables, Independent random variables, the multinomial distribution, Poisson approximation to the binomial distribution, infinite sequences of Bernoulli trials, sums of independent random variables; Expectation of Discrete Random Variables, Moments, Variance of a sum, Correlation coefficient, Chebyshev's Inequality.

Module 5: Basic Statistics (8 lectures)
Measures of Central tendency: Moments, skewness and Kurtosis - Probability distributions: Binomial, Poisson and Normal - evaluation of statistical parameters for these three distributions, Correlation and regression – Rank correlation.

Suggested Text/Reference Books:

1. B. S. Grewal, Higher Engineering Mathematics, Khanna Publication, 41 Edition, New Delhi.
2. Erwin Kreyszig, Advance Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.
3. Ramana B. V., Higher Engineering Mathematics, Tata McGraw Hill, New Delhi, 11th Reprint, 2010.
4. N. O. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2008.
5. (v)P. G. Hoel, S. C. Port and C. J. Stone, "Introduction to Probability Theory",
6. Universal Book Stall, 2003.
7. S. Ross, "A First Course in Probability", Pearson Education India, 2002.
8. W. Feller, "An Introduction to Probability Theory and its Applications", Wiley, 1968.

Course Outcomes:
The objective of this course is to familiarize with basics of Fourier series, Boundary value problems, calculus of complex variable, basics of probability and statistics.

The students will learn:
- The methods to expand a function in Fourier series.
- The methods to solve partial differential equations that are arising in engineering problems.
- The tools of differentiation and integration of functions of a complex variable that are used in various techniques dealing engineering problems.
- The basics of probability and statistics that are essential in most branches of engineering.

ME 231	Engineering Mechanics	3L:1T:0P	4 credits

Course objectives:

1. To enable students to apply fundamental laws and basic concepts of rigid body mechanics to solve problems of bodies under rest or in motion.
2. To learn the working knowledge of statics with emphasis on force equilibrium and free body diagrams.
3. To tackle equilibrium equations, moments and inertia problems
4. To gain a firm foundation in Engineering Mechanics for furthering the career in Engineering
5. To compute the properties of areas and bodies.

Contents:

Module 1: System of Forces (10 Hrs)

Introduction to mechanics, laws of mechanics, concept of force, system of forces, Principle of Transmissibility of force, Parallelogram law, Triangle law, and Polygon law of forces, resultant and equilibrium of system of coplanar concurrent forces, resultant and equilibrium of system of coplanar non- concurrent forces

Module 2: Friction (7 Hrs)

Frictional force, types of friction, laws of friction, coefficient of friction, angle of friction, angle of repose, cone friction, impending motion of connected bodies, wedge, screw jack and rope friction.

Module 3: Centroid & Area Moment of Inertia (6 Hrs)

Centroid, Centre of gravity, Centroid of simple figures and composite sections; Area moment of inertia, polar moment of inertia, radius of gyration, theorems of moment of inertia, moment of inertia of standard figures and moment of inertia of composite sections

Module 4: Centre of Gravity & Mass Moment of Inertia (6 Hrs)

Centre of gravity from first principles, centre of gravity of composite bodies and theorem of Pappus- Guldinus; Definitions, Mass moment of inertia from first principles, transfer formula and mass moment of inertia of composite bodies

Module 5: Kinematics (6 Hrs)

Introduction to Dynamics, Linear motion- motion with uniform velocity and uniform acceleration, Acceleration due to gravity, motion with varying acceleration; Curvilinear motion- motion of body associated with horizontal projection and inclined projection

Module 6: Kinetics (6 Hrs)

Introduction, laws of motion, rectilinear motion of a particle, D'Alembert's Principle, Work- Energy Principle- work energy equation for translation, motion of connected bodies

Module 7: Principle of virtual work (5 Hrs)

Virtual work – Principle of virtual work – System of connected rigid bodies – Degrees of freedom – Conservative forces – Potential energy – Potential energy criteria for equilibrium

Text Books/ References:

1. Meriam, James Lathrop, L. Glenn Kraige, and William J. Palm. *Engineering mechanics. Vol. 1, Statics*. Wiley, 1987.
2. Meriam, James L., and L. Glenn Kraige. *Engineering mechanics: dynamics*. Vol. 2. John Wiley & Sons, 2012.
3. Beer, Ferdinand P., et al. *Vector mechanics for engineers*. Vol. 1. Tata McGraw-Hill Education, 1977.
4. Engineering Mechanics by Ferdin and L. Singer, 3rd Edition.
5. Engineering Mechanics by S.S. Bhavikatti and K.G. Rajashekarappa, New Age International (P) Limited, Publishers

Course outcomes:
Upon successful completion of the course, student should be able to:
1. Compute the resultant of system of forces in plane and space acting on bodies.
2. Use scalar and vector analytical techniques for analysing forces in statically determinate structures
3. Analyse equilibrium problems with friction.
4. Apply transfer theorems to determine properties of various sections.
5. Apply basic knowledge of maths and physics to solve real-world problems
6. Understand basic kinematics concepts – displacement, velocity and acceleration (and their angular counterparts)
7. Understand basic dynamics concepts – force, momentum, work and energy;
8. Analyse equilibrium of connected bodies virtual work method.
9. Predict motion parameters of bodies under rectilinear, curvilinear and general plane motion

EE 231	Electrical Circuit Analysis	3L:1T:0P	3 credits

Course Outcomes:
At the end of this course, students will demonstrate the ability to :
- Apply network theorems for the analysis of electrical circuits.
- Obtain the transient and steady-state response of electrical circuits.
- Analyze circuits in the sinusoidal steady-state (single-phase and three-phase).
- Analyze two port circuit behavior.

Module 1: Network Theorems (10 Hours)
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.

Module 2: Solution of First and Second order networks (8 Hours)
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 state response.

Module 3: Sinusoidal steady state analysis (8 Hours)
Representation of sine function as rotating phasor, phasor diagrams, impedances and admittances, AC circuit analysis, effective or RMS values, average power and complex power. Three-phase circuits. Mutual coupled circuits, Dot Convention in coupled circuits, Ideal Transformer.

Module 4: Electrical Circuit Analysis Using Laplace Transforms (8 Hours)
Review of Laplace Transform, Analysis of electrical circuits using Laplace Transform for standard inputs, convolution integral, inverse Laplace transform, transformed network with initial conditions. Transfer function representation. Poles and Zeros. Frequency response (magnitude and phase plots), series and parallel resonances

Module 5: Two Port Network and Network Functions (6 Hours)
Two Port Networks, terminal pairs, relationship of two port variables, impedance parameters, admittance parameters, transmission parameters and hybrid parameters, interconnections of two port networks.

Text / References:

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

EE 232	Analog Electronic Circuits	3L:1T:0P	3 credits

Course Outcomes:

At the end of this course, students will demonstrate the ability to :

- Understand the characteristics of transistors.
- Design and analyse various rectifier and amplifier circuits. Design sinusoidal and non-sinusoidal oscillators.
- Understand the functioning of OP-AMP and design OP-AMP based circuits.

Module 1: Diode circuits (4 Hours)

P-N junction diode, I-V characteristics of a diode; review of half-wave and full-wave rectifiers, Zener diodes, clamping and clipping circuits.

Module 2: BJT circuits (8 Hours)

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

Module 3: MOSFET circuits (8 Hours)

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, trans-conductance, high frequency equivalent circuit.

Module 4: Differential, multi-stage and operational amplifiers (8 Hours)

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)

Module 5: Linear applications of op-amp (8 Hours)

Idealized analysis of op-amp circuits. Inverting and non-inverting amplifier, differential amplifier, instrumentation amplifier, integrator, 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.

Module 6: Nonlinear applications of op-amp (6 Hours)

Hysteretic Comparator, Zero Crossing Detector, Square-wave and triangular-wave generators. Precision rectifier, peak detector. Monoshot.

Text/References:

1. A. S. Sedra and K. C. Smith, "Microelectronic Circuits", New York, Oxford University Press, 1998.
2. J. V. Wait, L. P. Huelsman and G. A. Korn, "Introduction to Operational Amplifier theory and applications", McGraw Hill U. S., 1992.
3. J. Millman and A. Grabel, "Microelectronics", McGraw Hill Education, 1988.

4. P. Horowitz and W. Hill, "The Art of Electronics", Cambridge University Press, 1989.
5. P. R. Gray, R. G. Meyer and S. Lewis, "Analysis and Design of Analog Integrated Circuits", John Wiley & Sons, 2001.

EE 233	Electrical Machines-I	3L:1T:0P	3 credits

Course Outcomes:

At the end of this course, students will demonstrate the ability to

- Understand the concepts of magnetic circuits.
- Understand the operation of dc machines.
- Analyse the differences in operation of different dc machine configurations.
- Analyse single phase and three phase transformers circuits.

Magnetic fields and magnetic circuits (6 Hours)

Review of magnetic circuits - MMF, flux, reluctance, inductance; review of Ampere Law and Biot Savart Law; Visualization of magnetic fields produced by a bar magnet and a current carrying coil - through air and through a combination of iron and air; influence of highly permeable materials on the magnetic flux lines.

Module 2: Electromagnetic force and torque (9 Hours)

B-H curve of magnetic materials; flux-linkage vs current characteristic of magnetic circuits; linear and nonlinear magnetic circuits; energy stored in the magnetic circuit; force as a partial derivative of stored energy with respect to position of a moving element; torque as a partial derivative of stored energy with respect to angular position of a rotating element. Examples - galvanometer coil, relay contact, lifting magnet, rotating element with eccentricity or saliency

Module 3: DC machines (8 Hours)

Basic construction of a DC machine, magnetic structure - stator yoke, stator poles, pole-faces or shoes, air gap and armature core, visualization of magnetic field produced by the field winding 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, armature MMF wave, derivation of torque equation, armature reaction, air gap flux density distribution with armature reaction.

Module 4: DC machine - motoring and generation (7 Hours)

Armature circuit equation for motoring and generation, Types of field excitations - separately excited, shunt and series. Open circuit characteristic of separately excited DC generator, back EMF with armature reaction, 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

Module 5: Transformers (12 Hours)

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 Three-phase transformer - construction, types of connection and their comparative features, Parallel operation of single-phase and three-phase transformers, Autotransformers - construction, principle, applications and comparison with two winding transformer, 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.

Text / References:

1. A. E. Fitzgerald and C. Kingsley, "Electric Machinery", New York, McGraw Hill Education, 2013.
2. A. E. Clayton and N. N. Hancock, "Performance and design of DC machines", CBS Publishers, 2004.
3. M. G. Say, "Performance and design of AC machines", CBS Publishers, 2002.
4. P. S. Bimbhra, "Electrical Machinery", Khanna Publishers, 2011.
5. I. J. Nagrath and D. P. Kothari, "Electric Machines", McGraw Hill Education, 2010.

HU 231	Economics for Engineers	2L:0T:0P	2 Credits

Course Objectives:

1. To explain engineering economics decision making process, state and explain the law of demand and supply, law of diminishing returns and solve problems on interest factors.
2. To understand the relevance of present worth and future worth comparisons and compare the Net present worth and Net future worth of co-terminated assets, assets with unequal lives and infinite lives.
3. To understand the relevance of Equivalent annual worth comparisons and compare the equivalent annual worth of co-terminated assets and assets with unequal lives and infinite lives.
4. To appraise investments using non-discounted and discounted cash flow techniques, show the depreciation calculations using straight line and declining balance methods and explain the procedure for determining the corporate income tax.
5. To explain the various cost concepts, cost estimation methods, the principles of cost accounting, the elements of balance sheet and profit and loss account and the use of financial ratios for measuring financial performance.

Course Content

Module 1: Introduction (5 Hours)

Introduction: Engineering Decision-Making, Engineering and Economics, Problem solving and Decision making, Intuition and Analysis, Tactics and Strategy. Engineering Economic Decision, Maze. Law of demand and supply, Law of returns, Interest and Interest factors: Interest rate, Simple interest, Compound interest, Cash - flow diagrams, Personal loans and EMI Payment, Exercises and Discussion.

Module 2: Present-Worth and Future worth Comparisons (5 Hours)

Present-Worth and Future worth Comparisons: Conditions for present worth comparisons, Basic Present worth comparisons, Present-worth equivalence, Net Present-worth, Assets with unequal lives, infinite lives, Future-worth comparison, Pay-back comparison, Exercises, Discussions and problems.

Module 3: Equivalent Annual-Worth Comparisons (5 Hours)

Equivalent Annual-Worth Comparison methods, Situations for Equivalent Annual-Worth Comparisons, Consideration of asset life, Comparison of assets with equal and unequal lives, Use of sinking fund method, Annuity contract for guaranteed income, Exercises, Problems.

Module 4: Rate-Of-Return Calculations and Depreciation (5 Hours)

Rate of return, Minimum acceptable rate of return, IRR, IRR misconceptions, Cost of capital concepts. Causes of Depreciation, Basic Methods of computing depreciation charges, Tax concepts, corporate income tax.

Module 5: Introduction to and Scope of Finance Functions (5 Hours)
Statements of Financial Information: Introduction, Source of financial information, financial statements, Balance sheet, and Profit and Loss account, relation between Balance sheet and Profit and Loss account. Financial performance analysis using financial ratios, Simple Numerical.

Text Books:
1. James L Riggs, Engineering Economy, McGraw Hill, 2002.

Reference Books:
1. Gerald J Thuesen, Engineering economy, Prentice-Hall-India, Pvt Ltd, 2002.
2. Prasanna Chandra, Financial Management, Tata Mc Graw Hill, 2002.

PRACTICALS/DESIGN

EE 232P	**Analog Electronics Lab**	**0L:0T:2P**	**1 credits**

Hands-on experiments related to the course contents of EE 232P.

EE 233P	**Electrical Machines-I Lab**	**0L:0T:2P**	**1 credits**

Hands-on experiments related to the course contents of EE 233P.

