# DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

## B.Tech. in ELECTRICAL & ELECTRONICS ENGINEERING

Course Structure (Applicable to 2011-12 admission onwards)

| | | THIRD SEMESTER | | | | | | FOURTH SEMESTER | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Yr | Subject Code | Subjects Name | L | T | P | C | Subject Code | Subject Name | L | T | P | C |
| II | MAT 203 | Engineering Mathematics III | 3 | 1 | 0 | 4 | MAT 214 | Engineering Mathematics IV | 3 | 1 | 0 | 4 |
| | ELE 201 | Electrical Circuit Analysis | 3 | 1 | 0 | 4 | ELE 202 | Signals & Systems | 3 | 1 | 0 | 4 |
| | ELE 203 | Digital Electronic Circuits | 3 | 1 | 0 | 4 | ELE 204 | Electrical Machinery - II | 3 | 1 | 0 | 4 |
| | ELE 205 | Electrical Machinery - I | 3 | 1 | 0 | 4 | ELE 206 | Digital System Design & Computer Architecture | 3 | 1 | 0 | 4 |
| | ELE 207 | Electromagnetic Theory | 3 | 1 | 0 | 4 | ELE 208 | Analog Systems Design | 3 | 1 | 0 | 4 |
| | ELE 209 | Analog Electronic Circuits | 3 | 1 | 0 | 4 | *** *** | Open Elective I | 3 | 0 | 0 | 3 |
| | ELE 211 | Electrical Circuits Lab | 0 | 0 | 3 | 1 | ELE 210 | Electrical Machinery Lab. - I | 0 | 0 | 3 | 1 |
| | ELE 213 | Integrated Electronics Lab - I | 0 | 0 | 3 | 1 | ELE 212 | Integrated Electronics Lab - II | 0 | 0 | 3 | 1 |
| | | TOTAL | 18 | 6 | 6 | 26 | | TOTAL | 18 | 6 | 6 | 25 |
| | | FIFTH SEMESTER | | | | | | SIXTH SEMESTER | | | | |
| III | ELE 301 | Linear Control Theory | 3 | 1 | 0 | 4 | HSS 302 | Essentials of Management & Engineering Economics | 3 | 1 | 0 | 4 |
| | ELE 303 | Digital Signal Processing | 3 | 1 | 0 | 4 | ELE 302 | Modern Control Theory | 3 | 1 | 0 | 4 |
| | ELE 305 | Communication Systems | 3 | 1 | 0 | 4 | ELE 304 | Power Electronics | 3 | 1 | 0 | 4 |
| | ELE 307 | Generation, Transmission & Distribution | 3 | 1 | 0 | 4 | ELE 306 | Measurements & Instrumentation | 3 | 1 | 0 | 4 |
| | ELE 309 | Power System Analysis | 3 | 1 | 0 | 4 | ELE *** | Program Elective-I | 3 | 1 | 0 | 4 |
| | ELE 311 | Microcontroller based System Design | 3 | 1 | 0 | 4 | *** *** | Open Elective II | 3 | 0 | 0 | 3 |
| | ELE 313 | Electrical Machinery Lab - II | 0 | 0 | 3 | 1 | ELE 308 | Measurements & Instrumentation Lab | 0 | 0 | 3 | 1 |
| | ELE 315 | Microcontroller & Embedded Systems Lab | 0 | 0 | 3 | 1 | ELE 310 | Systems Simulation Lab | 0 | 0 | 3 | 1 |
| | | TOTAL | 18 | 6 | 6 | 26 | | TOTAL | 17 | 5 | 6 | 25 |
| | | SEVENTH SEMESTER | | | | | | EIGHTH SEMESTER | | | | |
| IY | ELE 401 | Switchgears & Protection | 3 | 1 | 0 | 4 | ELE 402 | Industrial Training/ Tour | 0 | 0 | 0 | 1 |
| | ELE 403 | Solid State Drives | 3 | 1 | 0 | 4 | ELE 499 | Project Work/ Practice School | 0 | 0 | 0 | 20 |
| | ELE 405 | Illumination Technology | 3 | 1 | 0 | 4 | | | | | | |
| | ELE *** | Program Elective-II | 3 | 1 | 0 | 4 | | | | | | |
| | ELE *** | Program Elective-III | 3 | 1 | 0 | 4 | | | | | | |
| | ELE *** | Program Elective-IV | 3 | 1 | 0 | 4 | | | | | | |
| | ELE 407 | Power Electronics & Drives Lab | 0 | 0 | 3 | 1 | | | | | | |
| | ELE 409 | Advanced Energy Systems Lab | 0 | 0 | 3 | 1 | | | | | | |
| | ELE 411 | Seminar | 0 | 0 | 3 | 1 | | | | | | |
| | | TOTAL | 18 | 6 | 9 | 27 | | TOTAL | 0 | 0 | 0 | 21 |

Program Electives

| | |
|---|---|
| ELE 320 | Computational Techniques in PSA |
| ELE 322 | Renewable Energy |
| ELE 324 | Applications of DSP |
| ELE 326 | VLSI Design -I |
| ELE 328 | Soft Computing |
| ELE 330 | Embedded Systems |
| ELE 421 | Power System Operation & Control |
| ELE 423 | Energy Auditing & Management |
| ELE 425 | Building Automation Systems |
| ELE 427 | VLSI Design -II |
| ELE 429 | Data Structures & Algorithms |
| ELE 431 | Advanced Control Systems |
| ELE 433 | HVDC & FACTS |
| ELE 435 | Utilization of Electric Energy |
| ELE 437 | Industrial Automation & Control |
| ELE 439 | Integrated Lighting Design |
| ELE 441 | Data Base Management Systems |
| ELE 443 | High Voltage Engineering |
| ELE 445 | Power Quality Issues |
| ELE 447 | Distributed Energy Resources |
| ELE 449 | Special Electrical Machines |
| ELE 451 | Solid State Lighting and Controls |
| ELE 453 | Computer Networks |
| ELE 455 | Modern Power Converters |

Open Elective

| | |
|---|---|
| ELE 340 | Energy Conversion Technologies |
| ELE 342 | Renewable Energy Sources |
| ELE 344 | Analog & Digital Circuits |
| ELE 346 | Electrical Energy Systems |
| ELE 348 | Electric Drives |
| ELE 350 | Industrial Automation & Control |
| ELE 352 | Energy Auditing & Management |
| ELE 354 | Microprocessors & Microcontrollers |

# COURSE CONTENTS

## THIRD SEMESTER

### MAT 203 ENGINEERING MATHEMATICS III [4 0 0 4]

*(Common for Electrical stream - BM / E&C/ E&E/ ICE)*

Complex Variables: C-R equations, conformal mappings, bilinear transformation. Taylor's and Laurent Series, Residues, Fourier Series, PDE, derivation and solution of wave equation and heat equations. Numerical Methods; Interpolation and extrapolation; Vector Calculus, Gradient, divergence and curl, Line, surface and volume integrals, Related theorems

**References:**


1. E. Kreyszig, Advanced Engineering Mathematics, Wiley Eastern
2. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers
3. S.S. Sastry, Introductory Methods of Numerical Analysis, PHI


### ELE 201 ELECTRICAL CIRCUIT ANALYSIS [3 1 0 4]

Network theorems: Superposition, Reciprocity, Thevenin's, Norton's, Substitution, Compensation, Maximum power transfer, and Millman's theorems; Locus diagrams: Impedance, admittance and current locii of series and parallel circuits; Signals and waveforms: Classification of Signals, elementary signals, characteristics, representation of waveforms; Transients in RL, RC, RLC circuits, Initial and final conditions, time domain specification, State variable representation of circuits; Laplace transforms – definition, properties, initial and final value theorems, inverse, Laplace transform of standard signals, periodic waveforms, transform circuits, analysis of networks by Laplace transform method, network functions, poles and zeros, convolution integral; Two-port network: Two-port parameters, z-, y-, T- and h-parameters, relationship between parameters, inter-connection of two-port networks, ladder networks.

**References:**


1. Hayt W.H. & J.E. Kemmerly, Engineering Circuit Analysis (6e), TMH 2002.
2. Kuo, F.F., Network Analysis and Synthesis (2e), Wiley, 1999
3. Van Valkenberg, Network Analysis (3e), PHI, 1990


### ELE 203 DIGITAL ELECTRONIC CIRCUITS [3 1 0 4]

Number Systems and Codes: Binary arithmetic, Logic gates and Boolean algebra, De Morgan's theorem, Combinational logic circuits: representation and simplification of logic expressions - Karnaugh map, variable entered mapp; Quine-McCluskey algorithm, realization using logic gates; Combinational circuit design using Multiplexers; demultiplexers; encoders; decoders; Arithmetic circuits, ALU; Sequential logic circuits: Memory cell, Latches & Flip fops, excitation tables, Ripple counters; Shift registers; Finite state machines, Classification of FSM, analysis and design of FSM; linked state machines; Logic families and their characteristics.

**References:**

1. Wakerly, Digital Design Principles & Practices (3e), Pearson 2002
2. Givone, Digital Principles & Design, TMH 2003
3. Fletcher, Engg Approach to Digital Design, TMH 1993

**ELE 205 ELECTRICAL MACHINERY – I [3 1 0 4]**

Transformers: types, principle, equivalent circuit, O.C and S.C. tests, losses, efficiency and regulation, All-day efficiency, polarity test, Sumpner's test, Cooling, Inrush current phenomenon. Parallel operation, tap changers, Auto-transformers; Connection of single phase transformers for three phase operation, Scott connection, Open delta, three-phase to six phase conversion, Harmonics, Three winding transformer.

