Electrical Engineering			
EE601	**Power Electronics**	**L**	**T**
		3	**1**

Course Outcomes:

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

CO's	CO Description
CO1	To **understand** different power semiconductor devices and their switching characteristics.
CO2	To **understand** the operation, characteristics and performance parameters of AC to DC Converters.
CO3	To **study** the operation, switching techniques and basic topologies of DC-DC Converters
CO4	To learn the different modulation techniques of PWM inverters and to **understand** commutation techniques.
CO5	To **study** the operation of AC voltage controller and various configurations.

CO's-PO's Mapping Matrix:

Enter correlation levels1, 2 or 3 as defined below-

1. Slight (low) 2. Moderate (Medium) 3. Substantial (High)

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	1		1					1
CO2	2	2	3	3	2		1					1
CO3	2	2	3	2	1	1	1					1
CO4	2	3	2	2	2	1	1					1
CO5	2	3	3	2	1	1	1					1
Avg.	**2.2**	**2.4**	**2.6**	**2.2**	**1.4**	**1**	**1**					**1**

DETAILED SYLLABUS

Module I: Power Semiconductor Devices (7 Lectures)

Diode, Thyristor, MOSFET, IGBT, GTO: constructional features, I-V Characteristics; Firing circuit for thyristor; protection of thyristor and gate drive circuit, Turn on techniques, Voltage and current commutation of a thyristor.

Module II: AC-DC Converters (6 Lectures)

Single-phase half-wave and full-wave rectifiers, Single-phase full-bridge thyristor rectifier with R, R-L and R-L-E load; effect of source inductance, Three-phase full-bridge thyristor rectifier with R, R-L and R-L-E load; freewheeling effect, power factor improvement.

Module III: DC-DC Buck and Boost Converter (10 Lectures)
Elementary chopper with an active switch and diode, concepts of duty ratio and average voltage, power circuit of a buck converter, analysis and waveforms at steady state, duty ratio control of output voltage.

Power circuit of a boost converter, analysis and waveforms at steady state, relation between duty ratio and average output voltage.

Module IV: Single-Phase Voltage Source Inverter (8 Lectures)
Power circuit of single-phase voltage source inverter, switch states and instantaneous output voltage, square wave operation of the inverter, concept of average voltage over a switching cycle, sinusoidal pulse width modulation, modulation index and output voltage**.**

Module V: Three-Phase Voltage Source Inverter (7 Lectures)
Power circuit of a three-phase voltage source inverter, switch states, instantaneous output voltages, average output voltages over a sub-cycle, 120- degree conduction, 180-degree conduction, three-phase sinusoidal pulse width modulation

Module VI: AC Voltage Controllers (4 Lectures)
Introduction, principle of on-off control, principle of phase control and integral cycle control, configuration of three phase controllers, cycloconverter.

Text/References Books:

[1]. M. H. Rashid, "Power electronics: circuits, devices, and applications", Pearson Education India, 2009.
[2]. N. Mohan and T. M. Undeland, "Power Electronics: Converters, Applications and Design", John Wiley & Sons, 2007.
[3]. R. W. Erickson and D. Maksimovic, "Fundamentals of Power Electronics", Springer Science &Business Media, 2007.
[4]. L. Umanand, "Power Electronics: Essentials and Applications", Wiley India, 2009.

Electrical Engineering			
EE611	**Power Systems-II**	**L**	**T**
		3	**0**

Course Outcomes:

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

CO's	CO Description
CO1	**Illustrate** power system components using single line diagram and usage of per unit system.
CO2	**Calculate** symmetrical components and **Examine** different types of faults (both symmetrical and unsymmetrical).
CO3	**Formulate** nodal admittance (Y-bus) matrix, and **develop** load flow equations and **find** its solution.
CO4	**Illustrate** the concept of stability, power angle curve, and swing equation and **diagnose** steady-state and transient stability of the power system.
CO5	**Apply** different types of active, reactive and voltage control techniques.

CO's-PO's Mapping Matrix:

Enter correlation levels1, 2 or 3 as defined below-

1. Slight (low) 2. Moderate (Medium) 3. Substantial (High)

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1									
CO2	3	2	1	3	2							
CO3	3	2	1	3	2							2
CO4	3	3	1	2	2							2
CO5	3	3	1	2	2							2
Avg.	**3**	**2.4**	**1**	**2.5**	**2**							**2**

DETAILED SYLLABUS

Module I: Per Unit System and Faults (10 Lectures)

Per Unit meaning and its calculation. Need and advantages of per unit system, Selection of base quantities, per unit impedance for 1-φ and 3 – φ system. Change of base value. Faults causes and consequences. Classification of faults and statistics of occurrence.

Fortescue theorem, Method of symmetrical components (positive, negative and zero sequences). Symmetrical component transformation. Sequence networks for generators, lines and transformers. Sequence network for power system. Balanced and Unbalanced faults, computation of fault currents.

Module II: Load Flow Analysis (10 Lectures)

Review of the structure of power system and its components, Bus classification, formulation of Y_{bus} matrix, power flow equations. Gauss – Seidel method, algorithm, derivation of iterarative

equation, modification for PV bus, Advantages and disadvantages, acceleration factor. Newton – Raphson method, algorithm, power mismatch vector, size of Jacobian matrix and its elements. Advantages and disadvantages.

Module III: Power system Stability (11 Lectures)

Concept of power system stability and it's classification. Dynamic equation of synchronous machine. Swing equation and power angle curve. Single machine infinite bus system. Large signal stability, Equal area criteria, derivation. Critical clearing angle and effect of clearing time on stability. Methods for improvement of transient stability. Introduction to Multi – machine transient stability.

Module IV: Economic Operation of Power Systems (5 Lectures)

Input-output characteristics of thermal and hydro plants, Optimum generator allocations without and with transmission losses, calculation of penalty factors, incremental transmission loss, transmission loss coefficients and their calculations.

Module V: Load Frequency Control: (6 Lectures)

Concept of load frequency control, load frequency control of single area system, effect of governor droop and load damping, block diagram representation of single area system, steady state frequency error, dynamic response.

Text Books

[1]. J Grainger and W.D. Stevenson , " Power System Analysis '' , McGraw Hill Education , 1994.
[2]. A.J. Wood and B.F. Wollenberg, "Power Generation, Operation and Control", John Wiley and Sons,2011.
[3]. D.P. Kothari and I.J. Nagrath, " Modern Power System Analysis '' ,McGraw Hill Education 2003
[4]. O.L. Elgerd , " Electric energy systems theory '' , McGraw Hill Education , 1995.

Reference Books

[1]. Soni Gupta & Bhatnagar , " A course in Electric Power '' , Dhanpat Rai & Sons.
[2]. A R Bergen and V Vittal , " Power system analysis '' , Pearson Education Inc, 1999.