EE 234P	**Internship I**	**0L:0T:0P**	**1 credits**

FOURTH SEMESTER

MA 241	Numerical Methods and Computation	3L:0T:0P	3 credits

Course Objectives: The main objective of this course is:

1. Introduction to Computer arithmetic and errors.
2. Introduction to solution of Algebraic and Transcendental equation, Linear System of equations and differential equations
3. Introduction to Eigen values and Eigen vectors.

Module1: Accuracy and Errors in Computation: (6 hrs)

Basic concepts on accuracy of numbers, significant figures, rounding of numbers, Errors representation-Inherent and truncation, Absolute and relative errors, errors in the approximation and series approximation of functions.

Module 2: Solution of Algebraic and Transcendental Equations: (9 hrs)

Bisection, Regula-Falsi method, Newton-Raphson and iterative methods with their convergence conditions, Generalizations of Newton-Raphson and iterative methods to simultaneous non-linear equations.

Module 3: Solution of Linear System of Equations: (9 hrs)

Gaussian elimination method with partial pivoting, Factorization method, Matrix Inverse method, Gauss-Jacobi and Gauss-Siedel iterative methods, Fitting of curve by method of least square.

Module 4: Numerical solution of Differential Equations: (10hrs)

Picard's and Taylor series, Euler's method and its modified form, Runge-Kutta methods, Solution of two-point boundary value problems using finite difference: One dimensional parabolic equations-Schmidt method, Crank-Nicolson method; Elliptic equations-Solution of Laplace equation-Jacobi's and Guass-Siedel methods; Hyperbolic Equations: Solution of wave equation.

Module 5: Eigen values and Eigen-vectors problems: (6hrs)

Gershgorin's theorem(without proof) with simple problems, Power method for dominant Eigen-values, Jacobi and Given methods for symmetric matrices.

Suggested Text Book s& References:

1. Grewal B.S., "Numerical Methods", Khanna Pub., New Delhi
2. Shartry S.S., "Numerical Methods", Prentice Hall Inc., India
3. C.F. Gerald and P.O. Wheatley, "Applied Numerical Analysis", Addison Wesley,
4. J.H. Wilkinson, "Algebraic Eigen –Value Problems", Oxford Univ. Press
5. G.D. Smith, "Numerical Solution of Partial Differential Equations", Oxford Univ. Press

Course outcomes: Students completing the course will be able to

1. Understand fundamental arithmetic operations and Errors Estimation.
2. Solve algebraic and transcendental equations.
3. Solve the system of linear equations of various methods.
4. Solve the differential equations.
5. Determine the Eigen values and Eigen vectors.

EE 241	Digital Electronics	3L:0T:0P	3 credits

Course Outcomes:

At the end of this course, students will demonstrate the ability to

- Understand working of logic families and logic gates.
- Design and implement Combinational and Sequential logic circuits.
- Understand the process of Analog to Digital conversion and Digital to Analog conversion.
- Be able to use PLDs to implement the given logical problem.

Module 1:Fundamentals of Digital Systems and logic families (7 Hours)
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 lCs, digital logic families, TTL, Schottky TTL and CMOS logic, interfacing CMOS and TTL, Tri-state logic.

Module 2: Combinational Digital Circuits (7 Hours)
Standard representation for logic functions, K-map representation, simplification of logic functions using K-map, minimization of logical functions. Don't care conditions, Multiplexer, De-Multiplexer/Decoders, Adders, Subtractors, BCD arithmetic, carry look ahead adder, serialadder, 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.

Module 3: Sequential circuits and systems (7 Hours)
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, parallelto serial converter, ring counter, sequence generator, ripple (Asynchronous) counters, synchronous counters, counters design using flip flops, special counter IC's, asynchronous sequential counters, applications of counters.

Module 4: A/D and D/A Converters (7 Hours)
Digital to analog converters: weighted resistor/converter, R-2R Ladder D/A converter, specifications for D/A converters, examples of D/A converter lCs, sample and hold circuit, analog to digital converters: quantization and encoding, parallel comparator A/D converter, successive approximation A/D converter, counting A/D converter, dual slope, A/D converter, A/D converter using voltage to frequency and voltage to time conversion, specifications of A/D converters, example of A/D converter ICs

Module 5: Semiconductor memories and Programmable logic devices. (7 Hours)
Memory organization and operation, expanding memory size, classification and characteristics of memories, sequential memory, read only memory (ROM), read and write memory(RAM), content addressable memory (CAM), charge de 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).

Text/References:

1. R. P. Jain, "Modern Digital Electronics", McGraw Hill Education, 2009.
2. M. M. Mano, "Digital logic and Computer design", Pearson Education India, 2016.
3. A. Kumar, "Fundamentals of Digital Circuits", Prentice Hall India, 2016.

EE 242	Electrical Machines – II	3L:0T:0P	3 credits

Course Outcomes:

At the end of this course, students will demonstrate the ability to

- Understand the concepts of rotating magnetic fields. Understand the operation of AC machines.
- Analyse performance characteristics of ac machines.

Module 1: Fundamentals of AC machine windings (8 Hours)

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, winding axis, 3D visualization of the above winding types, Air-gap MMF distribution with fixed current through winding - concentrated and distributed, Sinusoidally distributed winding, winding distribution factor

Module 2: Pulsating and revolving magnetic fields (4 Hours)

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.

Module 3: Induction Machines (12 Hours)

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.

Module 4: Single-phase induction motors (6 Hours)

Constructional features, double revolving field theory, equivalent circuit, determination of parameters. Split-phase starting methods and applications

Module 5: Synchronous machines (10 Hours)

Constructional features, cylindrical rotor synchronous machine - generated EMF, equivalent circuit and phasor diagram, armature reaction, synchronous impedance, voltage regulation. Operating characteristics of synchronous machines, V-curves. Salient pole machine - two reaction theory, analysis of phasor diagram, power angle characteristics. Parallel operation of alternators - synchronization and load division.

Text/References:

1. A. E. Fitzgerald and C. Kingsley, "Electric Machinery", McGraw Hill Education, 2013.
2. M. G. Say, "Performance and design of AC machines", CBS Publishers, 2002.
3. P. S. Bimbhra, "Electrical Machinery", Khanna Publishers, 2011.
4. I. J. Nagrath and D. P. Kothari, "Electric Machines", McGraw Hill Education, 2010.
5. A. S. Langsdorf, "Alternating current machines", McGraw Hill Education, 1984.
6. P. C. Sen, "Principles of Electric Machines and Power Electronics", John Wiley & Sons, 2007.

EE 243	Power Systems-I	3L:0T:0P	3 credits

Course Outcomes:

At the end of this course, students will demonstrate the ability to

- Understand the concepts of power systems.
- Understand the various power system components. Evaluate fault currents for different types of faults.
- Understand the generation of over-voltages and insulation coordination. Understand basic protection schemes.
- Understand concepts of HV dc power transmission and renewable energy generation.

Module 1: Basic Concepts (4 hours)

Evolution of Power Systems and Present-Day Scenario. Structure of a power system: Bulk Power Grids and Micro-grids.

Generation: Conventional and Renewable Energy Sources. Distributed Energy Resources. Energy Storage. Transmission and Distribution Systems: Line diagrams, transmission and distribution voltage levels and topologies (meshed and radial systems). Synchronous Grids and Asynchronous (DC) interconnections. Review of Three-phase systems. Analysis of simple three-phase circuits. Power Transfer in AC circuits and Reactive Power.

Module 2: Power System Components (15 hours)

Overhead Transmission Lines and Cables: Electrical and Magnetic Fields around conductors, Corona. Parameters of lines and cables. Capacitance and Inductance calculations for simple configurations. Travelling-wave Equations. Sinusoidal Steady state representation of Lines: Short, medium and long lines. Power Transfer, Voltage profile and Reactive Power. Characteristics of transmission lines. Surge Impedance Loading. Series and Shunt Compensation of transmission lines.

Transformers: Three-phase connections and Phase-shifts. Three-winding transformers, auto-transformers, Neutral Grounding transformers. Tap-Changing in transformers.

Transformer Parameters. Single phase equivalent of three-phase transformers.

Synchronous Machines: Steady-state performance characteristics. Operation when connected to infinite bus. Real and Reactive Power Capability Curve of generators. Typical waveform under balanced terminal short circuit conditions – steady state, transient and sub-transient equivalent circuits. Loads: Types, Voltage and Frequency Dependence of Loads. Per-unit System and per-unit calculations.

Module 3: Over-voltages and Insulation Requirements (4 hours)

Generation of Over-voltages: Lightning and Switching Surges. Protection against Over-voltages, Insulation Coordination. Propagation of Surges. Voltages produced by traveling surges. Bewley Diagrams.

Module 4: Fault Analysis and Protection Systems (10 hours)

Method of Symmetrical Components (positive, negative and zero sequences). Balanced and Unbalanced Faults. Representation of generators, lines and transformers in sequence networks. Computation of Fault Currents. Neutral Grounding.

Switchgear: Types of Circuit Breakers. Attributes of Protection schemes, Back-up Protection. Protection schemes (Over-current, directional, distance protection, differential protection) and their application.

Module 5: Introduction to DC Transmission & Renewable Energy Systems (9 hours)

DC Transmission Systems: Line-Commutated Converters (LCC) and Voltage Source Converters (VSC). LCC and VSC based dc link, Real Power Flow control in a dc link. Comparison of ac and dc transmission. Solar PV systems: I-V and P-V characteristics of PV panels, power electronic interface of PV to the grid. Wind Energy Systems: Power curve of wind turbine. Fixed and variable speed turbines. Permanent Magnetic Synchronous Generators and Induction Generators. Power Electronics interfaces of wind generators to the grid.

Text/References:

1. J. Grainger and W. D. Stevenson, "Power System Analysis", McGraw Hill Education, 1994.
2. O. I. Elgerd, "Electric Energy Systems Theory", McGraw Hill Education, 1995.
3. A. R. Bergen and V. Vittal, "Power System Analysis", Pearson Education Inc., 1999.
4. D. P. Kothari and I. J. Nagrath, "Modern Power System Analysis", McGraw Hill Education, 2003.
5. B. M. Weedy, B. J. Cory, N. Jenkins, J. Ekanayake and G. Strbac, "Electric Power Systems", Wiley, 2012.

EE 244	Signals and Systems	3L:0T:0P	3 credits

Course Outcomes:

At the end of this course, students will demonstrate the ability to -

- Understand the concepts of continuous time and discrete time systems.
- Analyse systems in complex frequency domain.
- Understand sampling theorem and its implications.

Module 1: Introduction to Signals and Systems (6 hours):

Signals and systems as seen in everyday life, and in various branches of 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, reliability. Examples.

Module 2: Behavior of continuous and discrete-time LTI systems (12 hours)

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. 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.

Module 3: Fourier, Laplace and z- Transforms (14 hours)

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. 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.

Module 4: Sampling and Reconstruction (6 hours)

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.

Text/References:

1. A. V. Oppenheim, A. S. Willsky and S. H. Nawab, "Signals and systems", Prentice Hall India, 1997.

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

HU 241	Universal Human Values II	2L:1T:0P	3 credits

OBJECTIVE:

The objective of the course is four fold:

1. Development of a holistic perspective based on self-exploration about themselves (human being), family, society and nature/existence.
2. Understanding (or developing clarity) of the harmony in the human being, family, society and nature/existence
3. Strengthening of self-reflection.
4. Development of commitment and courage to act.

COURSE TOPICS:

The course has 28 lectures and 14 practice sessions in 5 modules:

Module 1:

Course Introduction - Need, Basic Guidelines, Content and Process for Value Education

1. Purpose and motivation for the course, recapitulation from Universal Human Values-I
2. Self-Exploration–what is it? - Its content and process; 'Natural Acceptance' and Experiential Validation-as the process for self-exploration
3. Continuous Happiness and Prosperity-A look at basic Human Aspirations
4. Right understanding, Relationship and Physical Facility- the basic requirements for fulfilment of aspirations of every human being with their correct priority
5. Understanding Happiness and Prosperity correctly- A critical appraisal of the current scenario
6. Method to fulfill the above human aspirations: understanding and living in harmony at various levels.

Include practice sessions to discuss natural acceptance in human being as the innate acceptance for living with responsibility (living in relationship, harmony and co-existence) rather than as arbitrariness in choice based on liking-disliking.

Module 2:

Understanding Harmony in the Human Being-Harmony in Myself!

1. Understanding human being as a co-existence of the sentient 'I' and the material 'Body'
2. Understanding the needs of Self ('I') and 'Body' - happiness and physical facility
3. Understanding the Body as an instrument of 'I' (I being the doer, seer and enjoyer)
4. Understanding the characteristics and activities of 'I' and harmony in 'I'
5. Understanding the harmony of I with the Body: Sanyam and Health; correct appraisal of Physical needs, meaning of Prosperity in detail
6. Programs to ensure Sanyam and Health.

Include practice sessions to discuss the role others have played in making material goods available to me. Identifying from one's own life. Differentiate between prosperity and accumulation. Discuss program for ensuring health vs dealing with disease

Module 3:

Understanding Harmony in the Family and Society- Harmony in Human-Human Relationship

1. Understanding values in human-human relationship; meaning of Justice (nine universal values in relationships) and program for its fulfilment to ensure mutual happiness; Trust and Respect as the foundational values of relationship
2. Understanding the meaning of Trust; Difference between intention and competence
3. Understanding the meaning of Respect, Difference between respect and differentiation; the other salient values in relationship
4. Understanding the harmony in the society (society being an extension of family): Resolution, Prosperity, fearlessness (trust) and co-existence as comprehensive Human Goals
5. Visualizing a universal harmonious order in society- Undivided Society, Universal Order-from family to world family.

Include practice sessions to reflect on relationships in family, hostel and institute as extended family, real life examples, teacher-student relationship, goal of education etc. Gratitude as a universal value in relationships. Discuss with scenarios. Elicit examples from students' lives

Module 4:

Understanding Harmony in the Nature and Existence - Whole existence as Coexistence

1. Understanding the harmony in the Nature
2. Interconnectedness and mutual fulfilment among the four orders of nature-recyclability and self regulation in nature
3. Understanding Existence as Co-existence of mutually interacting units in all-pervasive space
4. Holistic perception of harmony at all levels of existence.