Three phase induction motors: types, principle, equivalent circuit, windings design, no-load test, blocked rotor tests, circle diagram, cogging and crawling, induction generator, starting; deep bar and double cage motors. Speed control methods – voltage, frequency, rotor resistance, slip power recovery schemes, doubly fed machines.

D.C. Generators: Construction, principle of operation, emf equation, types, winding design, armature reaction, commutation, characteristics; D.C. Motors: Principle of operation, types, torque equation, characteristics speed control, starters, testing.

**References:**

1. Say M.G., Alternating Current Machines (5e), ELBS, 1994.
2. Langsdorf E.H., Theory of Alternating Current Machine (2e), TMH, 1994.
3. Clayton and Hancock, Performance and Design of DC Machines(3e), O& IBH, 1978

**ELE 207 ELECTROMAGNETIC THEORY [3 1 0 4]**

Electrostatics: Coulomb's law – Gauss law and applications, Divergence theorem, Electric scalar potential: Potential gradient, boundary conditions for dielectric materials, capacitance of parallel plate capacitor, co-axial cable, two wire line, Energy density in an electric field, Laplace's and Poisson's equations - Magnetostatics: Biot-Savart's Law and applications – Ampere's circuital law and applications, Curl – Stoke's theorem - magnetic flux and flux density. Magnetic boundary conditions – Inductance – Inductance of toroid, solenoid, two wire line, coaxial cable. Faraday's law: transformer emf, motional emf., Concept of displacement current – Electromagnetic waves: Maxwell's equations in integral and point form, uniform plane wave, wave motion in free space and in conductors, concept of skin depth – Poynting's Theorem and wave power, Reflection of uniform plane waves at normal incidence angle and at oblique incidence angle- Standing wave ratio.

**References:**

1. Hayt W, Engineering Electromagnetics (7e), TMH, 2006
2. Kraus J. D., Electromagnetics (4e), MGH, 1992
3. Gangadhar K.A., & M. Ramanathan, Field Theory (5e), Khanna, 1982.

**ELE 209 ANALOG ELECTRONIC CIRCUITS [3 1 0 4]**

Review of Semiconductor Theory – BJT Circuits- CB, CC, CE configurations, transistor as an amplifier/ switch, Biasing, stability of Quiescent point, Transistor at low frequencies: h-parameters, Analysis of a transistor amplifier using h parameters, Emitter follower, Darlington configuration, Analysis of CE, CB, CC cascade configuration using simplified hybrid model, current sources, current mirrors, Cascode connection - MOSFET – MOSFET as a Resistor, Capacitor and active Load, CMOS, biasing, small signal model. Current sources, current mirrors – Frequency response of Amplifiers – bandwidth, gain, stray & miller capacitances – Rectifier and Power supplies - Voltage regulation, capacitor filter, R-C filter, Series voltage regulator, Series regulator, shunt voltage regulator, design of linear series voltage regulators - Power amplifiers - Classification, Analysis and design with respect to efficiency - Series fed and transformer coupled amplifier, thermal run-away, complementary and quasi complementary push-pull amplifier.

**References:**

1. A.S.Sedra & K.C.Smith, Microelectronics Circuits, 4th Edition, Oxford Univ.Press, 1999.
2. Millman and Halkias, Integrated Electronics: Analog and Digital Circuits and Systems, TMH, 1992.
3. P.Boylestead and Nashalskey, Electronic Devices and Circuit Theory, 6th Edition, PHI, 1998.

**ELE 211 ELECTRICAL CIRCUITS LABORATORY [0 0 3 1]**

Module I: Electric circuit simulation using MATLAB – script files, data visualization, functions, file I/O and GUI, Introduction to SIMULINK: Steady state analysis of circuits – Transient analysis of RL, RC, and RLC circuits using ODE solver - , Circuit simulation using Simscape.

Module II: Electric circuit simulation using PSPICE – Steady state & transient analysis of DC & AC circuits.

Module III: Measurement and experimental verification of network theorems – Measurement of power, power factor and pf correction – Three phase power measurement – Measurement of self and mutual inductance.

**References:**

1. Hanselman, Mastering MATLAB 7, Pearson Education 2005.
2. Rashid M. H, SPICE for circuits and Electronics using PSPICE, PHI 1995

**ELE 213 INTEGRATED ELECTRONICS LABORATORY – I [0 0 3 1]**

Module I: Design, Simulate and Test basic analog electronic circuits using diodes such as clipping/clamping/ rectifier without and with capacitor filter - Fixed and variable voltage power supplies, Zener diodes, voltage regulators using 78XX, 79XX, LM317 – Biasing and Stability Studies of circuits – Frequency response of Amplifier Circuits.

Module II: Design and Testing of combinational circuits using gates, multiplexers, decoders, arithmetic circuits etc. – Design

and Testing of sequential digital electronic circuits such as counters, shift registers & sequence generators, sequence detectors etc.

**References:**


1. Millman and Halkias, Integrated Electronics: Analog and Digital Circuits and Systems, TMH, 1992
2. David Bell, Electronic Devices and Circuits, 5e, Oxford University Press
3. John Wakerly, Digital Design: Principles and Practices, 4/e, Prentice Hall, Inc, 2005


## FOURTH SEMESTER

### MAT 214 ENGINEERING MATHEMATICS IV [4 0 0 4]

*(Electrical & Electronics /Instrumentation & Control)*

Measure of central tendency; Probability, distributions, Finite difference, solutions of Laplace and Poisson equations by standard five points formula, heat and wave equations. Fourier transform, parseval's theorem. Difference equations, z transforms, Solutions of system of linear equations. Evaluations of largest Eigen value by power method.

**References:**


1. P.L. Meyer, Introduction to probability and Statistical Applications, IBH
2. S.S. Sastry, Introductory methods of Numerical analysis, PHI
3. Erwin Kreyszig, Advanced Engineering Mathematics, Wiley Eastern


### ELE 202 SIGNALS AND SYSTEMS [3 1 0 4]

Time domain analysis of continuous-time and discrete-time signals & systems – linear-time invariant systems, impulse response, convolution, correlation, causality and stability, representation of LTI systems, Frequency domain analysis of continuous time signals and systems - Fourier series, Fourier transform, applications, Frequency domain analysis of discrete-time signals and systems: Discrete-time Fourier series, Discrete-time Fourier transform, sampling in time domain, reconstruction, discrete-time processing of continuous-time signals, Relation between frequency domain representation in continuous and discrete-domain, Sampling in frequency domain, Discrete Fourier transform - Transform domain analysis of systems – Laplace and Z transform, representation of systems – signal flow graph, modeling on of a z-domain transfer function; relation between s-plane and z-plane.

**References:**


1. Haykin S., Signals and Systems, Wiley, 1999.
2. Oppenheim, Willisky, and Nawab, Signals and Systems (2e), PHI, 1997.
3. Ziemer R.E., Tranter W.H. & Fannin D.R., Signals and Systems (4e), Pearson, 2002.


### ELE 204 ELECTRICAL MACHINERY – II [3 1 0 4]

Synchronous machines: Constructional features, e.m.f. equation, suppression of harmonics, Armature reaction: Effect of power factor on armature reaction - Non-salient pole alternator: Synchronous impedance, O.C. and S.C. characteristics – Power input & power output, voltage regulation.

Synchronisation: Parallel operation of two alternators, Governor characteristics, alternator connected to infinite bus, Salient pole alternator: Two reaction theory, Blondel's diagram, Phasor diagram, voltage regulation, slip test power angle characteristics.

Synchronous motors: Principle of operation, power input and power developed, performance characteristics, O-curve and V-curve, inverted V curve, synchronous condenser, methods of starting - Synchronizing power: Synchronizing power and torque, hunting, periodicity of hunting, damping - Design of electrical machines: Design of main dimensions of transformer & rotating machines – Design of field pole of dc machine & alternator.

**References:**


1. Say M.G., Alternating Current Machinery, (5e), ELBS, 1994.
2. Langsdorf, E.H., Theory of Alternating Current Machine (2e), TMH, 1994.
3. A.K.Sawhney, Design of electrical machines


### ELE 206 DIGITAL SYSTEM DESIGN & COMPUTER ARCHITECTURE [3 1 0 4]

Digital implementation options; Comparison based on performance & cost, Design flow – Digital system Modeling: Domains – behavioural, structural, physical, levels of abstraction, high level, RTL level and logic synthesis, HDL – VHDL: Entity and architectures, behavioural, data-flow and structural Modeling, sequential and concurrent constructs, VHDL styles for synthesis, Design case studies; Architecture of Programmable ASICs; Reconfigurable computing.

Introduction to Computer Architecture; Instruction Set Architecture, Components of a CPU, Instruction formats, Opcode encoding techniques, Instruction Types and Addressing modes, Reduced Instruction Set Computers. Pipelining, I/O interfacing, Interrupts; Memory Organisation: Memory cells, Memory hierarchy, Datapath design: General Register design, Arithmetic units, Control path design: Hardwired and Micro-programmed.

**References:**


1. C.H. Roth, Digital system design using VHDL,PWS,1998
2. David Harris and Sarah Harris, Digital Design and Computer Architecture, Elsevier/Morgan Kaufman, 2008
3. M. Raffiquzzman & Rajan Chandra, Modern Computer Architecture, Galgotia Publications, 1990.
4. David Patterson and John Hennessy, Computer Organization and Design, Elsevier, 2007.