Electrical Engineering			
EE612	**Power System Restructuring**	**L**	**T**
		3	**0**

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

CO1	**Understand** the developments of restructuring worldwide.
CO2	**Identify** the roles and responsibilities of different entities in power market.
CO3	**Identify** issues like congestion management Ancillary Services Management.
CO4	**Evaluate** the transmission pricing schemes
CO5	**Explain** the Ancillary Services Management and the reforms in Indian power sector

CO's-PO's Mapping Matrix:
Enter correlation levels1, 2 or 3 as defined below-

1. Slight (low) 2. Moderate (Medium) 3. Substantial (High)

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12
CO1	1	2	1	1								2
CO2	1	2	1	2		1						2
CO3	2	2	1	2		1			2			2
CO4	1	1	1	2					1			2
CO5	2	2	1	1								2
Avg.	**1.4**	**1.75**	**1.0**	**1.6**		**1**			**1.5**			**2**

DETAILED SYLLABUS

Module I: Introduction to Restructuring of Power Industry (8 Lectures)
Introduction: Deregulation of power industry, Restructuring process, Issues involved in deregulation, Deregulation of various power systems – Fundamentals of Economics: Consumer behavior, Supplier behavior, Market equilibrium, Short and long run costs, Various costs of production – Market models: Market models based on Contractual arrangements, Comparison of various market models.

Module II: Electricity Market Model (8 Lectures)
Separation of ownership and operation, Deregulated models, pool model, pool and bilateral trades model, multilateral trade model. Competitive electricity market: Independent System Operator activities in pool market, Wholesale electricity market characteristics, central auction, single auction power pool, double auction power pool, market clearing and pricing, Market Power and its Mitigation Techniques, Bilateral trading.

Module III: Transmission Congestion Management (8 Lectures)
Introduction: Definition of Congestion, reasons for transfer capability limitation, Importance of congestion management, Features of congestion management – Classification of congestion management methods – Calculation of ATC - Non – market methods – Market methods – Nodal pricing – Inter zonal and Intra zonal congestion management – Price area congestion Management

Module IV: Locational Marginal Prices and Financial Transmission Rights (5 Lectures)
Mathematical preliminaries: - Locational marginal pricing– Lossless DCOPF model for LMP calculation – Loss compensated DCOPF model for LMP calculation – ACOPF model for LMP calculation – Financial Transmission rights.

Module – V: Transmission Pricing Schemes (7 Lectures)
Introduction to transmission pricing, Principles of transmission pricing, Classification of transmission pricing, Rolled-in transmission pricing paradigm, Marginal transmission pricing paradigm, Composite pricing paradigm, Merits and de-merits of different paradigms, Classification of loss allocation methods, Pro-rata methods, Incremental methods, Power flow tracing based allocation

Module – VI: Ancillary Service Management (4 Lectures)
Introduction of ancillary services – Types of Ancillary services – Classification of Ancillary services – Load generation balancing related services – Voltage control and reactive power support devices – Black start capability service.

Module-VII: Reforms In Indian Power Sector (2 Lectures)
Introduction – Framework of Indian power sector – Reform initiatives - Availability based tariff – Electricity act 2003 – Open access issues – Power exchange – Reforms in the near future.

Text Books

[1]. Mohammad Shahidehpour, Muwaffaq Alomoush, Marcel Dekker, "Restructured electrical power systems: operation, trading and volatility" Pub., 2001.
[2]. Kankar Bhattacharya, Jaap E. Daadler, Math H.J. Boolen, "Operation of restructured power systems", Kluwer Academic Pub., 2001.
[3]. Leo Lei Lai, "Power System Restructuring and Deregulation: Trading, Performance and Information Technology" Wiley Pub. November 2001.
[4]. Steven Stoft, "Power system economics: designing markets for electricity", John Wiley & Sons, 2002.

Text/Reference Books:

[1]. Making competition work in electricity Sally Hunt, John Wiley & Sons, Inc., 2002.
[2]. Marija llic, Francisco Galiana and Lestor Fink , Power System Restructuring Engineering & Economics , Kulwer Academic Publisher, USA-2000.

Electrical Engineering			
EE613	**Electrical Estimation and Costing**	**L**	**T**
		3	**0**

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

CO's	CO Description
CO1	**Understand** the purpose of estimation and costing.
CO2	**Understand** distribution of energy in a building, wiring and methods of wiring, cables used in internal wiring, wiring accessories and fittings, fuses and types of fuses..
CO3	**Analyze** design of lighting points and its number, total load, sub-circuits, size of conductor.
CO4	**Understand** types of service mains and estimation of service mains and power circuits.
CO5	**Estimate** overhead transmission and distribution systems and its components.

CO's-PO's Mapping Matrix:
Enter correlation levels1, 2 or 3 as defined below-

1. Slight (low) 2. Moderate (Medium) 3. Substantial (High)

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	1	1						2
CO2	3	3	3	2	1	1						2
CO3	3	3	3	2	1	1						2
CO4	3	3	3	2	1	1						2
CO5	3	3	3	2	1	1						2
Avg.	**3**	**3**	**3**	**2**	**1**	**1**						**2**

DETAILED SYLLABUS

Module I: Principles of Estimation (5 Lectures)
Introduction to estimation & costing, Electrical Schedule, Catalogues, Market Survey and source selection, Recording of estimates, Determination of required quantity of material, Labor conditions, Determination of cost material and labour,Contingencies, Overhead charges, Profit, Purchase system, Purchase enquiry and selection of appropriate purchase mode, Comparative statement, Purchase orders, Payment of bills, Tender form, General idea about IE rule, Indian Electricity Act and major applicable I.E rules.

Module II: Residential Building Electrification (7 Lectures)
Introduction to electrical symbols, their advantages and requirement. Concept of wiring diagram, schematic diagrams and their types. General Rules guidelines for wiring of residential installation and positioning of equipments**,** Principles of circuit design in lighting and power circuits Procedures for designing the circuits and deciding the number of circuits, Method of

drawing single line diagram. Selection of type of wiring and rating of wires and cables Load calculations and selection of size of conductor, Selection of rating of main switch Distribution board, protective switchgear ELCB and MCB and wiring accessories, Earthing of residential Installation, sequence to be followed for preparing estimate, Preparation of detailed estimates and costing of residential installation.

Module III: Electrification of Commercial Installation (7 Lectures)

Concept of commercial installation, Differentiate between electrification of residential and commercial installation, Fundamental considerations for planning of an electrical installation system for commercial building, Design considerations of electrical installation system for commercial building, Load calculation and selection of size of service connection and nature of supply, Deciding the size of the cables, busbar and bus bar chambers, Mounting arrangements and positioning of switchboards, distribution boards main switch etc, Earthing of the electrical installation, Selection of type wire, wiring system and layout, Sequence to be followed to prepare estimate, Preparation of detailed estimate and costing of commercial installation.