Include practice sessions to discuss human being as cause of imbalance in nature (film "Home" can be used), pollution, depletion of resources and role of technology etc.

Module 5:

Implications of the above Holistic Understanding of Harmony on Professional Ethics

1. Natural acceptance of human values
2. Definitiveness of Ethical Human Conduct
3. Basis for Humanistic Education, Humanistic Constitution and Humanistic Universal Order
4. Competence in professional ethics:
    a. Ability to utilize the professional competence for augmenting universal human order
    b. Ability to identify the scope and characteristics of people friendly and eco-friendly production systems,
    c. Ability to identify and develop appropriate technologies and management patterns for above production systems.
5. Case studies of typical holistic technologies, management models and production systems
6. Strategy for transition from the present state to Universal Human Order:
    a. At the level of individual: as socially and ecologically responsible engineers, technologists and managers
    b. At the level of society: as mutually enriching institutions and organizations
7. Sum-up.

Include practice Exercises and Case Studies will be taken up in Practice (tutorial) Sessions e.g. To discuss the conduct as an engineer or scientist etc.

Readings:

Text Book

1. Human Values and Professional Ethics by RR Gaur, R Sangal, GP Bagaria, Excel Books, New Delhi, 2010

Reference Books

1. Jeevan Vidya: Ek Parichaya, A Nagaraj, Jeevan Vidya Prakashan, Amarkantak, 1999.
2. Human Values, A.N. Tripathi, New Age Intl. Publishers, New Delhi, 2004.
3. The Story of Stuff (Book).
4. The Story of My Experiments with Truth-by Mohandas Karamchand Gandhi
5. Small is Beautiful-E.F Schumacher.
6. Slow is Beautiful-Cecile Andrews
7. Economy of Permanence-JC Kumarappa
8. Bharat Mein Angreji Raj-Pandit Sunderlal
9. Rediscovering India-by Dharampal
10. Hind Swaraj or Indian Home Rule –by Mohandas K. Gandhi
11. India Wins Freedom- Maulana Abdul Kalam Azad
12. Vivekananda - Romain Rolland (English)
13. Gandhi-Romain Rolland (English)

4. MODE OF CONDUCT (2L:1T:0P) (3credits)

Lectures hours are to be used for interactive discussion, placing the proposals about the topics at hand and motivating students to reflect, explore and verify them.
Tutorial hours are to be used for practice sessions.

While analysing and discussing the topic, the faculty mentor's role is in pointing to essential elements to help in sorting them out from the surface elements. In other words, help the students explore the important or critical elements.

In the discussions, particularly during practice sessions (tutorials), the mentor encourages the student to connect with one's own self and do self-observation, self-reflection and self-exploration. Scenarios may be used to initiate discussion. The student is encouraged to take up "ordinary" situations rather than" extra-ordinary" situations. Such observations and their analyses are shared and discussed with other students and faculty mentor, in a group sitting.

Tutorials (experiments or practical) are important for the course. The difference is that the laboratory is everyday life, and practical are how you behave and working real life. Depending on the nature of topics, worksheets, home assignment and/or activity are included. The practice sessions (tutorials) would also provide support to a student in performing actions commensurate to his/her beliefs. It is intended that this would lead to development of commitment, namely behaving and working based on basic human values.

It is recommended that this content be placed before the student as it is, in the form of a basic foundation course, without including anything else or excluding any part of this content. Additional content may be offered in separate, higher courses.

This course is to be taught by faculty from every teaching department, including HSS faculty.

Teacher preparation with a minimum exposure to at least one 8-day FDP on Universal Human Values is deemed essential.

5. ASSESSMENT:

This is a compulsory credit course. The assessment is to provide a fair state of development of the student, so participation in classroom discussions, self-assessment, peer assessment etc. will be used in evaluation.

Example:

Assessment by faculty mentor	: 10 marks
Self-assessment	: 10marks
Assessment by peers	: 10marks
Socially relevant project/Group Activities/Assignments	: 20 marks
Semester End Examination	: 50marks

The overall pass percentage is 40%.
In case the student fails, he/she must repeat the course.

6. OUTCOME OF THE COURSE:

By the end of the course, students are expected to become more aware of themselves, and their surroundings (family, society, nature); they would become more responsible in life, and in handling problems with sustainable solutions, while keeping human relationships and human nature in mind.

They would have better critical ability. They would also become sensitive to their commitment towards what they have understood (human values, human relationship and human society). It is hoped that they would be able to apply what they have learnt to their own self in different day-to-day settings in real life, at least a beginning would be made in this direction.

This is only an introductory foundational input. It would be desirable to follow it up by

a) faculty-student or mentor-mentee programs throughout their time with the institution
b) Higher level courses on human values in every aspect of living. e.g. as a professional

PRACTICAL/DESIGN

EE 241P	**Digital Electronics Lab**	**0L:0T:2P**	**1 credits**

Hands-on experiments related to the course contents of EE 241P.

EE 242P	**Electrical Machine-II Lab**	**0L:0T:2P**	**1 credits**

Hands-on experiments related to the course contents of EE 242P.

EE 243P	**Power systems Lab**	**0L:0T:2P**	**1 credits**

Hands-on experiments related to the course contents of EE 243P.

MANDATORY COURSE

NC 241	**Organizational Behavior**	**3L:0T:0P**	**0 credits**

Module-1

OB: Learning objectives, Definition & Meaning, Why to study OB, An OB model, New challenges for OB Manager
LEARNING: Nature of learning, How learning occurs, Learning & OB Case Study Analysis

Module-2

PERSONALITY: Meaning & Definition, Determinants of Personality, Personality Traits, personality & OB
PERCEPTION: Meaning & Definition, Perceptual process, Importance of Perception in OB
MOTIVATION: Nature & Importance, Herzberg's Two Factor theory, Maslow's Need Hierarchy theory, Alderfer's ERG theory
Case Study Analysis

Module-3

COMMUNICATION: Importance, Types, Barriers to communication, Communication as a tool for improving Interpersonal Effectiveness

GROUPS IN ORGANISATION: Nature, Types, Why do people join groups, Group Cohesiveness & Group Decision Making- managerial Implications, Effective Team Building

LEADERSHIP: Leadership & management, Theories of leadership- Trait theory, Behavioral Theory, Contingency Theory, Leadership & Followership, How to be an Effective Leader

CONFLICT: Nature of Conflict & Conflict Resolution

TRANSACTIONAL ANALYSIS: An Introduction to Transactional Analysis

Case Study Analysis

Module-4

ORGANISATIONAL CULTURE: Meaning & Definition, Culture & Organizational Effectiveness HUMAN RESOURCE MANAGEMENT: Introduction to HRM, Selection, Orientation, Training & Development, Performance Appraisal, Incentives

ORGANISATIONAL CHANGE: Importance of Change, Planned Change & OB Techniques INTERNATIONAL OB: An Introduction to Individual & Interpersonal Behaviour in Global Perspectives Case Study Analysis.

FIFTH SEMESTER

EE 351	Electrical Measurement and Measuring Instruments	3L:1T:0P	3 Credits

Course objectives:

1. To introduce basic principles of all the measuring Instruments.
2. To study different types of instrument and their applications.
3. To study the measurement of voltage, current, power factor, power, energy and magnetic measurement.

Introduction:

Introduction of signals, Measurement and instruments, Static and dynamic characteristics of instruments. Different types of instruments. Operating forces required for working of indicating instruments. Different types of damping and control systems. Construction and working principles of PMMC, MI, Induction type, Electrodynamometer type, their applications advantages and disadvantages.

Galvanometers and dynamics:

Dynamic behaviour of Galvanometer - equation of motion for different damping conditions. Response of galvanometer, operational constants, CDRX, relative damping, logarithmic decrement, sensibility. Ballistic Galvanometer and Flux meter construction and theory of operation.

Magnetic measurements:

Magnetic measurements, types of tests, Ballistic tests, measurement of flux density, determination of B.H. curve

Bridges for measurements:

Measurement of resistance (law) by kelvins Double Bridge Method, insulation resistance by loss of charge method. A.C. & D.C. bridges - Maxwell's commutated D.C. bridge, Anderson bridge, Schering Bridge, Hays Bridge, Wagner Earthing device, Campbell's Mutual Inductance Bridge, Circuit diagram, phasor diagram, derivations of equations for unknown, O-factor, dissipation factor. Advantages and disadvantages.

Potentiometers:

Standardization, Principle of working and construction of Crompton, potentiometer (D.C.) Polar and Co-ordinate type of potentiometers.

Measurement of power, power factor and energy:

Measurement of power and energy, use of Current transformer and potential transformer, Electrodynamometer type of Wattmeter, Induction type energy meter, Indicating type Frequency meter, Electrodynamometer type P.F. meter.

Reference Books:

1. A.K. Sawhney, "Electrical & Electronics Measurements and Instrumentation" Dhanpat Rai and Sons
2. Golding, "A Text Book of Electrical Measurement and Measuring Instruments" Wheeler Publications

Course outcomes:

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

- Understand different types of measuring instruments.
- Understand their construction, working and characteristics.
- Learn their applications advantages and disadvantages.
- Identify the instruments suitable for typical measurement.
- Learn the dynamic behavior of Galvanometer, magnetic measurement, potentiometer and different bridges for measurement.
- Apply the concept of the measurement of power, power factor and energy of the Instruments

EE 352	Control System - I	3L:1T:0P	3 Credits

Module 1: Motivation (2 hours)
What is control all about, the control problem and solution possibilities, the notion objectives/specifications, feedback as natural strategy, regulation and tracking problems

Module 2: Models and physical systems (5 hours)
Transfer function: Definition, Examples with mechanical, electrical, hydraulic, pneumatic systems and systems with dead zone; Description of control system components and their representation and transfer functions: Error detectors, Gears, Gyroscope, DC motors, Servomotors, Techo-generators, Servo amplifiers; Block diagram and reduction techniques, Signal flow graphs, Mason's Gain formulae.

Module 3: Time domain analysis (6 hours)
Transient response analysis (1^{st} and 2^{nd} order): response parameters and their qualitative analysis; Steady state response analysis (1^{st} and 2^{nd} order): response parameters and their qualitative analysis; Transient and steady state response analysis for 1^{st} and 2^{nd} order systems with unity negative feedback structure; Impact of close looping on system parameters and their sensitivity, Error analysis and error constants;

Module 4: Root locus analysis (4 hours)
Development of root loci, Root motions under close – looping, Pole/zero effects on loci, Effect of rate and reset times, Stability, relative stability and time domain specification using root locus.

Module 5: Frequency domain analysis (4 hours)
Routh array analysis; Bode plots, Nichols plot, polar plots, Nyquist plot; Stability, relative stability and frequency domain specifications analysis using these plots; Multiple point of view using Bode, Nichols, Polar and Nyquist plots simultaneously; M and N circles.

Module 6: Controller/ Compensator Design (4 hours)
Time domain specifications; Frequency domain specifications; Interrelation between TDS and FDS; How to choose a strategy to satisfy a given objective; P, PD, PI, PID error control strategies; Impact on transient response, Impact on S.S. response;

Module 7: Compensator design (2 hours)
Lead, lag and lag – lead compensation, Objectives in Time parameters, Objective in frequency parameters, the role of gains, the role of phase.

Reference Books:

1. D' Azzo and Houpis, "Linear Control Systems Analysis and Design", McGraw Hill
2. Katsuhiko Ogata, "Modern Control Engineering", Pearson Education
3. M. Gopal, "Control Systems Principles and Design", Tata McGraw Hill
4. N S Nise, "Control Systems Engineering", Wiley
5. Dorf and Bishop, "Modern Control Systems", Addison Wesley
6. Anadanatarajan & Ramesh Babu, "Control Systems Engineering", Scitech Publications (India) Pvt Ltd, Chennai

Course Outcomes:
At the end of this course, students will demonstrate the ability to
- Understand the modelling and physical systems
- Understand the concept of Time domain analysis and frequency domain analysis .
- Design simple feedback controllers and compensator

EE 353	Power System-II	3L:1T:0P	3 Credits

Course Objective

1. To study performance of overhead transmission lines and system stability.
2. To study methods to control the voltage, frequency and power flow.
3. Understand the monitoring and control of a power system.
4. To study Economic operation of steam power plant.

Module 1: Performance of overhead transmission lines

Introduction; classification of transmission lines; performance calculation of short and medium transmission lines, Nominal T and nominal π methods; Performance Long transmission lines; Power circle diagrams (PCD): Receiving end, sending end, universal PCD, calculation of SPM Capacity, maximum power limit, percentage regulation, sending end power factor, efficiency of transmission line from PCD. Loss and loss diagram.

Module 2: Power system stability

Introduction to synchronous machine, rotor angle, Infinite bus; Definition of stability, classification of stability, power limit of transmission lines, steady state stability, clarke's diagram, transient stability, the swing equations, equal area criterion, calculation of critical clearing angles, Calculation of power angle curves for fault and post fault conditions for various types of faults, step by step procedure for solution of swing equation, dynamic stability, factors effecting stability

Module 3: Control of active and reactive power

Active power and frequency control: fundamental speed governing system, Governor speed regulation parameter, , Fundamentals of automatic generation control, Frequency bias, Primary and secondary control, Basic simulation models of automatic generation control; Reactive power and voltage control: Production of absorber of reactive power, methods of voltage control; shunt reactors, series reactors, synchronous condensers, static VAR system, tap changing transformers.

Module 4: Economic operation of steam Power plant

Introduction; Methods of loading turbo - generators, Thermal plant cost modelling, Input - output curves, incremental cost, cost curve: Linear and quadratic, method of Lagrangion multiplier, Equality constraints and inequality constraints, transmission loss, optimum generator allocation with and without transmission loss; Penalty factors, iterative procedure to solve co-ordination equation.

Module 5: Elements of Hydrothermal co-ordination

Advantages of combined operation, plant requirement for base load and peak load operation, Combined working of runoff river plant and steam plant, Reservoir hydro plants and thermal, plant for long term operational aspects, co-ordination equation, scheduling methods, application of scheduling methods.