### ELE 208 ANALOG SYSTEM DESIGN [3 1 0 4]

Feedback amplifiers using BJT and FET – Operational Amplifier architecture – transfer characteristics of op.amp, offset voltage and current, slew rate limitations, inverting amplifier, non inverting amplifier, summing amplifier, voltage follower, integrator, differentiator, voltage to current converter, current to voltage converter, difference amplifier, instrumentation amplifier

Active filters: Universal Active filter, Biquad configuration for LPF, HPF, BPF, BRF, design of first and higher order low pass, high pass, band pass and band elimination and all pass active filters, Voltage controlled filter, Self tuning filters, Switched capacitor filters

Non-linear applications of operational amplifier: Precision half wave and full wave rectifiers, peak detector, sample and hold circuit, log and antilog amplifiers, analog multipliers, comparators, Schmitt trigger, square wave, triangular wave generators and pulse generator, astable and multivibrator using 555 timer, voltage controlled oscillator, phase-locked loops and applications

**References:**


1. Stanley William D., Operational Amplifiers with Linear Integrated Circuits, Prentice Hall, 2004,
2. Milman Jacob (1979), Microelectronics, McGraw Hill.
3. Franco Sergio, Design with Op amps & Analog Integrated Circuits, McGraw Hill , 1997


### ELE 210 ELECTRICAL MACHINERY LABORATORY – I [0 0 3 1]

OC and SC tests on single phase transformer -Sumpner's test – Polarity tests and connection of single phase transformers as three phase bank – Parallel operation of two single phase transformers – Scott connection of transformers – Open delta connection – Study of harmonics in - transformers, tertiary winding – Study of starters for three phase induction motor & DC Motor – No load & blocked rotor tests on three phase IM – Load test on three phase squirrel cage IM – Study of torque-slip characteristics by varying rotor resistance – Load test on induction generator – Magnetization characteristics of DC M/c.

### ELE 212 INTEGRATED ELECTRONICS LABORATORY–II [0 0 3 1]

Module I: Design, Simulation and Testing of operational amplifier based circuits.

Module II: Digital circuit design using VHDL - Functional simulation/timing simulation and synthesis of the combinational and sequential circuits using VHDL simulator and testing on FPGA demo boards – Combinational circuit design - Sequential circuit design - implementation of state machines for applications like traffic light control, vending machine etc.

**References:**


1. A.S.Sedra & K.C.Smith, Microelectronics Circuits, 4th Edition, Oxford Univ.Press, 1999.
2. John Wakerly, Digital Design: Principles and Practices, 4/e, Prentice Hall, Inc, 2005
3. Roth C H, Digital Systems Design Using VHDL, PWS Publishing Co, U.S. 1998


## FIFTH SEMESTER

### ELE 301 LINEAR CONTROL THEORY [3 1 0 4]

Mathematical models of electrical, mechanical and electro-mechanical systems, block diagram - signal flow graphs, Mason's gain formula - Time Response - transient response specifications of second order systems - system response with additional pole &zero, - Steady state error - non- unity feedback systems, sensitivity – Stability :Routh- Hurwitz criterion - frequency domain specifications, - Root locus plot - transient response design by gain adjustment - Frequency Response plots: Polar plots, Nyquist stability criterion - stability analysis - Bode plots - Controller design: Proportional, Derivative and Integral controllers, PI, PD & PID controller - State Model: electrical, mechanical and electromechanical systems, physical variable form and phase variable form.

**References:**


1. Ogata K, Modern Control Engineering (4th Ed.), Englewood Cliffs, NJ: Prentice Hall, 2001.
2. Norman S. Nise, Control Systems Engineering (3rd Ed), John Wiley & Sons, Inc, 2000.
3. K.R. Varmah, Control Systems, TMH, 2010.


### ELE 303 DIGITAL SIGNAL PROCESSING [3 1 0 4]

Review of time-domain and frequency domain properties of discrete-time signals and systems, Discrete Fourier series, Discrete-time Fourier transform, Sampling in time and frequency domain - Discrete Fourier Transform, Properties of DFT, Linear convolution using DFT; Fast Fourier Transform algorithms.Digital Filters: FIR and IIR filters, characteristics , Digital filter structures, FIR filter design: Window method, Frequency sampling method, Optimal FIR design; IIR filter design: Impulse invariant and bilinear transformation methods, Classical filter design using Butterworth and Chebyshev approximations, Frequency transformation technique for HP, BP and BS filter design, Direct design of IIR filters; Real time implementation of DSP algorithms.

**References:**


1. Proakis J.G. and D.G. Manolakis, Introduction to Digital Signal Processing, PHI, 2007
2. Oppenheim A.V. and R.W. Schafer, Discrete time signal processing, Pearson, 2001.
3. Mitra S. K., DSP: A computer based approach (2e), TMH, 2006
4. Johnson J.R., Introduction to Digital Signal Processing, PHI, 1999.

**ELE 305 COMMUNICATION SYSTEMS [3 1 0 4]**

Elements of an Electrical Communication System, Communication Networks - Analog Communication Systems - Principles of Amplitude modulation, double and single side band, suppressed carrier system, AM circuits, AM Transmitters and Receivers, Angle modulation, Frequency modulation, FM receivers, Digital Communication: Sampling theorem, pulse modulation techniques - PAM, PWM and PPM concepts, PCM encoder and decoder, Multiplexing – TDM ,FDM - Data communication techniques: Data transmission using analog carriers, MODEMS employing FSK, PSK, DPSK, QPSK, and QAM, error control coding techniques - Multiple Access Techniques, Microwave links, Satellite communication systems, Optical communication systems, Digital Telephony, Wireless Communication, Mobile Telephony, GSM and CDMA standards

**References:**


1. Tomasi W., Electronics Communications systems, Pearson, 2001
2. Haykin S., Analog and Digital Communications, Wiley, 1989
3. Wireless communications – Principles & Practice, Theodone S. Rappaport


**ELE 307 GENERATION, TRANSMISSION AND DISTRIBUTION [3 1 0 4]**

Generation of Electric Power : Hydro Electric Power Plants, Thermal and Nuclear Power Plants- Diesel Power Plant - Typical AC transmission and distribution scheme, Effect of system voltage and regulation, Distribution network elements - Transmission Line Parameter Calculations- Transmission Line Performance, Ferranti effect, receiving end power circle diagram, regulated system of transmission by reactive power control, power factor improvement - Mechanical characteristics of Overhead lines - Line Insulators - Corona - Underground cables.

**References:**


1. Gupta J.B., A Course in Electrical Power, S.K. Kataria & Sons, 1996.
2. Wadhwa C.L., Electrical Power System (3e), New Age Intl., 2000
3. S.N.Singh,,'Electric Power Generation ,Transmission and Distribution', PHI,


**ELE 309 POWER SYSTEM ANALYSIS [3 1 0 4]**

Representation of power systems: One line diagram, impedance diagram, per unit notations, selection and change of base quantities, Thevenin's model, equivalent circuit of three-winding transformers - Symmetrical three-phase faults: Short circuit current and reactances of synchronous machines, short-circuit current calculations of unloaded and loaded generators and power systems, selection of circuit breakers, current limiting reactors - Asymmetrical faults: Symmetrical components, Sequence components of line and phase voltages and currents of star-delta transformer banks, sequence impedances and sequence networks of power systems, analysis of unsymmetrical faults in generators and power systems under no-load and loaded conditions, faults through impedances - Stability studies: Steady-state and transient-state stability, swing equation, critical clearing time,. Multi machine stability - Admittance & impedance model for power systems & network calculations Load flow studies- Load flow solution techniques using Gauss-Siedel method, Newton-Raphson's method.

**References:**


1. John .J..Grainger stevenson W.D., Elements of Power System Analysis (4e),TMH, 2003
2. Nagrath I.J. & D.P.Kothari, Modern Power System Analysis (2e), TMH, 1988.
3. Hadi Saadat, Power System Analysis, MGH, 1999.


**ELE 311 MICROCONTROLLER BASED SYSTEM DESIGN [3 1 0 4]**

Introduction to microprocessors and microcontrollers, comparison, embedded system and general purpose systems - The 8051 architecture, signal descriptions - Assembly language programming, 8051 instruction set, addressing modes. Programming using 8051 instruction set - Timer/ Counter: Programming 8051 timers, counter programming. Serial communication: Basics of serial communication, programming the 8051 serial port. Interrupts: 8051 interrupts, programming 8051 interrupts, interrupt priority -.System design using 8051: Interfacing keyboards, LCD display, ADC and DAC to 8051 - Interfacing a stepper motor to 8051. Interfacing external memory to 8051 - Programmable peripheral interface: Programming the 8255, Interfacing 8255 to 8051 - Development tools: Simulators, debuggers, cross compilers, in circuit emulators for microcontrollers - Contemporary micro-controller architecture: PIC micro-controllers, Motorola family – MC68HC11, ARM processors, TI family – MSP430.

**References:**


1. Muhammad Ali Mazidi and Gillispie Mazidi, The 8051 Microcontroller and embedded system using assembly and C, Pearson education, 2009.
2. Kenneth. J. Ayala, 8051 Microcontroller and embedded systems using assembly and C, Cengage Learning, 2009.
3. Predko, Programming and customizing the 8051 Microcontroller, TMH.


**ELE 313 ELECTRICAL MACHINERY LAB-II [0 0 3 1]**

Load test on dc shunt and compound generators - Speed control of D.C. shunt motor by (I) Armature voltage control (ii) Flux control.

Load test on dc shunt, series and compound motors - Tests on DC Machines: Swinburne's test, Hopkinson's test, Field's test and Retardation test - V- and inverted V-curves of a three-phase alternator - V- and inverted V-curves of a synchronous motor - Measurement of Xd and Xq of a salient pole synchronous machine - Predetermination of regulation of alternator by EMF, MMF, and ZPF methods - Load test on Single Phase induction Motor.

**ELE 315 MICROCONTROLLER & EMBEDDED SYSTEMS LABORATORY [0 0 3 1]**

Introduction to 8051 simulation software and familiarization of 8051 Microcontroller Kit - Data Transfer, Arithmetic and logic operation programs - Array handling - Code conversion programs - Bit manipulation and programming using I/O ports - Timer/Counter programming - Monitor routines for keyboard and display - Programming 8051 trainer kit in serial mode and interrupt programs - Interfacing peripherals – 8255, ADC, DAC & Waveform generation - Interfacing a Stepper motor interface & Elevator interface - Interfacing logic controller & traffic light with 8051.