Module IV: Service Connection, Inspection and Testing of Installation (7 Lectures)

Concept of service connection, Types of service connection and their features, Method of installation of service connection, Estimates of underground and overhead service connections, Inspection of internal wiring installations, Inspection of new installations, testing of installations, testing of wiring installations, Reason for excess recording of energy consumption by energy meter.

Electrical Installation For Power Circuits: Introduction, Important considerations regarding motor installation wiring, Determination of input power, Determination of input current to motors Determination of rating of cables

Determination of rating of fuse, Determination of size of Condit, distribution Board main switch and starter.

Module V: Design and Estimation of Overhead Transmission & Distribution Lines (10 Lectures)

Introduction, Typical AC electrical power system, Main components of overhead lines, Line supports, Factors governing height of pole, Conductor materials, Determination of size of conductor for overhead transmission line, Cross arms, Pole brackets and clamps,Guys and Stays, Conductors configuration spacing and clearances, Span lengths, Overhead line insulators, Insulator materials, Types of insulators, Lightning Arrestors, Phase plates, Danger plates, Anti climbing devices, Bird guards, Beads of jumpers, Muffs, Points to be considered at the time of erection of overhead lines, Erection of supports, Setting of stays, Fixing of cross arms, Fixing of insulators, Conductor erection, Repairing and jointing of conductor , Dead end clamps, Positioning of conductors and attachment to insulators, Jumpers, Tee-offs, Earthing of transmission lines, Guarding of overhead lines, Clearances of conductor from ground, Spacing between conductors, Testing and commissioning of overhead distribution lines, Some important specifications.

Module VI: Design and Estimation of Substations (6 Lectures)

Introduction, Classification of substation, Indoor substations, Outdoor substations, Selection and location of site for substation, Main Electrical Connections, Graphical symbols for various types

of apparatus and circuit elements on substation main connection diagram, Key diagram of typical substations, Equipment for substation and switchgear installations, Substation auxiliaries supply, Substation Earthing.

Text/Reference Books:

[1]. Raina K.B. and Bhattacharya S.K., "Electrical Design, Estimating and Costing", New Age International, New Delhi, 2010

[2]. N. Alagappan & S. Ekambaram, "Electrical Estimating & Costing", TMH,2006

[3]. Dr.S.L.Uppal, "Electrical Wiring, Estimating and Costing", 5th Edition, Khanna Publishers,2003.

[4]. M.V. Deshpande, "Elements of Electrical Power Station Design", PHI 2009.

[5]. J. B. Gupta, "A Course in Electrical Installation Estimating and Costing", S. K. Kataria and Sons, India,2013.

[6]. ISI, National Electric Code, Bureau of Indian Standard Publications, New Delhi, 2011.

Electrical Engineering			
EE614	**Electrical Energy Conservation and Auditing**	**L**	**T**
		3	**0**

Course Outcomes:

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

CO's	CO Description
CO1	**Explain** about various energy sources, energy sector reforms and restructuring.
C02	**Explain** about energy management and auditing
C03	**Outline** various power factor improvement methods and energy saving methods
C04	**Illustrate** various energy efficient technologies and their energy saving potential

CO's-PO's Mapping Matrix:

Enter correlation levels1, 2 or 3 as defined below-

1. Slight (low) 2. Moderate (Medium) 3. Substantial (High)

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	1								
CO2	3	2	2	1		1	1					
CO3	3	2	2	1		2	2					
CO4	3	2	2	1		2	2					
Average	**3**	**2**	**2**	**1**		**1.66**	**1.66**					

DETAILED SYLLABUS

Module I: Energy Scenario (6 Lectures)

Commercial and Non-commercial energy, primary energy resources, commercial energy production, final energy consumption, energy needs of growing economy, long term energy scenario, energy pricing, energy sector reforms, energy and environment, energy security, energy conservation and its importance, restructuring of the energy supply sector, energy strategy for the future, air pollution, climate change. Energy Conservation Act-2001 and its features.

Module II: Basics of Energy and its various forms (7 Lectures)

Energy Electricity tariff, load management and maximum demand control, power factor improvement, selection & location of capacitors, Thermal Basics-fuels, thermal energy contents of fuel, temperature & pressure, heat capacity, sensible and latent heat, evaporation, condensation, steam, moist air and humidity & heat transfer, units and conversion.

Module III: Energy Management & Audit (6 Lectures)

Definition, energy audit, need, types of energy audit. Energy management (audit) approach understanding energy costs, bench marking, energy performance, matching energy use to

requirement, maximizing system efficiencies, optimizing the input energy requirements, fuel & energy substitution, energy audit instruments.

Module IV: Energy Efficiency in Electrical Systems (7 Lectures)

Electrical system: Electricity billing, electrical load management and maximum demand control, power factor improvement and its benefit, selection and location of capacitors.

Electric motors: Types, losses in induction motors, motor efficiency, factors affecting motor performance, rewinding and motor replacement issues, energy saving opportunities with energy efficient motors.

Module V: Energy Efficiency in Industrial Systems (8 Lectures)

Compressed Air System: Types of air compressors, compressor efficiency, efficient compressor operation, Compressed air system components, capacity assessment, leakage test, factors affecting the performance and savings opportunities in HVAC, Fans and blowers: Types, performance evaluation, efficient system operation, flow control strategies and energy conservation opportunities. Pumps and Pumping System: Types, performance evaluation, efficient system operation, flow control strategies and energy conservation opportunities.

Cooling Tower: Types and performance evaluation, efficient system operation, flow control strategies and energy saving opportunities, assessment of cooling towers.

Module VI: Energy Efficient Technologies (8 Lectures)

Maximum demand controllers, automatic power factor controllers, energy efficient motors, soft starters with energy saver. Variable speed drives, energy efficient transformers, electronic ballast, occupancy sensors, energy efficient lighting controls, energy saving potential of each technology.

Text/Reference Books:

[1]. Guide books for National Certification Examination for Energy Manager / Energy Auditors Book-1, General Aspects (available online)

[2]. Guide books for National Certification Examination for Energy Manager / Energy Auditors Book-3, Electrical Utilities (available online)

[3]. S. C. Tripathy, "Utilization of Electrical Energy and Conservation", McGraw Hill, 1991.