Module 6: Transients in power systems

Lightning phenomenon, Switching surges, travelling waves, shape and specifications of travelling waves, attenuation and distortions of travelling waves, alteration due to corona, behaviour of travelling waves at open, short and joints of overhead lines and cables, construction of lattice diagrams.

Reference Books:

1. C.L. Wadhwa, “Electrical Power Systems”, Wiley Eastern
2. Ashfaq Hussain, “Electrical Power System”, CBS Publishers
3. B.R. Gupta, “Generation of Electrical Energy”, S. Chand
4. Soni, Gupta, Bhatnagar, “Electric Power”, Dhanpat Rai & Sons
5. J.B. Gupta, “A course in Power Systems”, S.K. Katia & Sons
6. P. Kundur, “Power system stability and control”, McGraw-Hill

Course Outcomes:
At the end of this course, students will demonstrate the ability to
- Use numerical methods to analyse a power system in steady state.
- Understand stability constraints in a synchronous grid.
- Understand methods to control the voltage, frequency and power flow.
- Understand the monitoring and control of a power system.
- Understand the basics of power system economics.

EE 354	Microprocessor	3L:1T:0P	3 Credits

Module 1: Introduction
Important features, Educational need, Applications.

Module 2: Microprocessor architecture
Arithmetic Logic Unit (ALU), Timing and control Unit, Registers, Data and Address bus, Interface unit, Intel 8085 instructions, Instruction word size: one byte, two byte and three byte instructions, Timing and control signals, Fetch operations, Execution operations, Machine cycle and state, Instruction and data flow, System timing diagram.

Module 3: Programming microprocessors
Data representation, Instruction formats, Addressing modes, Instruction set, Assembly language programming, Program looping, Subroutine linkage.

Module 4: Memory interfacing
Types of main memories, Compatibility between memory and system BUS, Address space, Partitioning of address space, Special chips for address decoding, ROM and RAM interfacing.

Module 5: Data transfer techniques and their implementation
Programmed data transfer, DMA mode of transfer, I/O port, Device polling in interrupt driven mode of data transfer, DMA controller and data transfer in DMA mode, Serial mode of data transfer, Introduction to Standard interface chips: 8255, 8259, 8253, 8279.

Module 6: Common peripherals and their interfacing
Keyboard, LEDs, Common display and keyboard scanning.

Module 7: Important features of some advanced microprocessor
Bit microprocessor families: MOTOROLA 68000: The CPU components, Instruction sets, addressing modes etc, Intel 8086/8088: The CPU components, Instruction sets, addressing modes etc; 32 bit microprocessor families: MOTOROLA 68020, Intel 80386, 486, PENTIUM PRO; RISC microprocessors, SUN SPARC, HP precision architecture.

Module 8: Applications of Microprocessors
Temperature monitoring and control System, Speed controller of a DC Motor, Data acquisition system.

Course Outcomes:
At the end of this course, students will demonstrate the ability to
- Do assembly language programming.
- Do interfacing design of peripherals like I/O, A/D, D/A, timer etc.
- Develop systems using different microcontrollers.

Reference Books:

1. John P. Hayes, “Digital Systems and Microprocessors”, McGraw Hill I. E.
2. R.S. Gaonker, “Microprocessor Architecture, Programming and Applications”, Wiley Eastern
3. D.V. Hall, “Microprocessor and Interfacing: Programming and Hardware”, McGraw Hill I.E
4. John P. Hayes, “Digital Systems and Microprocessors”, McGraw Hill I.E

EE 356	Electromagnetic Fields	3L:1T:0P	3 Credits

Course Outcomes:

At the end of the course, students will demonstrate the ability

- To understand the basic laws of electromagnetism.
- To obtain the electric and magnetic fields for simple configurations under static conditions.
- To analyse time varying electric and magnetic fields.
- To understand Maxwell's equation in different forms and different media.
- To understand the propagation of EM waves.

This course shall have Lectures and Tutorials. Most of the students find difficult to visualize electric and magnetic fields. Instructors may demonstrate various simulation tools to visualize electric and magnetic fields in practical devices like transformers, transmission lines and machines.

Module 1: **Review of Vector Calculus (6 hours)**

Vector algebra-addition, subtraction, components of vectors, scalar and vector multiplications, triple products, Three orthogonal coordinate systems (rectangular, cylindrical and spherical). Vector calculus-differentiation, partial differentiation, integration, vector operator del, gradient , divergence and curl; integral theorems of vectors. Conversion of a vector from one coordinate system to another.

Module 2: Static Electric Field (6 Hours)

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.

Module 3: Conductors, Dielectrics and Capacitance (6 Hours)

Current and current density, Ohms Law in Point form, Continuity of current, Boundary conditions of perfect dielectric materials. Permittivity of dielectric materials, Capacitance, Capacitance of a two wire line, Poisson's equation, Laplace's equation, Solution of Laplace and Poisson's equation, Application of Laplace's and Poisson's equations.

Module 4: Static Magnetic Fields (6 Hours)

Biot-Savart Law, Ampere Law, Magnetic flux and magnetic flux density, Scalar and Vector Magnetic potentials. Steady magnetic fields produced by current carrying conductors.

Module 5: Magnetic Forces, Materials and Inductance (6 Hours)

Force on a moving charge, Force on a differential current element, Force between differential current elements, Nature of magnetic materials, Magnetization and permeability, Magnetic boundary conditions, Magnetic circuits, inductances and mutual inductances.

Module 6: Time Varying Fields and Maxwell's Equations (6 Hours)

Faraday's law for Electromagnetic induction, Displacement current, Point form of Maxwell's equation, Integral form of Maxwell's equations, Motional Electromotive forces. Boundary Conditions.

Module 7: Electromagnetic Waves (6 Hours)

Derivation of Wave Equation, Uniform Plane Waves, Maxwell's equation in Phasor form, Wave equation in Phasor form, Plane waves in free space and in a homogenous material. Wave equation for a conducting medium, Plane waves in lossy dielectrics, Propagation in good conductors, Skin effect. Poynting theorem.

Text / References:

1. M. N. O. Sadiku, "Elements of Electromagnetics", Oxford University Publication, 2014.
2. A. Pramanik, "Electromagnetism - Theory and applications", PHI Learning Pvt. Ltd, New Delhi, 2009.
3. A. Pramanik, "Electromagnetism-Problems with solution", Prentice Hall India, 2012.
4. G. W. Carter, "The electromagnetic field in its engineering aspects", Longmans, 1954.
5. W. J. Duffin, "Electricity and Magnetism", McGraw Hill Publication, 1980.
6. W. J. Duffin, "Advanced Electricity and Magnetism", McGraw Hill, 1968.
7. E. G. Cullwick, "The Fundamentals of Electromagnetism", Cambridge University Press, 1966.
8. B. D. Popovic, "Introductory Engineering Electromagnetics", Addison-Wesley Educational Publishers, International Edition, 1971.
9. W. Hayt, "Engineering Electromagnetics", McGraw Hill Education, 2012.

EE 351P	Electrical measurement & Measuring Instrument	0L:0T:2P	1 Credit

1. To calibrate a three phase Energy Meter by comparing with a Sub – standard meter.
2. Measurement of Power and Power Factor of a three phase circuit.
3. Measurement of Power in HV circuit using instrument transformer (CT & PT)
4. To measure high resistance by loss of charge method.
5. To calibrate Single – phase Energy meter by comparing with a substandard meter and also by calculation.
6. To measure medium resistance with the help of Wheatstone Bridge.
7. To measure the low resistance by using Kelvin Double Bridge Method.
   a. To measure the Medium resistance using Substitution Method.
   b. To measure the value of Earth – Resistance.
8. To measure self inductance of a coil using A.C Anderson's Bridge.
9. To measure capacitance of a given capacitor.
10. To determine the phase sequence of a three phase supply using phase sequence indicator.

Course outcomes:

Upon completion of this course, the student will be able to:

- Measure the electrical parameters using measuring instruments.
- Calibration and testing of measuring instruments.
- Test the Low Resistance by Kelvin's Double Bridge Method.
- Test the Self Inductance and Capacitance using Bridges.
- Test the Power in HV circuit by using CTs and PTs.
- Test the Power and Power Factor in a three phase AC circuit.

EE 354P	Microprocessor Laboratory	0L:0T:2P	1 Credit

Course Objectives

- Study the Architecture of 8085&8086 microprocessor.
- Learn the design aspects of I/O and Memory Interfacing circuits.
- Study the Architecture of 8051 microcontroller.

Experiment:

1. Write a Program to add two hexadecimal numbers.
2. Write a Program to subtract two hexadecimal numbers.

3. Write a Program to find the product of two hexadecimal numbers each of length 4 bits.
4. Write a Program to perform division of two hexadecimal numbers.
5. Write a Program to arrange a list of unsigned integers in ascending order.
6. Write a Program to arrange a list of unsigned integers in descending orders.
7. Write a Program to design a digital clock using only a single microcomputer.
8. Write a Program to design a digital clock using only a single microcomputer.
9. Write a Program to design and implementation of design clock in hardware using 8085 and its peripherals.
10. Write a Program to driving of Stepper Motor using 8085.

Course Outcomes (COs)

- Design and implement programs on 8085 microprocessor.
- Design interfacing circuits with 8085
- Design interfacing circuits with 8086.
- Design and implement 8051 microcontroller based systems

EE 357P	**Internship II**	**0L:0T:0P**	**1 credits**

NC 351	**Environmental Science**	**3L:0T:0P**	**0 credit**

Course Objectives:

1. Understanding the importance of ecological balance for sustainable development.
2. Understanding the impacts of developmental activities and mitigation measures.
3. Understanding the environmental policies and regulations

Contents:

MODULE-I: Ecosystems:

Definition, Scope, and Importance of ecosystem. Classification, structure, and function of an ecosystem, Food chains, food webs, and ecological pyramids. Flow of energy, Biogeochemical cycles, Bioaccumulation, Biomagnification, ecosystem value, services and carrying capacity, Field visits.

MODULE-II: Natural Resources:

Classification of Resources: Living and Non-Living resources, water resources: use and over utilization of surface and ground water, floods and droughts, Dams: benefits and problems. Mineral resources: use and exploitation, environmental effects of extracting and using mineral resources, Land resources: Forest resources, Energy resources: growing energy needs, renewable and non-renewable energy sources, use of alternate energy source, case studies.

MODULE-III: Biodiversity And Biotic Resources:

Introduction, Definition, genetic, species and ecosystem diversity. Value of biodiversity; consumptive use, productive use, social, ethical, aesthetic and optional values. India as a mega diversity nation, Hot spots of biodiversity. Field visit. Threats to biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts; conservation of biodiversity: In-Situ and Ex-situ conservation. National Biodiversity act.

Course Outcomes:

Based on this course, the Engineering graduate will understand /evaluate / develop technologies on the basis of ecological principles and environmental regulations which in turn helps in sustainable development

Text Books:

1. Textbook of Environmental Studies for Undergraduate Courses by Erach Bharucha for University Grants Commission.
2. Environmental Studies by R. Rajagopalan, Oxford University Press.

Reference Books:

1. Environmental Science: towards a sustainable future by Richard T. Wright. 2008 PHL Learning Private Ltd. New Delhi.
2. Environmental Engineering and science by Gilbert M. Masters and Wendell P. Ela. 2008 PHI Learning Pvt. Ltd.
3. Environmental Science by Daniel B. Botkin & Edward A. Keller, Wiley INDIA edition.
4. Environmental Studies by Anubha Kaushik, 4th Edition, New age international publishers.
5. Text book of Environmental Science and Technology – Dr. M. Anji Reddy 2007, BS Publications.
6. Introduction to Environmental Science by Y. Anjaneyulu, BS.Publications.

SIXTH SEMESTER

EE 361	CONTROL SYSTEM-II	3L:1T:0P	3 credits

Course Objective:

1. To provide with basic knowledge of state space representation of control systems, non linear system analysis, associated terminologies.
2. Analysis, design & implementation of SISO & MIMO systems using state space approach.
3. To make students familiar with digital control system and its analysis.
4. To provide basic idea of real time nonlinear systems, their analysis method

Module 1: Introduction to Digital Control

Z Transform, Signal processing in digital control, Principles of signal conversion, Transfer function models for discrete time systems, System response, Stability in the z – plane and the jury stability criterion, Sampling and data reconstruction process, Z – domain description of closed loop systems, Systems with dead – time, Implementation of digital controllers; Digital Controllers for deadbeat performance.

Module 2: State Space Representation of Continuous Time and Discrete time systems

Introduction to state space model, State Space equations in Canonical forms, Modeling of few electrical and mechanical systems in State Space form, Solution of time invariant, time variant continuous time systems & discrete time system state equations, Concept of state transition matrix, Controllability and Observability, Relation between transfer function and state variable representations, Pole-placement using state variable feedback, Design of full order state observers, reduced order observer, observer based state feedback controller.

Module 3: Introduction to nonlinear feedback control systems

Characteristics of Nonlinear systems, Linearization technique; Phase Plane analysis, Singular points, Limit cycle vs closed trajectory, Stability analysis using Phase Plane analysis; Describing function of common nonlinear functions, stability analysis using DF; Stability in the sense of Liapunov, Liapunov's stability theorems for linear and nonlinear systems; Effect of Non-linearity in Root Locus and Nyquist Plot.

Reference Books:

1. Dorf and Bishop, "Modern Control Systems", PHI
2. Ogata, "Modern Control Engineering", PHI
3. B.C. Kuo, "Digital Control System", PHI
4. M. Gopal, "Modern Control System Theory", PHI
5. Donald M Wiberg, "State Space and Linear Systems", Schuam's Outline Series

Course Outcome

After successful completion of the course students:

1. Can analyze MIMO systems using State variable approach.
2. Can understand and demonstrate discrete, digital, nonlinear control systems.
3. Can explain sampling, quantization, encoding and their mathematical modeling. Thus understand signal conversion techniques.
4. Can explain effects of common non linearities introduced in a system.
5. Can understand Z transform, pulse transfer function and able to apply that concept for digital system analysis.
6. Able to analyze digital system and nonlinear system stability using different analysis tools.