**References:**


1. Mazidi M. A. & J. G. Mazidi, (2002), The 8051 Microcontroller and embedded systems, Pearson.
2. Kenneth J Ayala, (2002), The 8051 Microcontroller architecture programming and applications, 2nd Edition, Penram International Publishers


## SIXTH SEMESTER

**HSS 302 ESSENTIALS OF MANAGEMENT & ENGINEERING ECONOMICS [3 1 0 4]**

Management - Definition of Management, Nature and scope of management, Functions of managers, Corporate social responsibility, Theories of Planning, Organizing, Staffing, Leading and Controlling.

Engineering Economics - Introduction to Micro and Macro Engineering Economics, Value, Utility, Consumer & Producer goods, Factors of Production, Law of demand and supply, Elasticity of demand & supply, Equilibrium of demand and supply. Time value of Money, Economic Evaluation of Alternatives, Replacement analysis and Depreciation

**References:**


1. Koontz D. (Latest Edition), "Essentials of Management" Mc Graw Hill, New York.
2. Peter Drucker (Latest Edition) " Management, Task and Responsibility" Allied Publishers.
3. Peter Drucker (2003) "The practice of management", Butterworth Hein Mann.
4. Tuesen G. J. & Tuesen H. G. (Latest Edition) "Engineering Economy" Prentice Hall of India, New Delhi.
5. De Garmo L. Paul (Latest Edition ) "Engineering Economy" Macmillan, New York.
6. Blank L. T. & Tarquin A. J. (Latest Edition) "Engineering Economy" Mc Graw Hill, New York.
7. James L. Riggs, David D. Bedworth, Sabah U. Randhawa (Latest Edition) "Engineering Economics" Tata McGraw – Hill Publishing Company Ltd, New Delhi.


**ELE 302 MODERN CONTROL THEORY [3 1 0 4]**

Introduction to continuous time and discrete time signals, sampling - transfer function of ZOH - Pulse transfer function - Mapping between s-plane and z-plane - Stability criterion in the z-plane, bi-linear transformation, Jury test, stability analysis using root locus and Nyquist plot, - State models for continuous-time and discrete-time systems - Solution of state equation for continuous-time systems by time domain &, s-domain solutions - state transition matrix - Solution of state equation for discrete-time systems by time domain and z-transform method, discrete-time equivalent of continuous-time systems - Controllability and Observability - Design of continuous time and discrete time systems - Phase lead and phase lag compensation by root locus and by frequency-response methods, pole placement design, Ackermann's formula, design of state observers - Lyapunov stability for continuous-time and discrete-time systems.

**References:**


1. Ogata, K., Discrete-Time Control Systems(2e), Pearson, 2001.
2. M. Gopal, Digital Control and State Variable Methods, Tata McGraw Hill New Delhi, 2005.
3. C.H. Houpis and G.B. Lamont, Digital Control Systems, McGraw Hill, 1992.


**ELE 304 POWER ELECTRONICS [3 1 0 4]**

Power Semiconductor devices: SCR, Triac, GTO, BJT, Power MOSFET, IGBT – characteristics, safe operating area, device rating, base/gate drive requirements, Converter Topologies: Controlled Rectifiers: Single phase converters - half wave, half controlled and fully controlled bridge converters, Three-phase Converters- half controlled & fully controlled bridge, triggering sequence, operation, effect of source inductance, Line commutated inverters, Dual converters, AC to AC converters: Cycloconverters and AC voltage regulators , DC – DC Converters: Step down and step up operation, Classification of choppers, DC – AC Converters: Single phase and three phase bridge inverters, Square wave operation, PWM Inverters- PWM techniques, harmonics in output voltage , Multi level inverters, Space vector modulation, Resonant converters: Principle of soft switching- concept of zero current switching and zero voltage switching.

**References:**


1. Hart D. W., Introduction to Power Electronics, PH, 1997.
2. Ned Mohan et. al., Power Electronics, Converters, Applications & Design (2e), Wiley.
3. Rashid M.H., Power Electronics, Circuits, Devices and Applications, PHI, 1994.


**ELE 306 MEASUREMENTS AND INSTRUMENTATION [3 1 0 4]**

Basic concepts of measurements - System configuration, calibration - Errors in measurements: Measuring instruments: Permanent magnet moving coil; Moving iron; and Electrodynamometer type Applications - Measurement of Resistance, Inductance & Capacitance: A.C. Bridges-

Instrument Transformers: CT and PT -Transducers: Electrical transducers: Analog signal conditioning: Instrumentation amplifiers, v/f and i/f converters, sample and hold circuits, noise cancellation filters - Data conversion: DAC –ADC –- Signal transmission: Digital data transmission, Protocols – wired & wireless. Examples - I/O devices and displays.- Oscilloscopes: Measurements using CRO - Virtual Instrumentation: Applications: Digital Energy Meter, ECG monitoring system.

**References:**


1. Sawhney A.K., A course in Electrical and Electronic Measurements and Instrumentation (4e), Dhanpat Rai & Sons, 1991.
2. Golding E.W. & Widdis F.C., Electrical Measurements and Measuring Instruments (5e), Wheeler, 1989.
3. Rangan, Sarma, & Mani, Instrumentation Devices and Systems (2e), TMH, 1998.


### ELE 308 MEASUREMENTS AND INSTRUMENTATION LAB [0 0 3 1]

Design & implementation of measurement systems on microcontroller platform - Sensing power signals - Sensing ECG signal - Realisation of instruments such as volt meter, ammeter, wattmeter .

Design & Realisation of common analog signal conditioning blocks using Analog System Design starter kit - ASLKv2010 - Study of ADC & DAC - Real time data acquisition, measurement & monitoring on Virtual instrumentation platform.

**References:**


1. Rangan, Sarma, & Mani, Instrumentation Devices and Systems (2e), TMH, 1998
2. K R K Rao , C P Ravikumar, Analog System Lab Manual, Texas Instruments,Wiley India
3. Jovitha Jerome, Virtual Instrumentation using LabVIEW, PHI,2010


### ELE 310 SYSTEM SIMULATION LABORATORY [0 0 3 1]

Mathematical models & time domain analysis of continuous and discrete-time systems - Stability Analysis of continuous time and discrete time systems - Controller design in s-domain and z-domain - design of state feedback controllers and observers using pole placement technique.

Digital Filter: Design: Design of FIR filters - Design of IIR filters

Modeling with SIMULINK - Analysis of simple systems using SIMULINK, armature voltage control of DC motors - Familiarization of graphical design tools

**References:**


1. Hanselman, Mastering MATLAB 7, Pearson Education 2005.
2. Norman S. Nise, Control Systems Engineering (3e), John Wiley & Sons (Asia) Pte Ltd, 2000.
3. Mitra S. K., DSP: A computer based approach (3e), TMH, 2006.


## SEVENTH SEMESTER

### ELE 401 SWITCHGEARS AND PROTECTION [3 1 0 4]

Circuit breakers - Bulk oil circuit breakers - arc controlled devices, MOCB, ACB, ABCB, SF6 CB, Vacuum CB, MCB, MCCB and DC circuit breakers - Fuses and switches, isolators and earthing switches, selection of fuses, - switchgears - Neutral grounding - Protective Relaying - Functions, characteristics, standard definition of relay terminologies, classifications & operating principles - differential protection schemes for bus bars, transformer, , frame leakage protection for bus bars and transformers, Buchholtz relay for transformer protection - Alternator protection - Line protection - Induction Motor Protection - Static Relays - Computer based protection: Microprocessor based relays, Types, Applications, Advantages, Introduction to SCADA, SCADA interfacing and metering, Introduction to network relays, Adaptive Protection.

**References:**


1. Rao S.S., Switchgear and Protection (11e), Khanna, 1999.
2. Badriram and Vishwakarma, Power System Protection & Switchgear, TMH, 2001
3. Ravindra P. Singh, Digital Power System Protection, PHI, 2007.


### ELE 403 SOLID STATE DRIVES [3 1 0 4]

Electric drives - Components, dynamics, multi-quadrant operation, equivalent moment of inertia, equivalent torque, Components, nature and classification of load torque, Steady state stability, Load equalization, Electric Traction, DC Drives-Single-phase converter fed, Three-phase converter fed, Dual converter fed and Chopper fed DC drives, AC Drives-Induction motor drives, Stator voltage control, static rotor resistance control, Slip power recovery scheme, Frequency control - Constant torque, constant power operation, Field-oriented control, Direct torque & flux control, Synchronous motor drives-Permanent magnet synchronous machine control, Synchronous reluctance machine control, current vector control, Wound field synchronous machine drives, brushless DC excitation, Load commutated inverter drives, Switched reluctance motor drives, Power conditioners and un-interruptible power supplies.

**References:**


1. Dubey G.K., Power Semiconductor Controlled Drives, PH, 1989.
2. Dewan S.B., G.R.Slemon & A.Straughen, Power Semiconductor Drives. Wiley, 1984
3. Murphy J.M.D.& F.G.Turnbull, Power Electronic Control of AC motors, Pergamon 1989.


### ELE 405 ILLUMINATION TECHNOLOGY [3 1 0 4]

Light & Vision : Photopic, Scotopic & Mesopic Visions - Visual functions-Fundamental photometric quantities and units - Spectral eye sensitivity curve - Radiometric quantities & units - Point by point method of illuminance calculations - Artificial light sources : color characteristics - Luminescence - gaseous

discharge - Construction - principle of operation - Luminous efficacy - Lamp life & Colour characteristics - Luminaire : optical characteristics of light control elements - C.I.E. classification - Applications of various light control elements - measurements using GONIO photometer - Evaluation of total luminous flux - Quantity and Quality of Illuminance - Artificial illumination design techniques : Lumen method of calculations - IES glare index computation method - Flood lighting of buildings - Road lighting - Energy conservation measures in illumination systems.