Electrical Engineering			
EE621	**High Voltage Engineering**	**L**	**T**
		3	**0**

Course Outcomes:

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

CO's	CO Description
CO1	**Read** the terms and numerical methods used in High Voltage engineering.
CO2	**Discuss** the different breakdown mechanisms in dielectrics and liquids.
CO3	**Analyze** the concept of Generation of High Voltages, High Currents, Impulse voltages and currents.
CO4	**Outline** the techniques employed in High Voltage Measurements.
CO5	**Generalize** with non-distractive test techniques in High Voltage Engineering.

CO's-PO's Mapping Matrix:

Enter correlation levels1, 2 or 3 as defined below

1. Slight (low) 2. Moderate (Medium) 3. Substantial (High)

COs/PO's	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3											
CO2	2	2		1								
CO3		2	3		2							
CO4	1		3		2							
CO5	2	2	2		2							
Avg.	**2**	**2**	**2.7**	**1**	**2**							

DETAILED SYLLABUS

Module I: Introduction (2 Lectures)

Introduction to High voltage Engineering, its scope, Latest Trends, HVDC Transmission.

Module II: Electrical Discharges (6 Lectures)

Introduction, breakdown in gases, Townsend's criterion for breakdown, numerical. Streamers theory, Paschen's law, time lag for break down, breaks down under ac voltage, impulse voltage. Break down in electro negative gases, vacuum break down.

Module III: Generation of high voltage in Lab (10 Lectures)

Generation of HVAC: Different methods for generation of HVAC in lab, comparison between power and testing transformer, Cascaded transformer method, Resonant transformers, numericals. Generation of HVDC: Rectifier circuits, electrostatic generator, Cockroft Walton voltage multiplier circuit, numericals. Generation of Impulse voltage: Impulse wave and its characteristics, different forms of impulse wave, Different types of impulse generator circuits and their analysis. Multi stage impulse generator, its construction, layout, triggering and synchronization, numericals.

Module IV: High Voltage Measurement (6 Lectures)

Purpose of HV testing in lab, sphere gap its construction, working. Use of sphere gaps in HV measurement, factors affecting measurement by sphere gap. CRO- their types, principle and working, recurrent surge oscillograph, measurement using CRO.

Module V: Over Voltages (12 Lectures)

Origin and characteristics of over voltages on transmission lines, wave propagation, use of modal theory in wave propagation. Reflection and refraction of voltage and current waves over the line, Lattice diagram, Ferro resonance, numerical. External over voltages- Lightning over voltages, theories about lightning, development of lightning stroke, direct and indirect stroke, line model for lightning. Protection against over voltages, use of ground wire, tower footing resistance, lightning arrestors, etc. Insulation co ordination.

Module VI: Testing of Insulators (6 Lectures)

Definitions of various terms used in testing, testing of insulators, power transformers, cables. Non destructive Testing- Use of Schering Bridge, Partial discharge technique for testing of insulation.

Text/Reference Books:

[1]. Khalifa **, "**High Voltage Engineering**",** Marcel Dekker; 1st Printing edition,1990.
[2]. Kuffel, **"**High Voltage Engineering**",** Newnes,2000.
[3]. R.D. Begamudre, "EHV AC Transmission Engineering", New Age International,2011
[4]. Kamraju and Naidu, **"**High Voltage Engineering**",** Tata McGraw-Hill Education,2004.
[5]. C.L.Wadhwa, **"**High Voltage Engineering**",** New Age International,2007.

Electrical Engineering			
EE622	**Industrial Electrical Systems**	**L**	**T**
		3	**0**

Course Outcomes:

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

CO's	CO Description
CO1	**Understand** the electrical wiring systems for residential, commercial and industrial consumers, representing the systems with standard symbols and single line drawings.
CO2	**Understand** various components of industrial electrical systems.
CO3	**Analyze and select** the proper size of various electrical system components.

COs-POs Mapping Matrix:

Enter correlation levels1, 2 or 3 as defined below-

1. Slight (low) 2. Moderate (Medium) 3. Substantial (High)

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3									1
CO2	3	3	3									1
CO3	3	3	3		2							1
Avg.	**3**	**3**	**3**		**2**							**1**

DETAILED SYLLABUS

Module 1: Electrical System Components (8 Lectures)

LT system wiring components, selection of cables, wires, switches, distribution box, metering system, Tariff structure, protection components- Fuse, MCB, MCCB, ELCB, inverse current characteristics, symbols, single line diagram (SLD) of a wiring system, Contactor, Isolator, Relays, MPCB, Electric shock and Electrical safety practices.

Module 2: Residential and Commercial Electrical Systems (8 Lectures)

Types of residential and commercial wiring systems, general rules and guidelines for installation, load calculation and sizing of wire, rating of main switch, distribution board and protection devices, earthing system calculations, requirements of commercial installation, deciding lighting scheme and number of lamps, earthing of commercial installation, selection and sizing of components.

Module 3: Illumination Systems (6 Lectures)

Understanding various terms regarding light, lumen, intensity, candle power, lamp efficiency, specific consumption, glare, space to height ratio, waste light factor, depreciation factor, various illumination schemes, Incandescent lamps and modern luminaries like CFL, LED and their operation, energy saving in illumination systems, design of a lighting scheme for a residential and commercial premises, flood lighting.

Module 4: Industrial Electrical Systems I **(8 Lectures)**
HT connection, industrial substation, Transformer selection, Industrial loads, motors, starting of motors, SLD, Cable and Switchgear selection, Lightning Protection, Earthing design, Power factor correction – kVAR calculations, type of compensation, Introduction to PCC, MCC panels. Specifications of LT Breakers, MCB and other LT panel components.

Module 5: Industrial Electrical Systems II **(6 Lectures)**
DG Systems, UPS System, Electrical Systems for the elevators, Battery banks, Sizing the DG, UPS and Battery Banks, Selection of UPS and Battery Banks.

Module 6: Industrial Electrical System Automation **(6 Lectures)**
Study of basic PLC, Role of in automation, advantages of process automation, PLC based control system design, Panel Metering and Introduction to SCADA system for distribution automation.

Text/Reference Books:

[1]. S. L. Uppal and G. C. Garg, "Electrical Wiring, Estimating & Costing", Khanna publishers, 2008.
[2]. K. B. Raina, "Electrical Design, Estimating & Costing", New age International, 2007.
[3]. S. Singh and R. D. Singh, "Electrical estimating and costing", Dhanpat Rai and Co., 1997.
[4]. H. Joshi, "Residential Commercial and Industrial Systems", McGraw Hill Education, 2008.

Electrical Engineering			
EE623	**Special Electrical Machines**	**L**	**T**
		3	**0**

Course Outcomes:
After Successful completion of course, the students will be able to:

COs	**Description**
CO 1	**Identify** and differentiate various electrical machines.
CO2	**Analyze** the torque speed characteristics and transfer function of Permanent Magnet Synchronous Motors(PMSM).
CO3	**Explain** the construction, working principle and performance of Stepper Motor
CO4	**Compare** and **contrast** the open loop and closed loop systems for servo motors.
CO5	**Classify** the different types of tachogenerators and its characteristics.