EE 362	POWER ELECTRONICS	3L:1T:0P	3 credits

Course Objective:

1. To introduce students to the basic theory of power semiconductor devices and passive components, their practical applications in power electronics.
2. To familiarize students to the principle of operation, design and synthesis of different power conversion circuits and their applications.
3. To provide strong foundation for further study of power electronic circuits and systems.

Module 1: Introduction

Concept of Power Electronics, Different types of power electronics devices, converter systems, areas of application, recent developments.

Module 2: Device characteristics, protection and operation

Terminal characteristics of major power electronics devices, ratings, protection, heating, cooling and mounting, series and parallel operation, firing circuits.

Module 3: Phase controlled rectifiers

Principles of operation of phase controlled, single phase & poly-phase, full-wave & half-wave converters with continuous and discontinuous load currents and harmonic analysis. Effect of source impedance on the performance of converters, dual converters.

Module 4: Choppers

Principle of chopper operation, Control strategies, Types of chopper circuits and steady state analysis. Commutation in chopper circuits, Multiphase chopper.

Module 5: Inverters

Classification of inverters, Single-phase and three-phase Voltage source Inverters, Methods of controlling output voltage, frequency and phase, Reduction of harmonics in the inverter output voltage, Current source inverters and operations.

Module 6: AC Voltage Controller

Types of AC voltage controllers, Single phase voltage controllers, Sequence control of ac voltage controllers, 3-phase AC voltage controller operation.

Module 7: Cyclo converters

Principles of cyclo converter operation, Methods of controlling output voltage and frequency in cases of: Single phase to single phase, three phase to single phase, three phase to three phase operation.

Module 8: Applications

Power supply applications, few applications in residential and industrial systems, Electric utility.

Reference Books:

1. P C Sen, “Power Electronics”, TMH
2. Dubey, “Power Electronics”, TMH
3. Dubey *et. al., “*Thyristorised Power Controllers”
4. Rashid Mohammed, “Power Electronics”, PHI
5. V. Subrahmanyam, “Power Electronics & Drives”, New Age
6. P.S. Bhimbhra, “Power Electronics”, Khanna Publishers

Course Outcomes:

At the end of this course students will demonstrate the ability to:-

- Understand the differences between signal level and power level devices.
- Analyse controlled rectifier circuits.
- Analyse the operation of DC-DC choppers.
- Analyse the operation of voltage source inverters.

EE 363	Switchgear and Industrial Protection	3L:1T:0P	3 credits

Course objective:-

1. To understand the need of protection of electric equipment and their protection schemes.
2. To understand operations & characteristics of various electromagnetic and static relays.
3. To understand the operations of various types of circuit breakers and their ratings.
4. To understand the unit protection and over voltage protection of different apparatus in power system.

Module 1: Symmetrical Fault Analysis

Causes of faults, types of faults, importance of fault analysis in electrical power systems, fault analysis for generators, transmission lines, concepts of generator reactance's; transient, sub-transients etc, current limiting reactors, types, functions.

Module 2: Symmetrical components and Unsymmetrical Fault Analysis

Concepts of symmetrical components, fortescue's theorem, power in terms of symmetrical components, sequence impedances and sequence networks for generators, transformers, transmission lines etc, unsymmetrical fault (L-G, L-L, LL-G) analysis.

Module 3: Neutral Grounding

Fundamentals of neutral grounding, ungrounded system analysis, arcing ground, solid grounding, types of grounding, resistance, reactance and resonant grounding, generator neutral breaker, grounding practice.

Module 4: Circuit Breakers

Function, importance, arc phenomenon, arc interruption theories, CB types and description, Circuit breaking transients, restriking and recovery voltages, CB ratings, testing of CB's.

Module 5: Protective Relays

Operating principle, classification, Electromagnetic type relays theories for torque generation, concepts of protective zones, Over Current relay characteristics, Directional relay torque generation, feeder protection, time grading & current grading, Distance protection philosophies, Distance relays and their characteristics, differential protections, Protection of Transmission lines, generator and transformers, Transley relay, negative sequence relay, Fuses.

Module 6: Sub-Stations

Function of sub-station, necessity, types and arrangement of sub-station equipments, single line diagram with different busbar arrangement including reactors, bus-tie breakers, substation grounding, surge protection,

Module 7: Lightning Arrester

Function, types, working principles and surge absorbers.

Reference Books:-

1. C. L. Wadhwa, "Electric Power systems", New Age International
2. Willium D. Stevenson Jr., "Elements of Power System Analysis", John Wiley & Sons
3. D P Kothari, I J Nagrath, "Modern Power System Analysis", TMH Publishing Co.
4. J B Gupta, "Switchgear and Protection", S.K. Kataria & Sons
5. Sunil S Rao, "Switchgear and Protection", Khanna Publisher
6. B. Ravindranath and M. Chander, "Power System Protection and Switchgear", Wiley Publisher
7. Ashfaq Hussain, "Power Systems", CBS Publishers

Course Outcomes:

1. Explain the working of different types of switchgear equipments like circuit breakers and relays
2. Design the ratings for fuses according to the requirement.
3. Understand the various protection schemes of various power system components like alternators, transformers and bus-bar.
4. Explain various methods of over voltage protection in power system.

EE 364	Program Elective-II	3L:1T:0P	3 credits

EE 365	Power System Protection	3L:0T:0P	3 credits

Course Objectives:

1. To discuss performance of protective relays, components of protection scheme and relay terminology.
2. To explain Overcurrent protection using electromagnetic and static relays and Overcurrent protective schemes.
3. To discuss types of electromagnetic and static distance relays, effect of arc resistance, power swings, line length and source impedance on performance of distance relays.
4. To discuss construction, operating principles and performance of various differential relays for differential protection.
5. To discuss protection of generators, motors, Transformer and Bus Zone Protection.

Module-1: Introduction to Power System Protection: Need for protective schemes, Nature and Cause of Faults, Types of Fault, Effects of Faults, Fault Statistics, Zones of Protection, Primary and Backup Protection, Essential Qualities of Protection, Performance of Protective Relaying, Classification of Protective Relays, Automatic Reclosing, Current Transformers for protection, Voltage Transformers for Protection.

Relay Construction and Operating Principles: Introduction, Electromechanical Relays, Static Relays – Merits and Demerits of Static Relays, Numerical Relays, Comparison between Electromechanical Relays and Numerical Relays.

Overcurrent Protection: Introduction, Time – current Characteristics, Current Setting, Time Setting.

Module-2: Overcurrent Protection : Overcurrent Protective Schemes, Reverse Power or Directional Relay, Protection of Parallel Feeders, Protection of Ring Mains, Earth Fault and Phase Fault Protection, Combined Earth Fault and Phase Fault Protective Scheme, Phase Fault Protective Scheme, Directional Earth Fault Relay, Static Overcurrent Relays, Numerical Overcurrent Relays.

Distance Protection: Introduction, Impedance Relay, Reactance Relay, Mho Relay, Angle Impedance Relay, Effect of Arc Resistance on the Performance of Distance Relays, Reach of Distance Relays. Effect of Power Surges(Power Swings) on Performance of Distance Relays, Effect of Line Length and Source Impedance on Performance of Distance Relays.

Module-3: Pilot Relaying Schemes: Introduction, Wire Pilot Protection, Carrier Current Protection

Differential Protection: Introduction, Differential Relays, Simple Differential Protection, Percentage or Biased Differential Relay, Differential Protection of 3 Phase Circuits, Balanced (Opposed) Voltage Differential Protection. Rotating Machines Protection: Introduction, Protection of Generators.

Transformer and Buszone Protection: Introduction, Transformer Protection, Buszone Protection, Frame Leakage Protection.

Module-4: Circuit Breakers: Introduction, Fault Clearing Time of a Circuit Breaker, Arc Voltage, Arc Interruption, Restriking Voltage and Recovery Voltage, Current Chopping, Interruption of Capacitive Current, Classification of Circuit Breakers, Air – Break Circuit Breakers, Oil Circuit Breakers, Air – Blast Circuit Breakers, SF6 Circuit Breakers, Vacuum Circuit Breakers, High Voltage Direct Current Circuit Breakers, Rating of Circuit Breakers, Testing of Circuit Breakers.

Module-5: Fuses: Introductions, Definitions, Fuse Characteristics, Types of Fuses, Applications of HRC Fuses, Selection of Fuses, Discrimination.

Protection against Overvoltage: Causes of Over voltages, Lightning phenomena, Wave Shape of Voltage due to Lightning, Over Voltage due to Lightning, Klydonograph and Magnetic Link, Protection of Transmission Lines against Direct Lightning Strokes, Protection of Stations and Sub – Stations from Direct Strokes, Protection against Travelling Waves, Insulation Coordination, Basic Impulse Insulation Level (BIL).

References/Text:

1. "Power System Protection and Switchgear" Badri Ram, D.N. Vishwakarma, McGraw Hill 2nd Edition
2. "Power System Protection and Switchgear" Bhuvanesh Oza et al, McGraw Hill 1st Edition, 2010.
3. "Protection and Switchgear" Bhavesh et al, Oxford 1st Edition, 2011.
4. "Power System Switchgear and Protection" N. Veerappan & S.R. Krishnamurthy, S. Chand 1st Edition, 2009

Course outcomes:

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

- Discuss performance of protective relays, components of protection scheme and relay terminology overcurrent protection.
- Explain the working of distance relays and the effects of arc resistance, power swings, line length and source impedance on performance of distance relays.
- Discuss pilot protection; wire pilot relaying and carrier pilot relaying.
- Discuss construction, operating principles and performance of differential relays for differential protection.
- Discuss protection of generators, motors, Transformer and Bus Zone Protection.

EE 366	**Open Elective-I**	**3L:1T:0P**	**3 credits**

EE 361P	**Control system Laboratory**	**0L:0T:3P**	**1.5 credits**

Hands-on experiments related to the course contents of **EE 261P**

EE 362P	**Power Electronics Laboratory**	**0L:0T:2P**	**1 credits**

Course Objective:
1. To understand the commutation techniques used in power electronics circuits
2. To test different power electronics converters.

Hands-on experiments related to the course contents of **EE362**

Course Outcomes:
Upon successful completion, the students will
1. Able to perform the basic operation of various power semiconductor devices and passive components.
2. Able to analyze power electronics circuits
3. Able to apply power electronic circuits for different loads.

NC 361	**Constitution of India**	**3L:0T:0P**	**0 credit**

Constitution of India – Basic features and fundamental principles

The Constitution of India is the supreme law of India. Parliament of India cannot make any law which violates the Fundamental Rights enumerated under the Part III of the Constitution. The Parliament of India has been empowered to amend the Constitution under Article 368, however, it cannot use this power to change the "basic structure" of the constitution, which has been ruled and explained by the Supreme Court of India in its historical judgments. The Constitution of India reflects the idea of "Constitutionalism" – a modern and progressive concept historically developed by the thinkers of "liberalism" – an ideology which has been recognized as one of the most popular political ideology and result of historical struggles against arbitrary use of sovereign power by state. The historic revolutions in France, England, America and particularly European Renaissance and Reformation movement have resulted into progressive legal reforms in the form of "constitutionalism" in many countries. The Constitution of India was made by borrowing models and principles from many countries including United Kingdom and America.

The Constitution of India is not only a legal document but it also reflects social, political and economic perspectives of the Indian Society. It reflects India's legacy of "diversity". It has been said that Indian constitution reflects ideals of its freedom movement; however, few critics have argued that it does not truly incorporate our own ancient legal heritage and cultural values. No law can be "static" and therefore the Constitution of India has also been amended more than one hundred times. These amendments reflect political, social and economic developments since the year 1950. The Indian judiciary and particularly the Supreme Court of India has played an historic role as the guardian of people. It has been protecting not only basic ideals of the Constitution but also strengthened the same through progressive interpretations of the text of the Constitution. The judicial activism of the Supreme Court of India and its historic contributions has been recognized throughout the world and it gradually made it "as one of the strongest court in the world".

Contents:

1. Meaning of the constitution law and constitutionalism
2. Historical perspective of the Constitution of India
3. Salient features and characteristics of the Constitution of India
4. Scheme of the fundamental rights
5. The scheme of the Fundamental Duties and its legal status
6. The Directive Principles of State Policy – Its importance and implementation
7. Federal structure and distribution of legislative and financial powers between the Union and the States
8. Parliamentary Form of Government in India – The constitution powers and status of the President of India
9. Amendment of the Constitutional Powers and Procedure
10. The historical perspectives of the constitutional amendments in India
11. Emergency Provisions : National Emergency, President Rule, Financial Emergency
12. Local Self Government – Constitutional Scheme in India
13. Scheme of the Fundamental Right to Equality
14. Scheme of the Fundamental Right to certain Freedom under Article 19
15. Scope of the Right to Life and Personal Liberty under Article 21.

SEVENTH SEMESTER

EE 471	Digital Signal Processing	3L:1T:0P	3 credits

Course objective:

1. To study about discrete time systems and to learn about FFT algorithms.
2. To study the design techniques for FIR and IIR digital filters.
3. To study the finite word length effect sin signal processing.
4. To study the properties of random signal, Multirate digital signal processing and about QMF filters.

Module 1: Discrete-Time Signals & Systems

Advantages of digital over analog signal processing, discrete-time signals and sequences, representation of sequences and elementary operations, classification of discrete-time systems. Resolution of discrete-time signals into impulses, analysis of discrete-time LTI systems. Response to arbitrary inputs, the convolution sum, properties of LTI systems and their interconnections, causality, stability. Linear constant coefficient difference equation and their solutions. Impulse response of LTI system, response to complex exponential and sinusoidal signals, the frequency response function.

Module 2: Transforms

Representation of sequences by Fourier transforms-symmetry properties and theorems. The Z-transform, two-sided and one-sided z-transforms, ROC, properties of z-transform, Inverse z-transform, Analysis of LTI system in the Z-domain.