References:


1. IESNA New York, Lighting Handbook (10e), 2011.
2. Jack L. Lindsey., Applied Illumination Engineering (2e), Fairmont Press, INC 1997
3. Durrant D.W, Interior lighting design (5e), Lighting industry federation Ltd., 1977.


### ELE 407 POWER ELECTRONICS AND DRIVES LABORATORY [0 0 3 1]

SCR characteristics - Measurement of latching and holding current - Study of Commutation circuits – Resonant commutation, Complimentary commutation and Auxiliary commutation - AC – DC converters - Speed control of D.C. motor - Speed control of Induction motor - DC – DC Converters using IGBT / MOSFET - Power electronic circuit simulation using PSPICE.

### ELE 409 ADVANCED ENERGY SYSTEMS LABORATORY [0 0 3 1]

Module I: Photometric measurements - Measurement of spectrum & colour characteristics - Performance of SPV panels - Power Quality Analysis - Lighting system with lighting controls and interfacing modules - Practice of Lighting software for design applications.

Module II: Introduction to Power System Simulators - Load flow analysis – transient stability – dynamic stability – short circuit studies for multi machine systems – relay coordination - load frequency control – Relay characteristics.

Module III: Introduction to PLC based Control - Study of P, PI, PD, PID characteristics using Controller trainer kits.

**References:**


1. IS: 10322(PART4) – 1984, IS: 10322(PART5/SEC3) – 1987, IS: 10322(PART5/SEC4) – 1987, IS: 10322(PART4/SEC5) – 1987


### ELE 411 SEMINAR [0 0 3 1]

- Each student has to present a seminar, on any technical topic not covered in the syllabus. The presentation time is a minimum of 30 minutes followed by a 10 minutes session for discussion/ question & answers.
- The seminar topic selected by the student must be approved by the authorized faculty of the department at least two weeks in advance.
- Each student has to submit to the department a seminar report at least three days before the day of seminar.
- Each student has to make the presentation with LCD projector.

## EIGHTH SEMESTER

### ELE 402 INDUSTRIAL TRAINING/ TOUR [0 0 0 1]

- Each student has to undergo industrial training for a minimum period of 4 weeks. This may be taken in a phased manner during the vacation starting from the end of third semester.
- Student has to submit to the department a training/tour report in the prescribed format.. The report should include the certificates issued by the industry.
- Students who opt for industrial visit should visit a minimum of ten industries and submit the report.
- Student has to make the presentation on the industrial training/ visits

### ELE 499 PROJECT WORK / PRACTICE SCHOOL [0 0 0 20]

- The project work may be carried out in the institution/ industry/ research laboratory or any other competent institutions.
- The duration of the project work shall be a minimum of 16 weeks which may be extended up to 24 weeks.
- A mid-semester evaluation of the project work shall be done after about 8 weeks.
- An interim project report on the progress of the work shall be submitted to the department during the mid-semester evaluation.
- The final evaluation and viva-voice will be conducted after submission of the final project report in the prescribed form.
- Student has to make a presentation on the work carried out, before the departmental committee as part of project evaluation.

## PROGRAM ELECTIVE

### ELE 320 COMPUTATIONAL TECHNIQUES IN POWER SYSTEM ANALYSIS [3 1 0 4]

Review of Power System Components, Network Matrices - Bus Impedance matrix - admittance matrix - formation and modification of bus impedance matrix in three phase networks - Short Circuit Studies - symmetrical and asymmetrical faults - ZBUS and YBUS matrices for short circuit studies - short circuit calculations using ZBUS - symmetrical component analysis-calculation of currents and voltages - load Flow Studies: PQ, PV and slack buses - bus mismatch - Gauss-Seidal, Newton-Raphson and Fast Decoupled methods of load flow analysis - Stability Studies - Transient Stability - Swing equation - synchronous machine and induction machine equations - representation of load - modified Euler and Range-Kutta methods of transient stability analysis.

**References:**


1. M. A. Pai, Computer Techniques in Power System Analysis, (2e) Tata McGraw-Hill, New Delhi, 2005.
2. A. K. Mahalanabis, D. P. Kothari and S. I. Ahson, Computer Aided Power System Analysis and Control, Tata McGraw-Hill, New Delhi, 1988.
3. E. V. Krishnamurthy and S. K. Sen, Computer Based Numerical Algorithms, East-West Press, New Delhi., 1976.


### ELE 322 RENEWABLE ENERGY SOURCES [3 1 0 4]

Energy sources and their availability - Solar Energy - solar radiation and measurements, solar energy storage, - Solar Photo-Voltaic systems design - Wind Energy- estimation, Maximum power and power coefficient, wind energy conversion systems - design considerations and applications - Energy from Bio-Mass - Sources of bio-mass, Bio-mass conversion technologies - Thermo-chemical conversion and Bio-chemical conversions, Anaerobic digestion and Fermentation, Bio-gas generation Pyrolysis and Liquefaction, Classification of Gasifiers, Energy plantation -Energy from the Oceans - Ocean Thermal Energy Conversion, Open and Closed Cycle plants, Site selection considerations, Origin of tides, Tidal energy conversion systems, Wave energy conversion systems - Hybrid Energy Systems

**References:**


1. Khan B. H., Non-conventional Energy Resources, TMH, 2006
2. Twidell J. W. & Weir A. D., Renewable Energy Resources, ELBS, 1986.
3. Mukherjee D. & Chakrabarti S., Fundamentals of Renewable Energy Systems, New Age Intl., 2004


### ELE 324 APPLICATIONS OF DSP [3 1 0 4]

Review of Time and frequency domain analysis of systems, Digital Filter Design; Implementation of DSP algorithms – options, Digital signal processors - Architectural features of digital signal processors, Case study of TMS320C24x processor; Applications of DSP in speech and audio processing, Speech recognition, Applications of DSP in image and video processing - Digital image fundamentals, Image transforms, Image enhancement, Image and Video compression standards - Applications of DSP in analysis of biomedical signals - ECG, EEG and EMG signals, Applications of DSP in power electronic systems, electric drives & embedded control.

**References:**


1. Douglas O'Shaghnessy, Speech communication – Human & Machines, (2e), 1999.
2. Gonzalez R. C. & Woods R. E, Digital Image Processing, Pearson, 2002
3. Keith Jack, Video Demystified, 2004


### ELE 326 VLSI DESIGN - I [3 1 0 4]

MOS Devices and circuits - Device operation, input-output characteristics, second order effects - device modeling, spice parameters - Inverter - Transfer characteristics, switching characteristics, delay models, super buffers, Pseudo NMOS inverter - Performance optimization - Fan-In, Fan-out, Power dissipation, layout, area, speed - CMOS fabrication process - VLSI Yield and economics - CAD tools for Layout and functional simulation - MOSFET logic gates - Pass transistors and transmission gates - Implementation of Boolean functions and combinational circuits - Pseudo NMOS inverter - Flip flops, shift registers and clocked sequential circuits, memory (ROM and RAM). Stick diagrams, Design rules and layouts, Scaling of MOS circuits - Analog VLSI Design; Issues, Challenges, Small signal modeling and analysis of MOSFET, single stage amplifiers, Current mirrors, sources and sinks, differential amplifier and single stage opamp.

**References:**


1. J.M. Rabaey, A. Chandrakasan, and B. Nikolic, Digital Integrated Circuits, Pearson, 2003.
2. Kang and Lablebici, CMOS Digital Integrated Circuits, TMH, 2002
3. B Razavi, Design of Analog CMOS Integrated Circuits, McGraw Hill, 2001


### ELE 328 SOFT COMPUTING [3 1 0 4]

Fundamentals of Artificial Neural Networks- Feed forward and feed back networks, learning rules- Single-layer feed forward networks - Multi layer feed forward networks - Linearly non-separable pattern classification, generalized delta learning rule, error back propagation training algorithms - Single layer feed back network - performance analysis of energy function reduction - Application of neural networks.

Introduction to Fuzzy control - Inference rules - Fuzzy knowledge based controllers - Fuzzification, membership function evaluation using neural networks, genetic algorithms, - Application of fuzzy logic to control systems - fuzzy-neural systems.

Familiarization with MATLAB Fuzzy logic & neural network

Toolbox

**References:**


1. Jacek M. Zurada, Introduction to Artificial Neural Networks, Jaico, 1997.
2. Yegnanarayana B., Artificial Neural Networks, PHI, 2001.
3. Timothy J. Ross, Fuzzy logic with engineering applications, MGH, 1997.


### ELE 330 EMBEDDED SYSTEMS [3 1 0 4]

Embedded Processing – Evolution, Issues and challenges - System and Processor Architecture - Von Neumann, Harvard and their variants; Memory Architecture and Devices; Input-Output Devices and Mechanisms; Instruction Set and Addressing Modes; Interfacing of Memory and Peripheral Devices – Functional and Timing Issues - Bus I/O and Networking Considerations; Bus and Wireless Protocols- Embedded Systems Software - Constraints and Performance Targets; Real-time Operating Systems: Introduction; Scheduling in Real-time Operating Systems; Memory and I/O Management: Device Drivers; Embedded Software Development - Flow, Environments and Tools - System Specification and Modeling; Testing of Embedded systems - System Design Example.