CO's-PO's Mapping Matrix:
Enter correlation levels1, 2 or 3 as defined below-

1. Slight (low) 2. Moderate (Medium) 3. Substantial (High)

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2			2	1						2
CO2	3	2			2	1						
CO3	3	1		2	2	1						

CO4	2	1	2			1						
CO5	2	1	1		3	1						
Avg.	**2.6**	**1.3**	**1.5**	**2**	**2.25**	**1**						**2**

DETAILED SYLLABUS

Module I: FHP Universal Commutator motors **(6 Lectures)**

Principle of operation and performance characteristics of universal commutator motor without and with compensating windings, phasor diagrams and expressions for power and torque, speed-torque characteristics with DC and AC excitations.

Module II: FHP Synchronous Motors **(12 Lectures)**

Permanent magnet synchronous motors, hysteresis motors, synchronous reluctance motors, switched reluctance motors, brushless dc motors.

Module III: Stepper motors **(12 Lectures)**

Introduction, Multi-stack variable-reluctance stepping motors, Principles of operation , Aspects of design ,Single stack variable-reluctance stepping motors, Hybrid stepping motors, comparison of motor types, design of drive circuits, torque/rotor position characteristics.

Module IV: Servomotors **(6 Lectures)**

DC and AC servomotors, transfer function analysis, Synchros.

Module V: Tacho generators **(6 Lectures)**

DC tachogenerators, Induction and synchronous AC tachgenerators, characteristics and applications.

Text/Reference Books:

[1]. P.C. Sen, "Principles of Electric Machines and Power Electronics", 2nd Edition, Wiley India Ltd. 2007

[2]. E. Openshaw Taylor, "The Performance and Design of AC Commutator Motors", Wheeler Publishing, 1997

[3]. R. Krishnan, "Switched Reluctance Motor Drives", 1st Edition, CRC Press. 2001

[4]. T.J.E. Miller and J.R. Hendershot, "Switched Reluctance Motors & Their Control", Magna Physics Publishing, 1st Edition 1993

[5]. T.J.E. Miller, "Electronic Control of Switched Reluctance Machines",1st Edition, Newnes. 2001

[6]. K.Venkataratnam, "Special Electrical Machines", Universities Press 2008

[7]. E.V. Armensky and G.B. Falk, "Fractional Horsepower Electrical Machines", Mir Publishers 1978

[8]. John Chiasson "Modeling and High-Performance Control of Electric Machines" John Wiley & Sons, Inc., Publication 2005

[9]. P. P. Acarnley "Stepping Motors : a guide to theory and practice" IET Control Engineering series 2002.

Electrical Engineering			
EE624	**Power System Transient**	**L**	**T**
		3	**0**

Course Outcomes:

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

CO's	CO Description
CO1	**Explain** the causes and characteristics for switching, lightning and temporary over voltages.
CO2	**Apply** and carry out simple analytical calculations of transient over voltages and currents in power systems
CO3	**Explain** critical switching and lightning voltages situations
CO4	**Illustrate** the travelling wave's phenomenon on transmission lines, use of Bewley's lattice to study travelling waves
CO5	**Illustrate** switching surges on integrated power system and application of EMTP for transient computations

CO's-PO's Mapping Matrix:

Enter correlation levels1, 2 or 3 as defined below-

1. Slight (low) 2. Moderate (Medium) 3. Substantial (High)
2.

COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12
CO1	1	2		2								2
CO2	3	3	2	3			1					2
CO3	2	2	2				1					2
CO4	3	3	2	2			2					2
CO5	3	3	2	2			2					2
Avg.	**2.4**	**2.6**	**2.0**	**2.25**			1.5					2.0

DETAILED SYLLABUS

Module I: Introduction and Survey **(9 Lectures)**

Review and importance of the study of transients - causes for transients. RL circuit transient with sine wave excitation - double frequency transients - basic transforms of the RLC circuit transients. Different types of power system transients - effect of transients on power systems role of the study of transients in system planning.

Module II : Switching Transients **(9 Lectures)**

Over voltages due to switching transients - resistance switching and the equivalent circuit for interrupting the resistor current - load switching and equivalent circuit - waveforms for transient voltage across the load and the switch - normal and abnormal switching transients. Current suppression - current chopping - effective equivalent circuit. Capacitance switching - effect of

source regulation - capacitance switching with a restrike, with multiple restrikes. Illustration for multiple restriking transients – ferro-resonance.

Module III: Lighting Transients (8 Lectures)

Review of the theories in the formation of clouds and charge formation - rate of charging of thunder clouds – mechanism of lightning discharges and characteristics of lightning strokes – model for lightning stroke - factors contributing to good line design - protection using ground wires – tower footing resistance-Interaction between lightning and power system.

Module IV: Raveling Waves On Transmission Line Computation of Transients (8 Lectures)

Computation of transients - transient response of systems with series and shunt lumped parameters and distributed lines. Traveling wave concept - step response - Bewely's lattice diagram – standing waves and natural frequencies - reflection and refraction of travelling waves.

Module V: Transient in Integrated Power System (8 Lectures)

The short line and kilometric fault - distribution of voltages in a power system - Line dropping and load rejection - voltage transients on closing and reclosing lines - over voltage induced by faults - switching surges on integrated system Qualitative application of EMTP for transient computation.

Text Books:

[1]. Allan Greenwood, 'Electrical Transients in Power Systems', Wiley Interscience, New York, 2nd edition 1991.

[2]. R.D.Begamudre, 'Extra High Voltage AC Transmission Engineering', Wiley Eastern limited, 1986.

References Books:

[1]. M.S.Naidu and V.Kamaraju, 'High Voltage Engineering', Tata McGraw Hill, 2nd edition, 2000.

Electrical Engineering			
EE631	**Power Electronics***	**L**	**T**
		3	**0**

(This course is not offered to Electrical Engg. Students)

Course Outcomes:

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

CO's	CO Description
CO1	To **understand** different power semiconductor devices and their switching characteristics.
CO2	To **understand** the operation, characteristics and performance parameters of AC to DC Converters.
CO3	To **study** the operation, switching techniques and basic topologies of DC-DC Converters
CO4	To learn the different modulation techniques of PWM inverters and to **understand** commutation techniques.
CO5	To **study** the operation of AC voltage controller and various configurations.