Module 3: Sampling

Sampling of continuous time signals, periodic sampling, frequency-domain representation of sampling.

Module 4: Transform Analysis of LTI System

System functions-linear constant coefficient difference equations, poles and zeros, rational system function, causality and stability, frequency response of LTI systems, phase distortion and delay, frequency response for rational system functions and for single pole or zero systems.

Module 5: Structures for Discrete-time Systems

Block diagram representation of linear constant coefficient difference equations and their interconnections. Direct form I, direct form II, cascade form and parallel form structures, Finite precision word-length effect-number representation, analysis of effect of coefficient quantization and rounding off of noise, zero input limit cycles in fixed point realization of IIR digital filters.

Module 6: Filter Design Techniques

Characteristics of practical frequency selective filters, design of FIR filters by windowing. Characteristics of Butterworth & Chebyshev filters, design of IIR filters from continuous time filters- impulse invariance and bilinear transformation methods.

Module 7: Discrete Fourier Transforms

Frequency domain sampling, the DFT and properties of DFT, circular convolution, linear convolution using DFT, Application of DFT for A.C. transient analysis

Module 8: Efficient Computation of DFT

Computational complexity, FFT algorithms- the decimation-in-time and decimation-in-frequency; signal flow graph-Butterfly computations, in-place computations, analysis of computational complexities.

Module 9: Multi-rate signal processing

Multi-rate signal processing and introduction to Wavelets

Module 10: VLSI implementation
VLSI implementation of digital filters and signal processing algorithms, implementation of signal processing algorithms in general purpose processor, specialized DSP processors

Module 11: Applications of Signal Processing
Spectral analysis using DFT, musical sound and audio processing, application of signal processing in power system, fault detection and improving power quality, MATLAB programming**.**

Text Books:
1. Oppenhein and Schaffer, "Discrete-time Signal Processing", PHI
2. Proakis & Manolakis, "Digital Signal Processing", PHI
3. Chen C.T., "Digital Signal Processing: Spectral Computation & Filter Design", Oxford Univ. Press
4. Sanjit K. Mitra, "Digital Signal Processing", TMH

Course Outcomes:
1. To apply DFT for the analysis of digital signals & systems
2. To design FIR filters
3. To design IIR filters.
4. To characterize finite Word length effect on filters
5. To have a deep understanding on basics of digital signal processing which can be applied to communication systems
6. To design the Multirate Filters.

EE 472	ELECTRICAL DRIVES	3L:1T:0P	3 credits

Course objective:
1. To impart knowledge on Performance of the fundamental control practice associated with AC and DC machines (starting, reversing, braking, plugging, etc.) using power electronics
2. To impart industry oriented learning.
3. To evaluate the use of computer-based analysis tools to review the major classes of machines and their physical basis for operation

Module 1: Introduction
Concept of Electrical Drive, Advantages over other drives, Different parts, Classification, choice of Electrical Drives, Status of dc and ac Drives.

Module 2: Dynamics of Electrical Drives
Fundamental torque equation, Speed Torque conventions and multi-quadrant operation, Nature and classification of load torques, Dynamics of motor-load combination and equivalent drive system, steady state stability & transient stability of electric Drive.

Module 3: Selection of Motor Power Rating
Thermal model of motor for heating and cooling, loading conditions and classes of motor duty, Determination of power rating of electric motors for different applications, effect of load inertia, load equalization, environmental factors.

Module 4: Starting
Effect of starting on power supply, motor and load, determination of acceleration time, energy relations during starting, methods to reduce the energy loss during starting.

Module 5: Electric Braking
Types of electric braking and advantages, braking of dc motors induction motors during lowering of loads and while stopping, braking of synchronous motors, energy relations during braking.

Module 6: Control of Electrical Drives
Modes of operation, speed control and drive classifications, closed-loop control of drives: current-limit control, torque control, speed control, speed control of multi-motor drives, Speed sensing, current sensing, phase-locked-loop (PLL) control, closed-loop position control (Methods employed and description of different schemes only).

Module 7: Control of DC Drives
Speed control of dc separately excited motor using: (a) single-phase and three-phase controlled rectifiers (b) Dual-converter and (c) Chopper, Steady state and transient analysis.

Module 8: Control of Induction Motor Drives
Control of IM using variable frequency operation based on VSI, CSI & Cycloconverter, Speed control of wound rotor Induction Motor by (a) Static rotor resistance control (b) Static Scherbius drive (c) Static Kramer drive.

Module 9: Industrial Applications
Drives for steel Mills, Paper Mills, and Textile Mills.

Reference books:

1. S.K. Pillai, "A first course on Electrical Drives", Willey Eastern Ltd.
2. G.K. Dubey, "Fundamentals of Electrical Drives", Narosa
3. V. Subrahmanyam, "Electric Drives", New Age

Course Outcomes:
At the end of the course, student will be able to:
1. Set up control strategies to synthesize the voltages in dc and ac motor drives.
2. Develop testing and experimental procedures applying basic knowledge in electronics, electrical circuit analysis, electrical machines, microprocessors, and programmable logic controllers.
3. An ability to use standard methods to determine accurate modeling/simulation parameters for various general-purpose electrical machines and power electronics devices required for designing a system and solve drives related problems.

EE 473	**Program Elective -III**	**3L:1T:0P**	**3 credits**

EE 474	**Program Elective -IV**	**3L:1T:0P**	**3 credits**

EE 475	**Open Elective -II**	**3L:1T:0P**	**3 credits**

EE 476P	**Internship III**	**0L:0T:0P**	**1 credit**

EIGHTH SEMESTER

EE 481	Analog & Digital Communications	3L:1T:0P	3 credits

Course Objectives:

1. To introduce the concepts of analogue and digital communication systems.
2. To equip students with various issues related to analogue communication such as modulation, demodulation, transmitters and receivers and noise performance.

Module 1: Introduction

The history of evolution of Electrical Communication, Concept of information, messages and signals, Knowledge of Signals and Information representation, Elements of a communication system, Communication channels, Base band and pass band signals, Fundamental limitations.

Module 2: Representation of signals and systems

Fourier transform, Properties of the Fourier transform, Parseval's theorem, Rayleig's energy theorem, Dirac-Delta function, Fourier transform of Periodic linear systems. Representation of energy and power signals and their spectral density; External noise, internal noise, Noise calculations, signal to noise ratio.

Module 3: Continuous Wave modulation

Amplitude modulation and spectra, DSB Signals and spectra, Tone modulation and phasor analysis, Switching modulator, Envelope detector, Ring modulator and balanced modulator, Single side band modulation, Phase Shift method for generation of SSB, Phase and frequency modulation, Narrowband F.M, Wideband F.M, Transmission B.W. of F.M. signal, Generation of F.M. signal. Indirect F.M. & Direct F.M, Demodulation of F.M. signal using balanced frequency discrimination. AM transmitters and receivers, super heterodyne receiver, IF amplifiers, AGC circuits.

Module 4: Random Variables and Stochastic Process

Concept of random variables, Probability density function and probability distribution function of α random variable, Mean & Mean square value of a R.V, Concept of Stochastic Process, Ensemble averages and correlation function, Stationary and Ergodic Process, Signal Power, Time average and Power spectral density, Shot noise, Thermal noise and White noise.

Module 5: Sampling and Pulse modulation

Sampling Process, Sampling Theorem (only statement), Analogy Pulse modulation : PAM, PPM and PDM, Time Division Multiplexing, Quantization Process (only uniform quantization), Quantization noise, Pulse code modulation, Delta modulation, Differential Pulse Code modulation.

Module 6: Digital Communication

Base band Pulse Transmission concept., Method filter, Pass band transmission model, Gram Schmidt Orthogonalization principle, Geometrical interpretation of signal, Digital modulation techniques, Coherent binary PSK, Coherent binary FSK, Coherent quadriphase shift keying.

Module 7: Introduction to Information Theory

Uncertainty, Information and Entropy, Properties of Entropy, Source coding theorem. Measure of information, Entropy & Information rate, channel capacity, Hartley Shannon law, Huffman coding, Shannon Fano coding.

Course outcome:

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

1. Gain the knowledge of components of analogue communication system.
2. To analyze various methods of baseband/band pass Analogue transmission and detection.

3. Analyze and allocate performance objectives to components of an analogue communication system and to design analogue communication systems.
4. To evaluate the performance of analogue communications in the presence of noise.

Reference Books:

1. Bruce Carlson, "Communication Systems", McGraw Hill I.E.
2. Taub and Schilling, "Principles of Communication Systems", McGraw Hill I.E.
3. Simon Hymins, "Communication Systems", PHI
4. BP Lathi, "Modern Digital and Analog Communication Systems", Oxford university Press
5. Couch, "Digital and Analog Communication", Pearson Education India
6. John Proakis, "Digital Communications", McGraw Hill

EE 482	HVDC Transmission Systems	3L:1T:0P	3 credits

Course Outcomes:

At the end of this course, students will demonstrate the ability to:

1. Understand the advantages of dc transmission over ac transmission.
2. Understand the operation of Line Commutated Converters and Voltage Source Converters.
3. Understand the control strategies used in HVdc transmission system.
4. Understand the improvement of power system stability using an HVdc system.

Module 1: Dc Transmission Technology (4 hours)

Comparison of AC and dc Transmission (Economics, Technical Performance and Reliability). Application of DC Transmission. Types of HVdc Systems. Components of a HVdc system. Line Commutated Converter and Voltage Source Converter based systems.

Module 2: Analysis of Line Commutated and Voltage Source Converters (10 hours)

Line Commutated Converters (LCCs): Six pulse converter, Analysis neglecting commutation overlap, harmonics, Twelve Pulse Converters. Inverter Operation. Effect of Commutation Overlap. Expressions for average dc voltage, AC current and reactive power absorbed by the converters. Effect of Commutation Failure, Misfire and Current Extinction in LCC links.

Voltage Source Converters (VSCs): Two and Three-level VSCs. PWM schemes: Selective Harmonic Elimination, Sinusoidal Pulse Width Modulation. Analysis of a six pulse converter. Equations in the rotating frame. Real and Reactive power control using a VSC.

Module 3: Control of HVdc Converters: (10 hours)

Principles of Link Control in a LCCHVdc system. Control Hierarchy, Firing Angle Controls - Phase-Locked Loop, Current and Extinction Angle Control, Starting and Stopping of a Link. Higher level Controllers Power control, Frequency Control, Stability Controllers. Reactive Power Control. Principles of Link Control in a VSC HVdc system: Power flow and dc Voltage Control. Reactive Power Control/AC voltage regulation.

Module 3: Components of HVdc systems: (8 hours)

Smoothing Reactors, Reactive Power Sources and Filters in LCC HVdc systems DC line: Corona Effects. Insulators, Transient Over-voltages. dc line faults in LCC systems. dc line faults in VSC systems. dc breakers. Monopolar Operation. Ground Electrodes.

Module 4: Stability Enhancement using HVdc Control (4 hours)

Basic Concepts: Power System Angular, Voltage and Frequency Stability. Power Modulation: basic principles – synchronous and asynchronous links. Voltage Stability Problem in AC/dc systems.

Module 5:MTdc Links (4 hours)
Multi-Terminal and Multi-Infeed Systems. Series and Parallel MTdc systems using LCCs. MTdc systems using VSCs. Modern Trends in HVdc Technology. Introduction to Modular Multi-level Converters.

Text/References:

1. K. R. Padiyar, "HVDC Power Transmission Systems", New Age International Publishers, 2011.
2. J. Arrillaga, "High Voltage Direct Current Transmission", Peter Peregrinus Ltd., 1983.
3. E. W. Kimbark, "Direct Current Transmission", Vol.1, Wiley-Interscience, 1971.

EE 483	**Program Elective - V**	**3L : 1T : 0P**	**3 Credits**

EE 484	**Open Elective- III**	**3L : 1T : 0P**	**3 Credits**

EE 482P	**Project -II**	**L: T :12P**	**6 Credits**

Course objectives:
It is intended to start the project work early in the seventh semester and carry out both design and fabrication of a mechanical device whose working can be demonstrated. The design is expected to be completed in the seventh semester.

PROGRAM ELECTIVES (I-V)

EE	**Program Electives (I – V)**	**3L:1T:0P**	**3 Credits**

EE 001 POWER GENERATION SYSTEMS

Course Objectives:
To understand the working of different types of power generation systems and to realize the necessity for interconnected operation of different power stations.

Hydro-electric power plants – selection of site, elements of power plant, classification, water turbines, governor action, hydro-electric generator, plant layout, pumped storage plants.

Thermal Steam power plants – selection of site, elements and operational circuits of the power plant, turbo-alternators, plant layout, steam turbines, controls and auxiliaries.

Nuclear power plants – selection of site, nuclear reaction – fission process and chain reaction, constituents of power plant and layout, nuclear reactor – working, classification, control, shielding and waste disposal.

Renewable power plants – Solar power generation – Photo-voltaic and solar thermal generation – solar concentrators, Wind power generation – types of wind mills, wind generators, tidal, biomass, geothermal and magneto-hydro dynamic power generation, micro-hydel power plants, fuel cells and diesel and gas power plants.

Combined operation of power plants – plant selection, choice of size and number of generator units, interconnected systems, real and reactive power exchange among interconnected systems. Major electrical equipment in power plants, DC systems in power plants, station control - switch yard and control room. Economic considerations – types of costs, tariff and consumers.

Text Books:

1. Chakrabarti A., Soni M.L., Gupta P.V., and Bhatnagar U.S., 'A text book on Power Systems Engg.', Dhanpat Rai and Sons, New Delhi, 2nd revised edition, 2010.
2. J.B.Gupta, 'A course in Power Systems', S.K.Kataria and sons, reprint 2010-2011.

Reference Books:

1. Wadhwa, C.L., 'Generation Distribution and Utilisation of Electrical Energy', New Age International publishers, 3rd edition, 2010.
2. Deshpande M.V, `Elements of Electrical Power systems Design', Pitman, New Delhi, PHI Learning Private Limited, 1st edition, 2009**.**

EE 002 DESIGN OF ELECTRICAL APPARATUS

Course Objectives:

This course offers the preliminary instructions and techniques to design the main dimensions and other major part of the transformer and DC and AC rotating machines. The course also provides the students with an ability to understand the step by step procedure for the complete design of electrical machines.