**References:**


1. Raj Kamal, Embedded systems, TMH 2003
2. Frank Vahid & Tony Givargis, Embedded system Design, Wiley India, 2002
3. Steve Heath, Embedded system Design (2e), Elsevier, 2003


### ELE 421 POWER SYSTEM OPERATION AND CONTROL [3 1 0 4]

Generator & voltage control system: Energy conversion, application to synchronous machines, park's transformation, voltage & mechanical equations, synchronous operation, steady state model, simplified dynamic model, generator connected to infinite bus - Exciter system block diagrams, generator models, stability of excitation systems. Voltage regulation, generator with excitation system connected to infinite bus, small signal stability analysis - Load frequency control, single area systems, speed governing system, static response characteristics, closed ALFC loops, static & dynamic response, secondary ALFC loops, two area system, Reactive power & voltage control - Generation & absorption of reactive power, methods of voltage control, performance requirements of transmission lines, uncompensated lines, voltage & current profiles, power/voltage characteristics, reactive power requirements, principles of transmission system compensation, series & shunt compensation - Introduction to facts controllers - Economic load dispatch & unit commitment

**References:**


1. R. Bergen, Vijay vital, Power system analysis, (2e), prentice Hall
2. P. Kundur, Power system stability analysis & control, Tata Mc Graw Hill, 2006.
3. Wood & woolenberg, Power system operation & control, John – Wiley, 2003.


### ELE 423 ENERGY AUDITING AND MANAGEMENT [3 1 0 4]

Energy Scenario - Energy Resources - Energy Sector Reforms & Restructuring - Energy Security - Energy Conservation Act and its features - Energy Conservation - Energy Audit - Energy Bench Marking - Maximizing System Efficiencies - Energy Audit Instruments - Duties and Responsibilities of Energy Managers and Auditors - Thermal Energy Efficiency & Audits - Electrical Energy Efficiency - Audits – Energy audit in power distribution system – Loss estimation- Application of Non Conventional and Renewable Energy Systems - Use of Energy Efficient Technologies - Energy Economics - Investment Need and Criteria - Discount rate - Simple Payback - ROI, NPV, IRR, LCC.

**References:**


1. Trivedi P R & Jolka K R, Energy Management, Commonwealth Pub., New Delhi, 1997
2. Amit Kumar Tyagi, Handbook on Energy Audits and Management, TERI, 2000
3. Soni M L., Gupta P V., Bhatnagar U S., & Chakrabarti A., Power System Engineering, Dhanpat Rai, 2001


### ELE 425 BUILDING AUTOMATION SYSTEMS [3 1 0 4]

Heating, Cooling and Lighting systems - Thermal comfort and visual comfort factors - sensor locations - real time systems and control interfaces - PID control - self tuning - PC Hardware communications - DCS Configurations - algorithm libraries - input/output communications - Building Management system - HVAC Control - Chiller control - AHU control (Air Handling unit) - FCU control, Primary and secondary pump VFD control - Electrical demand measurements - Industrial intranets - PCP Protocol - web browsers - Lighting control management systems - CCTV, - Estimation of building loads - daylight–artificial light integration - energy audit and energy targeting - building energy standards and codes - Building intelligence - potential and direction of future developments.

**References:**


1. Hordeski, Control and Instrumentation Technology in HVAC: PC's and environmental controls, Fairmont press (ISBN : 0-8247-0902-0)
2. J. Krieder and A. Rabi, Heating and cooling of buildings: Design for efficiency, McGraw-Hill, 1994.
3. IES Lighting Handbook, Reference and Application volume, IESNA, 1993.
4. Robert S Simpson, Lighting Control: Technology and Applications, Focal Press, 2003.


### ELE 427 VLSI Design-II [3 1 0 4]

Arithmetic Building blocks-logic design and circuit

considerations, power and speed trade-offs - High performance MOS logic families - Dynamic logic - Performance comparison of high performance logic families with static CMOS - Timing issues in digital circuits - Timing analysis- setup time, hold time, slack calculations, clock skew and maximum operating frequency calculations - Global set up and global hold time calculations - Limitations, pipelining.

Amplifiers - Differential Amplifiers -Single ended differential operation, Basic differential pair, Common-mode response, and Differential pair with MOS loads; Operational Amplifiers - General considerations, One-Stage Op Amps, Two-Stage Op Amps, Gain Boosting, Comparison, Common mode feedback, Input range limitations, Op-Amps.

**References:**


1. J.M. Rabaey, A. Chandrakasan, and B. Nikolic, Digital Integrated Circuits, Pearson, 2003.
2. Kang and Lablebici, CMOS Digital Integrated Circuits, TMH, 2003.
3. Razavi, Design of Analog CMOS Integrated Circuits, McGraw Hill, 2001.


### ELE 429 DATA STRUCTURES & ALGORITHMS [3 1 0 4]

Analysis of algorithms- Stacks - application to evaluation of postfix expressions, conversion from infix to postfix representation - Queues - Sequential representation, operations, priority queues, and array implementation Linked Lists – Trees – Graphs – Sorting - Searching - Greedy techniques - Prim's & Kruskal's algorithms for minimum spanning trees, shortest paths, optimal tape storage, job scheduling with deadlines, Knapsack problem - Divide and Conquer - General technique, maximum. and minimum., multiplying long integers, Strassen's matrix multiplication, finding the closest pair of points - Dynamic programming - matrix chain ordering, all pairs shortest paths, optimal BST – Backtracking - NP completeness - Introduction to parallel algorithms.

**References:**


1. Cormen, Leiserson and Rivest, Introduction to algorithms, MGH 2001
2. Aho, Hopcroft and Ulmann, Design and Analysis of Algorithms, Addison Wesley 2000
3. Horowitz and Sahni, Fundamentals of computer algorithms (2 ed.), Galgotia Pub. 1998


### ELE 431 ADVANCED CONTROL SYSTEMS [3 1 0 4]

Control system performance objectives - Design of cascade compensators for continuous time and discrete time control systems - Feed back compensation - Design using Nichols chart - Industrial PID controllers -state space systems and PID control - Automatic PID controller tuning - pole placement techniques for design of controllers and observers - design of integral controllers - Robust control - H techniques - Non-linear control system design - Linearization - Describing function - use of describing function to predict oscillations - compensation and design of non-linear systems - Phase plane analysis - analysis - Introduction to optimal control theory and applications - Characteristics of optimal control problem - Calculus of variation - Dynamic programming - Pontryagin's maximum principle – application Control system design examples - Control system design using Toolboxes.

**References:**


1. Stanley M. Shinners, Advanced modern control system theory and design, John Wiley & Sons, 1998.
2. Michael A. Johnson, Mohammad M. Moradi, PID Control: New Identification and Design Methods, Springer 2005.
3. Norman S. Nise, Control Systems Engineering, John Wiley & Sons, Inc, 2000.


### ELE 433 HVDC AND FACTS [3 1 0 4]

Basics of power transmission networks -Control of power flow in AC systems - Analysis of uncompensated AC line-passive compensation-FACTS controllers-Basic types,Equivalent circuit & Benefits, Configuration, operation and control of SVC, STATCOM,TCSC, SSSC, TCPAR & UPFC.

DC power transmission-Types–components used, Choice of converter configuration, Converter bridge characteristics,HVDC system control-Converter control characteristics-modifications, System control hierarchy, Firing angle control-IPC, EPC, current and extinction angle control, starting and stopping of DC link-Converter faults and protection - DC breakers-characteristics and types.

**References:**


1. K R Padiyar, FACTS Controllers in power transmission and distribution systems, New Age International publishers, New Delhi, 2007.
2. Narendra G Hingorani & L. Gyugyi, Understanding FACTS: Concepts and Technology of flexible AC transmission systems, IEEE Press, 2000.
3. K R Padiyaar, HVDC power transmission systems, Technology and System Interactions, New Age International publishers, New Delhi, 1999.


### ELE 435 UTILIZATION OF ELECTRICAL ENERGY [3 1 0 4]

Traction - Traction Drives- dc and ac traction drives, dc and ac traction using power semiconductor controlled drives, dc and ac traction employing polyphase ac motors, diesel electric traction – Electroplating: Preparation of work for electroplating, Electro – extraction and refining of copper and aluminium, Electrolysis of water - Electric Welding - Resistance welding: spot, seam, butt, projection and flash welding, Power supply, Arc welding, characteristics of arc, Carbon arc and metallic arc welding, Coated electrodes, Control of current in welding transformers - Electric Heating : Classification of heating equipments, Methods of heat transfer, Resistance heating, resistance ovens, Design of heating element, Temperature control, Induction heating, Core type furnace, Coreless Induction furnace, indirect induction oven, High frequency eddy current heating, Dielectric heating,

Arc furnaces.

**References:**


1. J.B.Gupta, Utilization of Electrical Power and Electrical Traction, S.K. Katharia & Sons, 1994.
2. E.O. Taylor, Utilization of Electric Energy, Orient Longman, 1971.
3. Suryanarayana N.V, Utilization of Electrical Power including Electric Drives and Electric Traction, Wiley Eastern, 1994.