CO's-PO's Mapping Matrix:

Enter correlation levels1, 2 or 3 as defined below-

1. Slight (low) 2. Moderate (Medium) 3. Substantial (High)

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	1		1					1
CO2	2	2	3	3	2		1					1
CO3	2	2	3	2	1	1	1					1
CO4	2	3	2	2	2	1	1					1
CO5	2	3	3	2	1	1	1					1
Avg.	**2.2**	**2.4**	**2.6**	**2.2**	**1.4**	**1**	**1**					**1**

DETAILED SYLLABUS

Module I: Power Semiconductor Devices (7 Lectures)

Diode, Thyristor, MOSFET, IGBT, GTO: constructional features, I-V Characteristics; Firing circuit for thyristor; protection of thyristor and gate drive circuit, Turn on techniques, Voltage and current commutation of a thyristor.

Module II: AC-DC Converters (6 Lectures)

Single-phase half-wave and full-wave rectifiers, Single-phase full-bridge thyristor rectifier with R, R-L and R-L-E load; effect of source inductance, Three-phase full-bridge thyristor rectifier with R, R-L and R-L-E load; freewheeling effect, power factor improvement.

Module III: DC-DC Buck and Boost Converter (10 Lectures)
Elementary chopper with an active switch and diode, concepts of duty ratio and average voltage, power circuit of a buck converter, analysis and waveforms at steady state, duty ratio control of output voltage.

Power circuit of a boost converter, analysis and waveforms at steady state, relation between duty ratio and average output voltage.

Module IV: Single-Phase Voltage Source Inverter (8 Lectures)
Power circuit of single-phase voltage source inverter, switch states and instantaneous output voltage, square wave operation of the inverter, concept of average voltage over a switching cycle, sinusoidal pulse width modulation, modulation index and output voltage**.**

Module V: Three-Phase Voltage Source Inverter (7 Lectures)
Power circuit of a three-phase voltage source inverter, switch states, instantaneous output voltages, average output voltages over a sub-cycle, 120- degree conduction, 180-degree conduction, three-phase sinusoidal pulse width modulation

Module VI: AC Voltage Controllers (4 Lectures)
Introduction, principle of on-off control, principle of phase control and integral cycle control, configuration of three phase controllers, cycloconverter.

Text/References Books:

[5]. M. H. Rashid, "Power electronics: circuits, devices, and applications", Pearson Education India, 2009.
[6]. N. Mohan and T. M. Undeland, "Power Electronics: Converters, Applications and Design", John Wiley & Sons, 2007.
[7]. R. W. Erickson and D. Maksimovic, "Fundamentals of Power Electronics", Springer Science &Business Media, 2007.
[8]. L. Umanand, "Power Electronics: Essentials and Applications", Wiley India, 2009.

Electrical Engineering			
EE632	**Green Energy Technology**	**L**	**T**
		3	**0**

Course Outcome:

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

CO1	**Identify** different non-conventional energy system and **explain** the principle of thermo-electrical and thermionic conversions
CO2	**Analyze** the performance and limitations of the solar and wind energy conversion system
CO3	**Illustrate** the concept of geothermal energy.
CO4	**Outline** the basics of fuel cells.
CO5	**Understand** the principles behind the bio-mass, ocean thermal and wave energy conversions.

CO's-PO's Mapping Matrix:

Enter correlation levels1, 2 or 3 as defined below-

1. Slight (low) 2. Moderate (Medium) 3. Substantial (High)

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1		1	1		1					1
CO2	3	2	2	2	1		1					1
CO3	1	1		1	1		1					1
CO4	2	1	1	1	1		1					1
CO5	2	1	1	1	1		1					1
Avg.	**2.2**	**1.2**	**1.33**	**1.2**	**1**		**1**					**1**

DETAILED SYLLABUS

Module I: Introduction **(6 Lectures)**

Basics of energy, conventional energy sources, fossil fuels limitations, renewable energy sources, advantages and limitations, global energy scenario, energy scenario of India, new technologies (hydrogen energy, fuel cells, bio fuels).

Module II: Solar Energy **(12 Lectures)**

Theory of solar cells, solar cell materials, I-V characteristics of solar cell, PV module, PV array, MPPT, PV systems, Stand alone and grid connected PV systems, storage, PV based water pumping, solar radiation and its measurement, flat plate collectors and their materials, applications and performance, solar thermal power plants, limitations.

Module III: Wind Energy **(10 Lectures)**

Wind power and its sources, site selection, power in the wind, impact of tower height, classification of wind turbine and rotors, wind energy extraction, betz'z limit, wind characteristics, performance and limitations of wind energy conversion systems.

Module IV: Biomass and Geothermal energy (8 Lectures)
Availability of biomass and its conversion theory, types of biomass, gasification, biogas plant, biomass cogeneration, resources of geothermal energy, thermodynamics of geo-thermal energy conversion, geothermal power generation, environmental considerations.

Module V: Emerging technologies for power generation (6 Lectures)
Introduction to tidal energy, tidal characteristics, tidal power plant, tidal power development in India, introduction to wave energy, factors affecting wave energy, principles of wave energy plant, OTEC, applications of OTEC, principle of working of various types of fuel cells and their working, performance and limitations, future potential of fuel cells, Emergence of hydrogen, cost analysis of hydrogen production, hydrogen storage.

Text/Reference Books:

[1]. Duffie and Beckmen, Solar Engineering of Thermal Processes, Wiley Publications, 1991.
[2]. S. P. Sukhatme, Solar Energy, TMH, India. 2008.
[3]. John Twiden and Tony Weir, Renewable Energy Resources, BSP Publications, 2006.
[4]. D. P. Kothari, Rakesh Ranjan, Renewable Energy Sources and Emerging Technologies, PHI, India,2011.
[5]. Non Conventional Energy Resources, D.S. Chauhan, New Age International Pvt Ltd., 2006.

Electrical Engineering			
EE633	**Mine Electrical Engineering***	**L**	**T**
		3	**0**

(This course is not offered to Electrical Engg. students)

Pre-requisite: Basic Electrical Engineering and Basic Electronics Engineering.

Course Outcomes:

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

CO's	CO Description
CO1	**Understand** different types of power supply systems and protection schemes used underground coal mines.
CO2	**Understand** different types of circuit breakers used in Mines.
CO3	**Analyze** illumination, Intrinsically Safe circuit methods of attaining intrinsic safety, Zener safety barriers and their applications in mines.

CO's-PO's Mapping Matrix:

Enter correlation levels1, 2 or 3 as defined below-

1. Slight (low) 2. Moderate (Medium) 3. Substantial (High)

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1		1						2
CO2	3	3	2	1		1						2
CO3	3	3	2	1		1						2
CO4	3	3	2	1		1						2
CO5	3	3	12	1		1						2
Avg.	**3**	**3**	**2**	**1**		**1**						**2**

DETAILED SYLLABUS

Module I:

Types of electrical power supply systems for underground coal mines–solidly earthed, restricted neutral and insulated – neutral systems of electrical power supply; their comparisons. Earth fault protection techniques for above mine power supply systems, sensitive and fail-safe earth fault relays. On-line insulation monitoring for insulated-neutral electrical distribution system.