General concepts in the design of rotating machines-output equation-Magnetic and electric loadings- Common design features of all rotating machines-Conducting, insulating and magnetic materials used in electrical apparatus-mmf calculation for the magnetic circuit of rotating machines-Leakage reactance calculation.

Armature winding –output equation-Choice of specific loadings-Choice of poles-design of conductors, winding, slot, air gap, field poles and field coils, commutator and brush-Predetermination of efficiency, temperature rise and open circuit characteristics from design data(qualitative treatment only)

Output equation-Design of core and coils for single phase and three phase transformers-Design of tank and cooling tubes-Predetermination of circuit parameters, magnetising current, losses, efficiency, temperature rise and regulation from design data (qualitative treatment only)

Output equation-Choice of specific loadings-Design of stator-Design of squirrel cage and slip ring rotors- Stator and rotor winding designs-Predetermination of circuit parameters, magnetising current, efficiency and temperature rise from design data (qualitative treatment only).

Constructional features of synchronous machines-SCR-Output equation-specific loadings-Main dimensions-Stator design-Design of salient pole field coil.

Text Books:

1. Sawhney, A.K.,'A course in Electrical Machines Design', Dhanpat Rai and sons Publications, 4th edition, 2010.

References:

1. Sen, S.K.,'Principles of Electrical Machine Design with computer Programmes', Oxford and I.B.H Publishing Co. Pvt. Ltd, 2nd edition, 2006.
2. Rai, H.M., "Principles of Electrical Machines Design", Sathya Prakash Publications, 3rd edition, 1994.

COURSE OUTCOMES:

Upon completion of this course**,**

1. The student will be able to understand the design of main dimensions and other major part of the transformer and DC and AC rotating machines.
2. The student will be capable of evaluating the procedure for the design of main dimensions and other major part of the transformer and DC and AC rotating machines.
3. The student will be equipped to apply in-depth knowledge related to the design of electrical machines.

EE 003 STATIC RELAYS

Course Objectives:

To emphasize on various type and implementation of relays using solid-state circuits and microprocessors.

Power system protection and its requirements – conventional Vs static relays - steady state and transient performance of signal deriving elements, signal mixing techniques and measuring techniques.

Over current protection - instantaneous over current relay – directional over current relay – applications – differential relays - generator and transmission line protection.

Static relay circuits for generator loss of field, under frequency, distance, impedance, reactance, mho and special characteristics - reverse power relays

Static relay circuits for carrier protection and testing of relays - Static relay circuits - tripping circuits using thyrsitor.
Microprocessor/Microcontroller based Relays-Hardware and software for the measurements of voltage, current, frequency and phase angle- implementation of over current, directional, impedance and mho relays.

Text Books:

1. Madhava Rao T.S., 'Power System Protection - Static Relays', McGraw Hill, New Delhi, 2nd Edition, 21st reprinted, 2008**.**

Reference Books:

1. Ram.B. `Fundamentals of Microprocessors and Microcomputers', M/s. Dhanpat Rai & sons, New Delhi, 2011.
2. Van C. Warrington, 'Protective Relays - Their Theory and Practice', Vols. I & II, Chapman & Hall Ltd. London, 2nd Edition,1994.

COURSE OUTCOMES:

Upon completion of the course the students would be able to

1. Distinguish between the conventional electro-mechanical relays and static relays
2. Design various electronic circuits to implement various relaying functions
3. Implement microprocessor based relays

EE 004 EHV AC AND DC TRANSMISSION

Course Objectives:

- To understand and analyze the HVAC and HVDC transmission systems.
- To plan an appropriate transmission system between two destinations based on the load requirement and anticipated technical performance of power transmission.

Design aspects of HVAC – conductor, tower, insulator and substation structure design, mechanical design sag-tension calculations, design of EHVAC lines based on steady state limits and transient over voltages design of extra HV cables - XLPE cables and gas insulated cables.

Real and reactive power flows in HVAC systems – reactive power compensation, FACTS devices in EHV Transmission, short circuit level & real power transfer capacity. Stability-voltage stability and control. Theory of travelling and stationary waves, radio interference, television interference, audible noise and corona.

Introduction to HVDC transmission - Bridge converters – rectifier and inverter operation, equivalent circuit representation, power reversal, desired features of control and actual control characteristics.

Basic HVDC controllers, converter faults, commutation failure, bypass action in bridges, protection issues in HVDC - DC reactors, voltage and current oscillations, DC circuit breakers and over voltage protection, HVDC cables

Harmonics in HVDC - characteristics and uncharacteristic harmonics, troubles due to harmonics, harmonic filters – active and passive filters, active and reactive power exchange in converters and recent trend in HVDC transmission – Hybrid HVDC and Off-shore wind power evacuation through HVDC, introduction to Wide Area Monitoring Systems.

Text Books:

1. S. Rao, EHV-AC, HVDC Transmission and Distribution Engineering', Khanna publishers, 3rd edition, 2012.
2. Rakosh Das Begamudre, 'Extra High Voltage AC Transmission Engineering', New Age International publishers, 3rd edition, 2009.

Reference Books:

1. Padiyar K.R., 'HVDC transmission systems', New Age International publishers, 2nd revised edition, 2012.

Useful web links:

1. http://nptel.iitm.ac.in/courses/108104013

EE005 FUNDAMENTALS OF FACTS

Course Objectives: To familiarize the students with the basic concepts, different types, scope and applications of FACTS controllers in power transmission.

Fundamentals of ac power transmission, transmission problems and needs, emergence of FACTS-FACTS control considerations, FACTS controllers.

Principles of shunt compensation – Variable Impedance type & switching converter type-Static Synchronous Compensator (STATCOM) configuration, characteristics and control. Principles of static series compensation using GCSC, TCSC and TSSC, applications, Static Synchronous Series Compensator (SSSC), TJE.

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.

Text Books:

1. Hingorani, L. Gyugyi, 'Concepts and Technology of flexible AC transmission system', Standard Publishers Distributors, 1st Edition, 2011.
2. R.M. Mathur and R.K. Varma, 'Thyristor-Based FACTS Controllers for Electrical Transmission Systems', Wiley India Pvt. Limited Publications, 1st Edition, 2011.

Reference Books:

1. K. R. Padiyar, 'FACTS Controllers in Power Transmission and Distribution', New Age International Publications, 1st Edition, 2009.

Course Outcomes:

Upon completion of the course, the students shall be able to

1. Understand various control issues, for the purpose of identifying the scope and for selection of specific FACTS controllers.
2. Apply the concepts in solving problems of simple power systems with FACTS controllers.
3. Design simple FACTS controllers

EE 006 UTILIZATION OF ELECTRICAL ENERGY

Course Objectives:

To design illumination systems, choose appropriate motors for any drive application, to debug a domestic refrigerator circuit and to design battery charging circuitry for specific applications.

Illumination – Terminology, Laws of illumination, Photometry, lighting calculations. Electric lamps – Different types of lamps, LED lighting and Energy efficient lamps. Design of lighting schemes - factory lighting - flood lighting – street lighting.

Refrigeration- Domestic refrigerator and water coolers. Air-Conditioning - Various types of air conditioning system and their applications, smart air conditioning units. Energy Efficient motors: Standard motor efficiency, need for more efficient motors, Motor life cycle, Direct Savings and payback analysis, efficiency evaluation factor.

Domestic utilization of electrical energy – House wiring. Induction based appliances, Online and OFF line UPS, Batteries. Power quality aspects – nonlinear and domestic loads. Earthing – domestic, industrial and sub-station.

Electric Heating- Types of heating and applications, Electric furnaces - Resistance, inductance and Arc Furnaces, Electric welding and sources of welding, Electrolytic processes – electro-metallurgy and electro-plating.

Traction system – power supply, traction drives, electric braking, tractive effort calculations and speed- time characteristics. Locomotives and train - recent trend in electric traction.

Text Books:

1. Dr. Uppal S.L. and Prof. S. Rao, 'Electrical Power Systems', Khanna publishers, New Delhi, 2009.
2. Gupta, J.B., 'Utilisation of Electrical Energy and Electric Traction', S.K. Kataria and sons, 10th Edition, 1990.
3. Rajput R.K., 'Utilisation of Electrical Power', Laxmi publications, 1st Edition, 2007.

Reference Books:

1. N.V. Suryanarayana, 'Utilisation of Electrical Power', New Age International publishers, Reprinted 2005.
2. C.L. Wadhwa, 'Generation Distribution and Utilization of Electrical Energy', New Age International publishers, 4th edition, 2011.
3. Energy Efficiency in Electrical Utilities, BEE guide book, 2010.

Course Outcomes:

Upon completion of the course the students would be able to

1. Develop a clear idea on various Illumination techniques and hence design lighting scheme for specific applications
2. Identify an appropriate method of heating for any particular industrial application
3. Evaluate domestic wiring connection and debug any faults occurred
4. Construct an electric connection for any domestic appliance like refrigerator as well as to design a battery charging circuit for a specific household application.
5. Realize the appropriate type of electric supply system as well as to evaluate the performance of a traction unit.

EE 007 SPECIAL ELECTRICAL MACHINES

Course Objectives: To expose the students to the construction, principle of operation and performance of special electrical machines as an extension to the study of basic electrical machines.

Constructional features – Types – Axial and Radial flux motors – Operating principles – Variable Reluctance and Hybrid Motors – SYNREL Motors – Voltage and Torque Equations - Phasor diagram - Characteristics.

Constructional features – Principle of operation – Variable reluctance motor – Hybrid motor – Single and multi-stack configurations – Torque equations – Modes of excitations – Characteristics – Drive circuits – Microprocessor control of stepping motors – Closed loop control.

Constructional features – Rotary and Linear SRMs - Principle of operation – Torque production – Steady state performance prediction- Analytical method -Power Converters and their controllers – Methods of Rotor position sensing – Sensor less operation – Closed loop control of SRM - Characteristics.

Permanent Magnet materials – Magnetic Characteristics – Permeance coefficient - Principle of operation – Types – Magnetic circuit analysis – EMF and torque equations – Commutation - Power controllers – Motor characteristics and control.

Principle of operation – Ideal PMSM – EMF and Torque equations – Armature reaction MMF – Synchronous Reactance – Sine wave motor with practical windings - Phasor diagram – Torque/speed characteristics - Power controllers - Converter Volt-ampere requirements

Text Books:

1. T.J.E. Miller, 'Brushless Permanent Magnet and Reluctance Motor Drives', Clarendon Press, Oxford, 1993.
2. T. Kenjo, 'Stepping Motors and Their Microprocessor Controls', Clarendon Press London, 1995.

Reference Books:

1. R. Krishnan, 'Switched Reluctance Motor Drives – Modeling, Simulation, Analysis, Design and Application', CRC Press, New York, 2001.
2. P.P. Aearnley, 'Stepping Motors – A Guide to Motor Theory and Practice', Peter Perengrinus London, 2002.
3. T. Kenjo and S. Nagamori, 'Permanent Magnet and Brushless DC Motors', Clarendon Press, London, 1988

Course Outcomes:

Upon completion of the course the students would be able to understand the construction, principle of operation and performance of

1. Synchronous reluctance motors
2. Stepping motors
3. Switched reluctance motors
4. Permanent magnet brushless D.C. motors
5. Permanent magnet synchronous motors.

EE 008 ELECTRICAL SAFETY

Course Objectives:

To provide a comprehensive exposure to electrical hazards , various grounding techniques, safety procedures and various electrical maintenance techniques .

Primary and secondary hazards- arc, blast, shocks-causes and effects-safety equipment-flash and thermal protection, head and eye protection-rubber insulating equipment, hot sticks, insulated tools, barriers and signs, safety tags, locking devices- voltage measuring instruments- proximity and contact testers-safety electrical one line diagram- electrician's safety kit.

General requirements for grounding and bonding- definitions- grounding of electrical equipment- bonding of electrically conducting materials and other equipment- connection of grounding and bonding equipment- system grounding- purpose of system grounding-grounding electrode system- grounding conductor connection to electrodes-use of grounded circuit conductor for grounding equipment- grounding of low voltage and high voltage systems.

The six step safety methods- pre job briefings- hot -work decision tree-safe switching of power system- lockout-tag out- flash hazard calculation and approach distances-calculating the required level of arc protection-safety equipment , procedure for low, medium and high voltage systems- the one minute safety audit

Electrical safety programme structure, development- company safety team- safety policy-programme implementation- employee electrical safety teams- safety meetings- safety audit- accident prevention- first aid- rescue techniques-accident investigation

Safety related case for electrical maintenance- reliability centered maintenance (RCM) - eight step maintenance programme- frequency of maintenance- maintenance requirement for specific equipment and location- regulatory bodies- national electrical safety code-standard for electrical safety in work place- occupational safety and health administration standards.

Text Books:

1. Dennis Neitzel, Al Winfield, 'Electrical Safety Handbook', McGraw-Hill Education, 4th Edition, 2012.

Reference Books:

1. John Cadick, 'Electrical Safety Handbook', McGraw-Hill School Education Group, 1994.
2. Maxwell Adams J., "Electrical safety- a guide to the causes and prevention of electric hazards", The Institution of Electric Engineers, 1994.
3. Ray A. Jones, Jane G. Jones, 'Electrical safety in the workplace', Jones & Bartlett Learning, 2000.

Course Outcomes:

Upon completion of the course the students would be able to:-

- Describe electrical hazards and safety equipment.
- Analyze and apply various grounding and bonding techniques.
- Select appropriate safety method for low, medium and high voltage equipment.
- Participate in a safety team.
- carry out proper maintenance of electrical equipment by understanding various standards

EE 009 COMPUTER RELAYING AND PHASOR MEASUREMENT UNIT

Course Objectives:

1. To understand and analyze the basic architecture of Digital Relay
2. Understand the basics of Phasor Measurement unit (PMU)
3. Applications of PMUs in power system

Mathematical background to protection algorithms-Finite difference technique-Numerical differentiation-Least Squares Method-Fourier analysis-Fourier analysis of analogue signals- Fourier analysis of discrete signals- Walsh function analysis.