### ELE 437 INDUSTRIAL AUTOMATION AND CONTROL [3 1 0 4]

Introduction to Industrial Automation and Control - Signal Conditioning and Processing, Estimation of errors and Calibration - Controller Tuning, Implementation of PID Controllers - Sequence Control - PLCs and Relay Ladder Logic, Structured Design Approach, Advanced RLL Programming, PLC Hardware environment - Control of Machine tools- CNC Machines, Analysis of a control loop - Actuators - Flow Control Valves, Hydraulic Actuator Systems - Pumps and Motors, Integrated Control Systems - Electric Drives - Stepper motors , DC Motor Drives - DC - DC Converters, Adjustable Speed Drives, Induction Motor Drives - Synchronous Motor Drives - Adjustable Speed and Servo Drives - Networking of Sensors, Communication Protocol

**References:**


1. Sawhney A.K., A course in Electrical and Electronic Measurements and Instrumentation, DhanpatRai& Sons, 2005
2. Dubey G.K., Power Semiconductor Controlled Drives, PH, 1989
3. Norman S. Nise, Control Systems Engineering, John Wiley & Sons, Inc, 2000


### ELE 439 INTEGRATED LIGHTING DESIGN [3 1 0 4]

Lighting Design Principles - Impact of room environment on luminaire selection - Maintenance aspects - applications - Design calculations - Road lighting Criteria - Road Surface reflection properties -Conventional road lighting arrangements - Road lighting Calculations - Energy and cost effectiveness of lighting schemes - Flood lighting of large working areas, buildings and monuments -General design considerations - Positioning and aiming of flood lights, Flood lighting for gardens and parks - Flood lighting for indoor and outdoor sports - lighting controls – lighting control strategies - occupancy sensors - Photo sensors – control algorithms – Daylight-artificial light integrated schemes - Magnetic and Electronic Ballast – Dimming Electronic Ballast for Fluorescent lamps - Lamp Ballast interactions - Digital control based system - lighting Automation platform - Networking – Central & distributed control – Control Signals and Protocols – standard protocols – Networks and Buses – Computer control - Wireless RF Lighting Control.

**References:**


1. I.E.S.N.A., New York, Lighting Hand Book 10th Edition, 2011
2. Robert S Simpson, Craig DiLouie , Advanced Lighting Controls: Energy Saving Productivity , Technology & Applications, Fairmont Press, Inc., 2006.
3. Craig DiLouie , Advanced Lighting Controls: Energy Saving Productivity , Technology & Applications, Fairmont Press, Inc., 2006.


### ELE 441 DATABASE MANAGEMENT SYSTEMS [3 1 0 4]

Database systems - Concepts overview, terminologies, data models - Physical data organization - B-tress, files with dense and space index, files with variable length records, look-up on non-key attributes, partial match retrieval, range queries - Network model: DBTG DLL, implementation, operation such as insertion, deletion and modification - Hierarchical model implementation - Hierarchical model architecture, data definition and manipulation in hierarchical database - Relational Model Storage Organization, relational algebra, relational calculus, relational query language, overview of SEQUEL, QUEL, QBE - Design theory for relational database, functional dependencies, decomposition of relational scheme, normalisation - Database protection integrity and security, concurrent operations on database.

**References:**


1. Elmasri R. & Navathe S.B., Fundamentals of database systems (3e), Addison Wesley, 2000.
2. Korth H.F. & Silberschatz A., Database system concepts (4e), MGH, 2002.
3. Vllman J.D. & Widom J., A first course in Database systems, PH, 1997.


### ELE 443 HIGH VOLTAGE ENGINEERING [3 1 0 4]

Breakdown phenomenon in dielectrics : Breakdown in electro-negative gases, Breakdown in high vacuum, Breakdown in solid dielectrics, Breakdown in liquid dielectrics - Generation of High Voltages and Currents - Transformers in Cascade Series resonant circuit, Resonant transformer - Single Stage and Multi Stage Impulse Generators, Trigatron gap - Switching surges - Tesla coils, Direct voltages - Voltage doubler and multiplier circuits, Van-de-Graaf Generator, Impulse Current Generator. High Voltage Measurement - Measurement of AC, DC and impulse voltages and currents, Capacitive voltage transformer, Sphere gap, Electro optical signal converter, Hall Generator, Resistive shunts, CRO for impulse measurements. High Voltage Testing - Testing of insulators, Power Transformers, Circuit Breakers, Surge diverters, Cables, Bushings and Transformer oil, Schering's bridge for loss tangent measurement.

**References:**


1. Kamaraj & Naidu, High Voltage Engineering, TMH, 1996.
2. Kuffel & Abdulla, High Voltage Engineering, Pergamon, 1981.
3. Wadhwa C.L., High Voltage Engineering, Wiley, 1994.


### ELE 445 POWER QUALITY ISSUES [3 1 0 4]

Power Quality Issues –Standards and indices - Voltage sags -

Interruptions - Harmonics - harmonic distortion of fluorescent lamps-effect of power system harmonics on power system equipment and loads - Power factor improvement- Passive Compensation- Passive Filtering- Harmonic Resonance - Control Methods for Single Phase APFC-Three Phase APFC and Control Techniques- PFC Based on Bilateral Single Phase and Three Phase Converter-static var compensators- SVC and STATCOM - Active Harmonic Filtering-Shunt Injection Filter for single phase , three-phase three-wire and three-phase four-wire systems- UPS-constant voltage transformers- series active power filtering techniques for harmonic cancellation and isolation - Dynamic Voltage Restorers - Grounding and wiring- NEC grounding requirements - solutions to grounding and wiring problems.

**References:**


1. Pogei C. Dugan, Mark F. McGranghan, Surya santoso, H. Wayne Beaty, Electrical power system quality, Second edition, McGraw Hill Pub, 1996.
2. Math H. Bollen , Understanding Power Quality Problems, IEEE Press, 1st Edition,2001
3. J. Arrillaga, Power System Quality Assessment, John Wiley, 2000


### ELE 447 DISTRIBUTED ENERGY RESOURCES [3 1 0 4]

Overview of Electric Grid - Distributed Generation - Definition, Need and advantages- Renewable Energy Resources as DGs - Fuel cell powered DG-Gas Turbine Powered DG- Hybrid System- Energy Storage Systems applicable to DGs - Grid interconnection options-Integration of DERs with grid-, Analysis of small Generating systems-Equivalent Models - Generators used with DERS for grid interconnection - Control Techniques for DER integration systems- Standards and codes for interconnection- future structure of grid.

**References:**


1. H. Lee Willis & W. G. Scott, Distributed Power Generation- Planning & Evaluation , CRC Press, 2000.
2. Dr. Felix A. Farret, Dr. M. Godoy Simões, Integration of Alternative Source of Energy, Wiley InterScience, 2006.
3. M. H. Nehrir & C. Wang , Modelling and Control of Fuel Cells : Distributed generaion Applications,- IEEE Wiley- IEEE Press, 2009


### ELE 449 SPECIAL ELECTRICAL MACHINES [3 1 0 4]

Introduction to special machines - stepper motors, switched reluctance motor, brushless dc motor, linear induction motor - Induction Generators: review of construction, operating principle, modelling & analysis - Stepper Motors - construction, principle of operation, configurations, control circuits, open & closed loop control, modelling & analysis, applications -Switched reluctance motor: construction, principle of operation, design aspects, torque-speed characteristics, control circuits, modelling & analysis, applications - Brushless dc motor: construction, principle of operation, sensing & logic schemes, drive & power circuits, steady & transient analysis, control strategies - Linear induction motor - construction, principle of operation, schematic drive, field analysis.

**References:**


1. K. Venkataratnam, Special Electrical Machines, University Press Hyderabad, 2008
2. R Krishnan, Electric Motor Drives – Modeling, Analysis and Control, PHI, 2003.


### ELE 451 SOLID STATE LIGHTING AND CONTROLS [3 1 0 4]

Review of Light sources-. Basics of solid state lamps –white light generation techniques- Characterization of LEDs for illumination application - Power LEDs- High brightness LEDs- Electrical and optical properties – LED driver considerations - Power management topologies- Thermal management considerations- Heat sink design - photometry and colorimetry - color issues of white LEDs- Dimming of LED sources - Designing usable lamp from white LEDs - Luminaire design steps - SSL test standards.

**References:**


1. Arturas Zukauskus, Michael S. Shur and Remis Gaska, Introduction to solid state lighting, Wiley-Interscience, 2002
2. E. Fred Schubert, Light Emitting Diodes (2nd edition), Cambridge University Press, 2006.
3. Mohan, Undeland and Robbins, Power Electronics: Converters, Applications and Design, John Wiley and Sons, 1989


### ELE 453 COMPUTER NETWORKS [3 1 0 4]

Introduction to Computer Networks - Reference models - Internet Standards - Internet Administration - Addressing - Physical, Logical (IP) and Ports - IP Addressing - Unicast, Multicast and Broad cast Addresses - A sample Internet - Subnetting and masking - Delivery and Routing of IP packets - Routing methods, Internet Protocol (IP) and related protocols - Datagram structure, fragmentation, options, checksum, IP package. IPV6 addresses, packet format, Transition from IPV4 to IPV6 - User Datagram Protocol (UDP) - Process to process communication, User Datagram, Checksum, use of UDP, UDP package - Transmission Control Protocol (TCP) - Applications of TCP/IP - DNS, TELNET, FTP, TFTP, SMTP, SNMP, and HTTP.

**References:**


1. Forouzan Behrouz A., TCP/IP Protocol suite, Tata Mcgraw Hill Publishing Co. Ltd., New Delhi 2000.
2. Tanenbaum A. S., Computer Networks, 3rd Edition, Prentice Hall of India Pvt Ltd.(EEE), New Delhi 1996.