Module II:

Mining type circuit breakers–Air circuit breaker, vacuum and Hexa Sulfa Flouride(SF6) circuit breakers, Field switch, Tran switch unit, Gate End Box, Drill Panel.

Module III:

Electrical power planning for mechanized longwall faces–general scheme of electrical power distribution, voltage drop problems and remedial measures; in bye substation capacity selection.

General scheme of electrical power distribution in opencast projects, Quarry substation capacity selection. Choice of restricted-neutral and insulated-neutral systems in open cast mines.

Module IV:
Illumination planning for mines–underground roadway lighting system; intrinsically-safe lighting system for longwall faces, opencast mine lighting. Earthing practice in mines – earth pits, earthing of mobile electrical equipment in mines. Mining cables – types, constructional details; layout of cables through shaft and other locations.

Module V:
Principles of flame proof enclosures. Intrinsically safe circuit methods of attaining intrinsic safety, Zener safety barriers and their applications. Indian electricity rules as applied to mines.

Text/Reference Books:

[1]. A Text Book on Power Systems Engineering – Soni Gupta, Bhatnagar, Chakarbarti, Dhanpat Rai & Sons.
[2]. Electrical Equipment in mines- Harry Cotton, George Newness
[3]. Switchgear and Protection- S.S. Rao, Khanna Publications.
[4]. Indian Electricity Rules.
[5]. Principles of Mine Planning J. Bhattacharya, Allied Publications.
[6]. Universal Mining School Series (UK)
[7]. Coal Mining Practice- J.C. F Statham Vol III, Heart Series.
[8]. Electrical Power Systems – C.L. Wadhwa, New Age International Publishers.

Electrical Engineering			
EE641	**Special Electrical Machines***	**L**	**T**
		3	**0**

(This course is not offered to Electrical Engg. Students)

Course Outcomes:

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

COs	Description
CO 1	**Identify** and differentiate various electrical machines.
CO2	**Analyze** the torque speed characteristics and transfer function of Permanent Magnet Synchronous Motors(PMSM).
CO3	**Explain** the construction, working principle and performance of Stepper Motor
CO4	**Compare** and **contrast** the open loop and closed loop systems for servo motors.
CO5	**Classify** the different types of tachogenerators and its characteristics.

CO's-PO's Mapping Matrix:

Enter correlation levels1, 2 or 3 as defined below-

1. Slight (low) 2. Moderate (Medium) 3. Substantial (High)

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2			2	1						2
CO2	3	2			2	1						
CO3	3	1		2	2	1						
CO4	2	1	2			1						
CO5	2	1	1		3	1						
Avg.	**2.6**	**1.3**	**1.5**	**2**	**2.25**	**1**						**2**

DETAILED SYLLABUS

Module I: FHP Universal Commutator motors (6 Lectures)

Principle of operation and performance characteristics of universal commutator motor without and with compensating windings, phasor diagrams and expressions for power and torque, speed-torque characteristics with DC and AC excitations.

Module II: FHP Synchronous Motors (12 Lectures)

Permanent magnet synchronous motors, hysteresis motors, synchronous reluctance motors, switched reluctance motors, brushless dc motors.

Module III: Stepper motors (12 Lectures)

Introduction, Multi-stack variable-reluctance stepping motors, Principles of operation , Aspects of design ,Single stack variable-reluctance stepping motors, Hybrid stepping motors, comparison of motor types, design of drive circuits, torque/rotor position characteristics.

Module IV: Servomotors **(6 Lectures)**

DC and AC servomotors, transfer function analysis, Synchros.

Module V: Tacho generators **(6 Lectures)**

DC tachogenerators, Induction and synchronous AC tachgenerators, characteristics and applications.

Text/Reference Books:

[1]. P.C. Sen, "Principles of Electric Machines and Power Electronics", 2nd Edition, Wiley India Ltd. 2007

[2]. E. Openshaw Taylor, "The Performance and Design of AC Commutator Motors", Wheeler Publishing, 1997

[3]. R. Krishnan, "Switched Reluctance Motor Drives", 1st Edition, CRC Press, 2001.

[4]. T.J.E. Miller and J.R. Hendershot, "Switched Reluctance Motors & Their Control", Magna Physics Publishing, 1st Edition 1993

[5]. T.J.E. Miller, "Electronic Control of Switched Reluctance Machines",1st Edition, Newnes,2001

[6]. K.Venkataratnam, "Special Electrical Machines", Universities Press 2008

[7]. E.V. Armensky and G.B. Falk, "Fractional Horsepower Electrical Machines", Mir Publishers 1978

[8]. John Chiasson "Modeling and High-Performance Control of Electric Machines" John Wiley & Sons, Inc., Publication 2005

[9]. P. P. Acarnley "Stepping Motors : a guide to theory and practice" IET Control Engineering series ,2002.

Electrical Engineering			
EE642	**Soft Computing Techniques**	**L**	**T**
		3	**0**

Course Outcomes:

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

CO1	**Distinguish** the concept between the hard and soft computing techniques.
CO2	**Understand** the basic concept of the Artificial Neural Network (ANN).
CO3	**Understand** the basic concept of the fuzzy logic system
CO4	**Explain** the concept of Genetic Algorithm (GA) and its limitation.
CO5	**Choose** the different kind of evolutionary programming for multi objective optimization problem based on their application.

CO's-PO's Mapping Matrix:

Enter correlation levels1, 2 or 3 as defined below-

1. Slight (low) 2. Moderate (Medium) 3. Substantial (High)

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	1	2							2
CO2	3	3	3	2	2							2
CO3	3	3	3	2	2							2
CO4	3	3	3	3	2							2
CO5	3	3	3	2	2							2
Avg.	**3**	**3**	**3**	**2**	**2**							**2**

DETAILED SYLLABUS

Module I: Fundamentals of Soft Computing Techniques (4 Lectures)

Conventional and Modern Control System, Intelligence, Soft and Hard Computing, Artificial Intelligence.

Module-II: Artificial Neural Network (10 Lectures)

Introduction to Artificial neural networks-biological neurons, Basic models of artificial neural networks- Connections, Learning, Activation Functions, McCulloch and Pitts Neuron.

Learning rule- Hebbian Learning, Perceptron Learning, Delta Learning- Training and Testing algorithm, Adaptive Linear Neuron, Back Propagation Network – Architecture, Training algorithm.

Module-III: Fuzzy Logic System-I (8 Lectures)

Fuzzy Logic- Fuzzy sets- Properties- Operation on fuzzy sets, fuzzy relations- operations on fuzzy relations.