Basic elements of digital protection-Signal conditioning subsystem-Transducers-Surge protection circuits- Analogue filtering-Analog multiplexers-Conversion subsystem-Sampling theorem-Signal aliasing error- Sample and hold circuit-Digital multiplexing-Digital to Analogue Conversion-Analogue to Digital Conversion- Processor-Data and Program memory-Digital relay hardware unit.

Phasor Measurement Unit– Introduction- Phasor representation of sinusoids- Phasor Estimation of Nominal Frequency Signals- Formulas for updating phasors - Nonrecursive updates-Recursive updates- Frequency Estimation.

Phasor Measurement Applications-State Estimation-History- Operator's load flow-weighted least square least square- Linear weighted least squares; Nonlinear weighted least squares- Static state estimation- State estimation with Phasors measurements- linear state estimation.

Adaptive protection- Differential and distance protection of transmission lines- Adaptive out-of-step protection.

Text Books:

1. Arun G. Phadke, James S. Thorp, 'Computer Relaying for Power Systems', A John Wiley and Sons Ltd., Research Studies Press Limited, 2009.
2. A.G. Phadke J.S. Thorp, 'Synchronized Phasor Measurements and Their Applications', Springer, 2008.

Reference Books:

1. A.T. Johns and S.K. Salman, 'Digital Protection For Power Systems', Peter Peregrinus Ltd, 1997.

Course Outcomes:

Upon completion of the course, the student will be able to:

1. Understand the operation of computer relay.
2. Understand the basics of phasor measurement unit.
3. Understand the different applications of PMUs on power system.

EE 010 SOLID STATE DRIVES

Course Objectives:

1. To understand the basic concept of DC and AC Drives.
2. To understand the various control techniques involved with both DC and AC Drives.
3. To brief about the working principle of Special Electrical Drives.

Pre-requisites: Electrical machines, Power Electronics.

Introduction to solid state drives, various components-power converters, motors, loads, coupling mechanisms, Stabilityof drive.

Modeling of d.c. motor drives. Transfer function and state-space models. Experimental determination of drive parameters. Speed control using ac to dc converters, Input performance parameters, Speed reversal schemes.

Chopper fed d.c. motor drives. Four quadrant operation. Input filters design. Dynamic braking with dc chopper. Type-c chopper fed regenerative braking. Operation with non-receptive lines.

Power converters for induction motor speed control. Harmonic behavior of induction motors-harmonic currents and harmonic torques using per phase equivalent circuit. Stator voltage control schemes.

State-space modeling of induction motors. Voltage source-Inverter fed operation. Field oriented control schemes. Current source – inverter drives. Principle of vector control.

Text Books:

1. P.C. Sen, 'Thyristor DC Drives' John Wiley & Sons Publishers, New York, 2008.
2. R. Krishnan, 'Electric Motor Drives-Modeling, Analysis, and Control', Pearson Education Publishers, 1st edition, 2003.
3. B.K. Bose, 'Modern Power Electronics and AC drives', Pearson Education Publications, 2nd edition, 2005.

Reference Books:

1. G.K. Dubey, 'Fundamentals of Electrical Drives', Narosa Publishing house, 2nd edition, 2008.
2. T. Wildi, 'Electrical Machines Drives and Power Systems', Pearson Education Publications, 6th edition, 2004.

Course Outcomes:

Upon completion of this course,

1. The student learns the fundamental concepts of power electronic converter fed DC and AC machines.
2. The student can analyze the converter fed motor under different torque/speed conditions.
3. The student will be able to design converter fed drives with existing/new control techniques.

OPEN ELECTIVE (I - III)

EE	Open Electives (I – III)	3L : 1T : 0P	3 Credits

EE 01 POWER SYSTEM DYNAMICS

Course Objectives:

- To explain the power system stability problem
- To understand the behavior of synchronous and induction machines during disturbance
- To employ mathematical tools for power system stability analysis

Stability considerations – Dynamic modeling requirements- angle stability – equal area criterion- Critical fault clearing time and angle-numerical integration techniques.

Synchronous machines - Park's transformation – flux linkage equations – formulation of normalized equations – state space current model – simplified models of the synchronous machine – turbine, Generator – steady state equations and phasor diagrams.

Dynamics of Synchronous machines - Mechanical relationships – electrical transient relationships – adjustment of machine models – Park's equation in the operational form.

Induction motor equivalent circuits and parameters - free acceleration characteristics – dynamic performance – effect of three phase short circuit and unbalanced faults.

Transient and dynamic stability distinction – linear model of unregulated synchronous machine and its oscillation modes – distribution of power impacts – effects of excitation on stability – supplementary stabilization signals.

Text Books:

1. Krause P.C., 'Analysis of Electric Machinery', McGraw-Hill, 3rd revised Editions, 2013.
2. Ramanujam R, 'Power System Dynamics', PHI Learning Pvt. Ltd., New Delhi, 2009**.**

Reference Books:

1. Kundur P, 'Power System Stability and Control', McGraw-Hill, New York, 1st Edition, 2006.

Course Outcomes:

Upon completion of the course, the students will have acquired

1. Understanding of the dynamic phenomena of the power system operation
2. Knowledge to employ modeling techniques for investigating the response of system during disturbance.
3. Ability to interpret results coming from the simulation of differential - algebraic systems

EE 02 POWER SYSTEM RESTRUCTURING

Course Objectives: To understand the electricity power business and technical issues in a restructured power system in both Indian and world scenario.

Introduction – Market Models – Entities – Key issues in regulated and deregulated power markets; Market equilibrium- Market clearing price- Electricity markets around the world

Operational and planning activities of a Genco - Electricity Pricing and Forecasting - Price Based Unit Commitment Design - Security Constrained Unit Commitment design. – Ancillary Services - Automatic Generation Control (AGC).

Introduction-Components of restructured system-Transmission pricing in Open- access system - Open transmission system operation; Congestion management in Open-access transmission systems- FACTS in congestion management - Open-access Coordination Strategies; Power Wheeling- Transmission Cost Allocation Methods

Open Access Distribution - Changes in Distribution Operations- The Development of Competition – Maintaining Distribution Planning

Power Market Development – Electricity Act, 2003 - Key issues and solution; Developing power exchanges suited to the Indian market - Challenges and synergies in the use of IT in power- Competition- Indian power market- Indian energy exchange- Indian power exchange- Infrastructure model for power exchanges- Congestion Management-Day Ahead Market- Online power trading.

Text Books:

1. Loi Lei Lai, 'Power System Restructuring and Deregulation', John Wiley & son LTD, New York, HRD Edition, 2001.
2. Mohammad Shahidehpour, Hatim Yamin,' Market operations in Electric power systems', John Wiley & son LTD, Publication, 2002.
3. Lorrin Philipson, H. Lee Willis, 'Understanding Electric Utilities and Deregulation', Taylor & Francis, New York, 2nd Edition, 2006.

Reference Books:

1. Mohammad S hahidehpour, Muwaffaq Alomoush, 'Restructured Electrical Power Systems'," Marce Dekker, INC., New York, 1st Edition, 2001.

Useful web links

1. Indian energy exchange: http://www.iexindia.com/
2. Indian power India limited: http://www.powerexindia.com/
3. Indian Electricity Regulations: http://www.cercind.gov.in/

COURSE OUTCOMES:

Upon completion of the course the students would be able to

1. Explain and differentiate the key issues involved in the regulator and de-regulated power markets.
2. Describe the operational activities in Generation, Transmission and Distribution system in the restructured environment.
3. Illustrate and Solve problems in the de-regulated power System.
4. Explain and analyze the restructuring activities in Indian Power System.

EE 03 POWER SWITCHING CONVERTERS

Course Objectives: This course aims at modelling, analysis and control of various power converter circuits.

Basic converter topologies: Buck, Boost, Buck-Boost converter; steady state converter analysis - Equivalent circuit modeling

State space averaging of converters- Transfer function of converters- Design of feedback compensators-voltage and current loop

Design constraints of reactive elements in Power Electronic Systems: Design of inductor, transformer and capacitors for power electronic applications, Input filter requirement.

Isolated converters: forward converter, push-pull converter, fly back converter, half bridge and full bridge converter-operating principles.

Soft-switching DC - DC Converters: zero-voltage-switching converters, zero-current switching converters, Multi-resonant converters and Load resonant converters-operating principles

Text Books:

1. Simon Ang, Alejandro Oliva, 'Power Switching Converters', Taylor & Francis, 3rd Edition, 2010.
2. Robert W. Erickson, Dragan Maksimovic,, 'Fundamentals of Power Electronics', springer, 2nd edition, 2001

Reference Books:

1. N. Mohan, T. Undeland, and W. Robbins, 'Power Electronics: Converters, Applications, and Design', 2nd edition, John Wiley & Sons, 1995.
2. M. Rashid, 'Power Electronics: Circuits, Devices, and Applications', Prentice Hall, 2nd edition 1993

COURSE OUTCOMES:

Upon completion of this course the students will be able to

1. Understand the classification and operation of different types of DC-DC converters.
2. Analyze the Steady-state operation of DC-DC converter circuits

EE 04 MODERN OPTIMIZATION TECHNIQUES FOR ELECTRIC POWER SYSTEMS

Course Objectives:

To learn the concepts and techniques of evolutionary and optimization techniques in power system applications.

Definition-Classification of optimization problems-Unconstrained and Constrained optimization-Optimality conditions-Classical Optimization techniques (Linear and nonlinear programming, Quadratic programming, Mixed integer programming)-Intelligent Search methods (Optimization neural network, Evolutionary algorithms, Tabu search, Particle swarm optimization, Application of fuzzy set theory).

Evolution in nature-Fundamentals of Evolutionary algorithms-Working Principles of Genetic Algorithm- Evolutionary Strategy and Evolutionary Programming-Genetic Operators-Selection, Crossover and Mutation-Issues in GA implementation- GA based Economic Dispatch solution-Fuzzy Economic Dispatch including losses- Tabu search algorithm for unit commitment problem-GA for unit commitment-GA based Optimal power flow- GA based state estimation.

Fundamental principle-Velocity Updating-Advanced operators-Parameter selection-Hybrid approaches (Hybrid of GA and PSO, Hybrid of EP and PSO) -Binary, discrete and combinatorial PSO-Implementation issues-Convergence issues- PSO based OPF problem and unit commitment-PSO for reactive power and voltage control-PSO for power system reliability and security.

Simulated annealing algorithm-Tabu search algorithm-SA and TS for unit commitment-Ant colony optimization- Bacteria Foraging optimization.

Concept of pareto optimality-Conventional approaches for MOOP-Multi objective GA-Fitness assignment- Sharing function-Economic Emission dispatch using MOGA-Multiobjective PSO (Dynamic neighbourhood PSO, Vector evaluated PSO) – Multiobjective OPF problem.

Text Books:

1. Soliman Abdel Hady, Abdel Aal Hassan Mantawy, "Modern optimization techniques with applications in Electric Power Systems", Springer, 2012.

Reference Books:

1. D.P. Kothari and J.S. Dhillon, "Power System Optimization", 2nd Edition, PHI learning private limited, 2010.
2. Kalyanmoy Deb, "Multi objective optimization using Evolutionary Algorithms", John Wiley and Sons, 2008.
3. Kalyanmoy Deb, "Optimization for Engineering Design", Prentice Hall of India first edition, 1988.

COURSE OUTCOMES:

Upon completion of this course the students will be able to

1. Understand the concept of optimization techniques.
2. Apply evolutionary algorithms for unit commitment and economic dispatch problems.
3. Interpret hybrid approach for power system reliability and security.
4. Develop the transfer function of DC-DC converter circuits
5. Design the compensator and reactive elements of DC-DC converter circuits
6. Illustrate different soft switching techniques in DC-DC converter circuits

EE 05 COMPUTER ARCHITECTURE

Course Objectives: This Course will render the basic structure of computers their control design, memory organizations and an introduction to parallel processing.

Computer – Functional units, Addressing modes, Instruction formats, Stacks and Subroutines. Processing Unit - Execution of instructions - Control step sequence.

Control Design - Hardwired control- design - multiplier control unit - CPU control unit and Micro programmed control - micro instructions- Sequencing - perfecting.

Arithmetic and Logic Unit-Fixed point and arithmetic units. Floating point numbers and operation Design.

Memories - cache memories - virtual memories. Input-Output Organization - Data transfer- synchronization- Interrupt handling-I/O interfaces.

Introduction to parallel processing- Generation of computer systems – Parallelism in uniprocessor system –Parallel computer structures - architectural classification schemes.

Text Books:

1. David A. Patterson and John L. Hennessy, 'Computer Organization and Design: The Hardware/Software interface', 4th Edition, Elsevier, 2009.
2. Morris Mano.M., 'Computer system Architecture', PHI, New Delhi, 3rd Edition 1993.
3. William Stallings, 'Computer Organization and Architecture – Designing for Performance', 8th Edition, Pearson Education, 2010.

Reference Books:

1. Behrooz Parhami, 'Computer Architecture from up to super computer', Oxford press, reprinted 2014
2. John P. Hayes, 'Computer Architecture and Organization', Tata McGraw Hill, 3rd Edition, 1998.
3. Carl Hamachar, Zvonko Uranesic, Safwat zaky, ' Computer Organization', Tata McGraw Hill, 6th revised Edition , 2011

COURSE OUTCOMES:

Upon completion of this course , students will:

1. Describe the general architecture of computers.
2. Be familiar with the history and development of modern computers, the Von Neumann architecture and functional units of the processor such as the register file and arithmetic- logical unit,
3. Understand the major components of a computer including CPU, memory, I/O and storage, how computer hardware has evolved to meet the needs of multi-processing systems, the uses for cache memory, parallelism both in terms of a single processor and multiple processors.
4. Design principles in instruction set design including RISC architectures.
5. Analyze and design computer hardware components.