### ELE 455 MODERN POWER CONVERTERS [3 1 0 4]

Switched Mode Power Converters: generalized comparison between switched mode and linear D.C. regulators, operation and steady state performance of buck, boost, buck-boost and cuk' converters, continuous conduction mode, discontinuous conduction mode; D.C - D.C Converters with isolation - Fly-back converter, forward-converter, push-pull converter, half bridge and full bridge D.C-D.C converters; Resonant Converters - series and parallel loaded converters in continuous and discontinuous mode of operation, zero current switch resonant

converter(ZCS), zero voltage switch resonant converter (ZVS); Control Techniques - Voltage feed forward PWM control, current mode control, digital pulse width modulation control; Converter modelling - Equivalent circuit modelling of converters using state space averaging technique; EMI and RFI - conducted and radiated noise, EMI suppression, EMI reduction at source, EMI filters, EMI screening, EMI measurements and specifications; UPS

**References:**


1. Hart D. W., Introduction to Power Electronics, PH, 1997.
2. Mohan, Undeland & Robbins, Power Electronics: Converters, Application and Design (2e) Wiley, 1999.
3. Pressman A. I., Switching Power Supply Design


## OPEN ELECTIVES

### ELE 340 ENERGY CONVERSION TECHNOLOGIES [3 0 0 3]

Transformers - construction, operating principle, types, equivalent circuit, voltage regulation, efficiency, auto-transformer, Three-phase transformers – Construction, operating principle, types, emf equation, armature reaction, equivalent circuit, power input & output expressions, losses, efficiency & applications of AC Generators - Induction Motors three phase & single-phase – Synchronous Motors - power factor correction – DC Motors - Special Machines – Working principle & equivalent circuits of stepper motors, switched reluctance motors, brushless dc motor, ac & dc servo motors, universal motors, linear induction motor.

**References:**


1. I.J. Nagrath and D.P. Kothari, Electric Machines, Tata McGraw Hill, New Delhi 2001
2. P.S. Bhimbhra, Electrical Machines, Khanna Publishers 1984, 3rd Edition
3. J.D. Edwards, Electrical Machines and Drives, Macmillan, UK 1991


### ELE 342 RENEWABLE ENERGY SOURCES [3 0 0 3]

Energy sources and their availability - Solar Energy - solar radiation and measurements, solar energy storage, - Solar Photo-Voltaic systems design – Wind Energy- estimation, Maximum power and power coefficient, wind energy conversion systems - design considerations and applications – Energy from Bio-Mass – Sources of bio-mass, Bio-mass conversion technologies – Thermo-chemical conversion and Bio-chemical conversions, Anaerobic digestion and Fermentation, Bio-gas generation Pyrolysis and Liquefaction, Classification of Gasifiers, Energy plantation – Energy from the Oceans – Ocean Thermal Energy Conversion, Open and Closed Cycle plants, Site selection considerations, Origin of tides, Tidal energy conversion systems, Wave energy conversion systems – Hybrid Energy Systems

**References:**


1. Khan B. H., Non-conventional Energy Resources, TMH, 2006
2. Twidell J. W. & Weir A. D., Renewable Energy Resources, ELBS, 1986.
3. Mukherjee D. & Chakrabarti S., Fundamentals of Renewable Energy Systems, New Age Intl., 2004


### ELE 344 ANALOG AND DIGITAL ELECTRONIC CIRCUITS [3 0 0 3]

*(Not offered to Electrical stream)*

Operational amplifiers and applications – dc voltage follower, bridge amplifier, integrator, differentiator, low pass, high pass and band pass active filters, precision diode and clamp, log – antilog amplifiers, astable, monostable and triangular wave generators, Schmitt Trigger, analog multiplier – Phase locked loop and applications – Phase comparator, Voltage controlled Oscillator, Functional block Schematic of PLL, PLL applications in communication- Number systems- Conversions between Number Systems – Subtraction using 1's and 2's. Complements – Karnaugh maps, Logic gates – Truth tables, Realization of Boolean functions using Gates, Universal Gates – Msi combinational circuits - Half and Full adders, magnitude comparator, Decoder, Encoder, Multiplier, ROM, PLA, - Sequential circuits - Flip Flops – Synchronous and Asynchronous Counters, Design of counters, 74194 Shift Register IC based design.

**References:**


1. Franco Sergio, "Design with Op amps & Analog Integrated Circuits" McGraw Hill, 1997.
2. Ramakant A. Gayakwad," Op-Amps and Linear Integrated Circuits" Prentice Hall of India
3. Givone, Digital Principles & Design, TMH 2003


### ELE 346 ELECTRICAL ENERGY SYSTEMS [3 0 0 3]

Power Systems – Voltage and Frequency Standards – Energy - Power Plants - Thermal Power – Nuclear Power Plant - Diesel Power Plant – Hydro Electric Power Plants - Gas turbine power plant - Applications – Combined operation of power plants, load division among different types of power plants – Renewable Energy - Solar, Wind, Biomass, Geothermal, tidal, Fuel Cell – Transmission Systems - Overhead lines, Line representation, Insulators, Underground cables, Classification – Distribution Systems - Types, Feeders, Distributors, Service Mains, Substation Layout – Protection Systems - Faults, Earthing, Fuse, Circuit Breakers, Relays, Electric Safety, Shock, Grounding practice, Standards, Domestic Wiring – Performance Analysis - Transformers, Induction Motors, HVAC & Lighting loads – Load Characteristics & Economic Aspects, Power Factor correction, Tariff.

**References:**

1. M. A. El-Sharkawi, Electric Energy – An Introduction, CRC press, 2nd Edition
2. J. B. Gupta, A Course in Electrical Power, S.K. Kataria & Sons, 1996.
3. C. L. Wadhwa, Electrical Power System (3e), New Age Intl., 2000

**ELE 348 ELECTRIC DRIVES [2 1 0 3]**

Electric Drives - Components of electric drives, factors affecting choice of drives, dynamics of electrical drives, fundamental torque equation, speed-torque conventions, multi-quadrant operation of electric drives, load torque components, nature and classification of load torque, equivalent moment of inertia, steady state stability, load equalization - Motor power rating, thermal model, classes of motor duty - Introduction to thyristors, characteristics, power converters: AC to DC, DC to DC, AC to AC, DC to AC - DC Drives Systems - characteristics, starting, speed control, braking - AC Drives Systems: characteristics, starting, speed control, braking - Closed loop motor control schemes - Constant Torque, Speed, Position control systems.

**References:**

1. Dubey G.K, Fundamentals of Electric Drives (2e), Narosa, 2001
2. De N.K and Sen P.K, Electric Drives, PHI, 1999
3. Pillai S.K, A First Course on Electric Drives, New Age International, 1989

**ELE 350 INDUSTRIAL AUTOMATION AND CONTROL [3 0 0 3]**

Architecture of Industrial Automation Systems - sensors and measurement systems: Signal Conditioning and Processing, Estimation of errors and Calibration - Process Control - Controller Tuning, Implementation of PID Controllers, Special Control Structures - Sequence Control - PLCs and Relay Ladder Logic, Scan Cycle, RLL Syntax, Structured Design Approach, Advanced RLL Programming, PLC Hardware environment - Control of Machine tools - CNC Machines, Analysis of a control loop - Pumps and Motors, Proportional and Servo Valves, Pneumatic Control Systems - Integrated Control Systems - Electric Drives - Energy Saving with Adjustable Speed Drives, Stepper motors - DC Motor Drives – DC -DC Converters, Adjustable Speed Drives, Induction Motor Drives - Synchronous Motor Drives - Networking of Sensors, Actuators and Controllers - Field bus, Field bus Communication Protocol. - Introduction to Production Control Systems.

**References:**

1. Sawhney A.K., A course in Electrical and Electronic Measurements and Instrumentation, DhanpatRai& Sons, 2005
2. Dubey G.K., Power Semiconductor Controlled Drives, PH, 1989
3. Norman S. Nise, Control Systems Engineering, John Wiley & Sons, Inc, 2000

**ELE 352 ENERGY AUDITING & MANAGEMENT [3 0 0 3]**

Energy: Energy Types, Needs, Scenario, Security, Environmental Impact, Costs, Material & Energy Balance, Consumption Pattern, Sankey Diagram, Energy Policy, Information Systems, Energy Conservation Act 2001 - Energy Audit - Purpose, Scope, Types, Methodologies, Reporting, Instruments, Energy Auditor Responsibilities - Energy Management - Energy Management principles, Strategy, Benchmarking, Energy Manager Responsibilities - Performance Assessment - Boilers, Steam Systems, Furnaces, Insulation & Refractories, Cogeneration, Waste Heat Recovery, Transformers, Motors, Compressors, Refrigeration Systems, Fans, Blowers, Pumps, Cooling Towers, Illumination Systems, DG Sets - Energy Economics - Economic analysis of investments, Simple payback method, return on investment, net present value, internal rate of return, life cycle costing, energy performance contracts and role of ESCOs.

**References :**

1. Paul W. O'Callaghan, Energy Management - A comprehensive guide to reducing costs by efficient energy use, McGraw Hill, England, 1992
2. IEEE Std. 739-1995, IEEE recommended practice for energy management in industrial and commercial facilities.
3. BEE Study Material, Energy Management & Energy Audit, www.bee-india.com

**ELE 354 MICROPROCESSORS AND MICROCONTROLLERS [3 0 0 3]**

*(Not offered for Electrical stream)*

Review of Number System, Logic gates, buffers, tristate devices, latches and decoders - Introduction to microprocessors and microcontrollers - comparison embedded system and general purpose systems - Architecture and pin diagram of 8085 Microprocessor - Introduction to assembly language programming. Addressing modes, Instruction set, Programming using 8085 instructions - Stack and subroutines, time delay generation using 8085 instructions - Interfacing memory devices to 8085 - Interrupts of 8085 - Interfacing peripherals - 8255 and 8253 - Architecture and pin diagram of 8051 microcontroller, instruction set, programming using 8051 instruction set - Development tools - Simulators, debuggers, cross compilers, in circuit emulators for microprocessors and microcontrollers - Applications of Microprocessors and Microcontrollers - Criteria for selection of processors and controllers.

**References:**

1. Ramesh S Gaonkar, Microprocessor Architecture, Programming and Applications (3e), Penram Pub., 2008.
2. Muhammad Ali Mazidi and Gillispie Mazidi, The 8051 Microcontroller and embedded system using assembly and C, Pearson education, 2009.
3. Kenneth. J. Ayala, 8051 Microcontroller and embedded systems using assembly and C, Cengage Learning, 2009.