Fuzzy membership functions, fuzzification, Methods of membership value assignments- intuition- inference- rank ordering, Lambda- cuts for fuzzy sets, Defuzzification methods.

Module –IV: Fuzzy Logic System-II **(7 Lectures)**

Truth values and Tables in Fuzzy Logic, Fuzzy propositions, Formation of fuzzy rules – Decomposition of rules- Aggregation of rules, Fuzzy Inference Systems- Mamdani and Sugeno types, Neuro-fuzzy hybrid systems – characteristics- classification

Module-V: **(8 Lectures)**

Introduction to genetic algorithm, operators in genetic algorithm – coding – selection – cross over – mutation, Stopping condition for genetic algorithm flow, Generational Cycle, Applications.

Module-VI: **(5 Lectures)**

Evolutionary Programming, Multi-objective Optimization Problem Solving and its applications, Genetic- neuro hybrid systems, Genetic-Fuzzy rule based system.

Text Books:

[1]. N.P Padhy, Artificial Intelligence and Intelligent Systems- Oxford University Press.
[2]. S. N. Sivanandam and S. N. Deepa, Principles of Soft Computing- Wiley India.
[3]. Timothy J. Ross, Fuzzy Logic with engineering applications – Wiley India.
[4]. M.E. E1- Hawary , Artificial Intelligence application in Power Systems, IEEE Press,2009
[5]. Jan Jantzen, Foundations of Fuzzy Control, A practical approach, Wiley,2013
[6]. M Gopal, Digital Control and State Variable Methods, conventional and neural-fuzzy control system, Published by Tata McGraw Hill Education Private Ltd,2012
[7]. David E Goldberg, Genetic Algorithms, published by Pearson 2008

Reference Books:

[1]. Satish Kumar, Neural Networks- Prentice Hall of India.

Electrical Engineering			
EE643	**Energy Storage Systems**	**L**	**T**
		3	**0**

Course Outcomes:

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

CO's	CO Descriptions
CO1	analyze the characteristics of energy from various sources and need for storage
CO2	classify various types of energy storage and various devices used for the purpose
CO3	Identify various real time applications

CO's-PO's Mapping Matrix:

Enter correlation levels1, 2 or 3 as defined below-

1. Slight (low) 2. Moderate (Medium) 3. Substantial (High)

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	1	1							2
CO2	3	3	3	2	1							2
CO3	3	3	3	2	1							2
CO4	3	3	3	3	1							2
CO5	3	3	3	2	1							2
Avg.	**3**	**3**	**3**	**2**	**1**							**2**

DETAILED SYLLABUS

Module I: Electrical Energy Storage Technologies (8 Lectures)

Characteristics of electricity, Electricity and the roles of EES, High generation cost during peak-demand periods, Need for continuous and flexible supply, Long distance between generation and consumption, Congestion in power grids, Transmission by cable.

Module II: Needs for Electrical Energy Storage (8 Lectures)

Emerging needs for EES, More renewable energy, less fossil fuel, Smart Grid uses, The roles of electrical energy storage technologies, The roles from the viewpoint of a utility, The roles from the viewpoint of consumers, The roles from the viewpoint of generators of renewable energy.

Module III: Features of Energy Storage Systems (8 Lectures)

Classification of EES systems , Mechanical storage systems, Pumped hydro storage (PHS), Compressed air energy storage (CAES), Flywheel energy storage (FES),Electrochemical storage systems, Secondary batteries, Flow batteries, Chemical energy storage, Hydrogen (H2),Synthetic natural gas (SNG).

Module IV: Types of Electrical Energy Storage systems (6 Lectures)

Electrical storage systems, Double-layer capacitors (DLC) ,Superconducting magnetic energy storage (SMES),Thermal storage systems ,Standards for EES, Technical comparison of EES technologies.

Module V: Applications **(10 Lectures)**

Present status of applications, Utility use (conventional power generation, grid operation & service) , Consumer use (uninterruptable power supply for large consumers),New trends in applications ,Renewable energy generation, Smart Grid, Smart Micro grid, Smart House, Electric vehicles, Management and control hierarchy of storage systems, Internal configuration of battery storage systems, External connection of EES systems ,Aggregating EES systems and distributed generation (Virtual Power Plant), Battery SCADA–aggregation of many dispersed batteries.

Text Books:

[1]. "James M. Eyer, Joseph J. Iannucci and Garth P. Corey ", "Energy Storage Benefits and Market Analysis", Sandia National Laboratories, 2004.

[2]. The Electrical Energy Storage by IEC Market Strategy Board.

Reference Book:

[1]. "Jim Eyer, Garth Corey", Energy Storage for the Electricity Grid: Benefits and Market Potential Assessment Guide, Report, Sandia National Laboratories, Feb 2010.

Electrical Engineering			
IC601	**Entrepreneurship**	**L**	**T**
		2	**0**

Course objective:

1. To have Understanding of the dynamic role of entrepreneurship and small businesses
2. To know about Organizing and Managing a Business
3. To know about Financial Planning and Control
4. To know about Business Plan Creation
5. To know about Forms of Ownership for Small Business

Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** An Overview of Entrepreneurs and Entrepreneurship, Definition, Concept of Entrepreneurship & Intrapreneurship, Characteristics and skills of entrepreneurs	08
2.	**Entrepreneurial Development:** Entrepreneurship & Economic development, Contribution of Small and big enterprises to the economy, Entrepreneurial environment, Types of Entrepreneurs.	08
3.	**Developing the Business Plan :** Identification of Business idea, Elements of a Business Plan, Building Competitive Advantage, Conducting feasibility Analysis, Strategy and Planning for Starting Your Small Business, Developing Marketing Strategies, Managing Human Resources.	08
4.	**Sources of Finance:** Equity vs. Debt Capital, Sources of Equity Finance, Institutional finance, Venture Capital, Lease Finance,Obtaining the Right Financing.	06
5.	**Forms of Business Ownership:** Forms of Ownership, Becoming an Owner ,Sole Proprietorship, Partnership, Corporations and other forms of ownership.	04
6.	**Intellectual Property Management:** Importance of innovation, patents& trademarks in small businesses, introduction to laws relating to IPR in India.	04
7.	**Institutional support for small businesses in India:** Support in areas of technology, finance, inputs & infrastructure, marketing, entrepreneurship development .	04
	Total	**42**

Suggested Books:

[1].Hisrich & Peters, "Entrepreneurship", Tata McGraw Hill

[2].Roy, Rajeev, "Entrepreneurship", Oxford University Press

[3]. Norman M. Scarborough, "Essentials of Entrepreneurship & Small Business Management", 6th ed., Prentice Hal

[4]. Dutta, Bholanath, "Entrepreneurship management" ,Excel Books