SYLLABUS

UNDERGRADUATE PROGRAMME
B.TECH.

DEPARTMENT OF
ELECTRICAL ENGINEERING
NATIONAL INSTITUTE OF TECHNOLOGY, MANIPUR
TAKYELPAT, IMPHAL-795001
MANIPUR, INDIA

2022

Electrical Engineering (EE)

SEMESTER - III			
COURSE NO.	**COURSE NAME**	**L -T-P**	**CREDIT**
EE201	Network Analysis	3-0-0	6
EE203	Semiconductor Devices and Circuits	3-0-0	6
EE205	Analog Circuits	3-0-0	6
MA201	Mathematics –III	3-0-0	6
HS201	Engineering Economics and Accountancy	2-0-0	**4**
EE231	Network Analysis Laboratory	0-0-3	3
EE233	Semiconductor Devices and Circuits Laboratory	0-0-3	3
EE235	Analog Circuits Laboratory	0-0-3	3
		14-0-9	**37**

SEMESTER - IV			
COURSE NO.	**COURSE NAME**	**L - T - P**	**CREDIT**
EE202	Digital Electronics and Computer Architecture	3-0-0	6
EE204	Electrical Machines –I	3-0-0	6
EE206	Measurement and Instrumentation	3-0-0	6
EE208	Signals and Systems	3-0-0	6
MA204	Numerical Methods	3-0-0	6
EE232	Digital Electronics Laboratory	0-0-3	3
EE234	Electrical Machines-I Laboratory	0-0-3	3
EE236	Measurement and Instrumentation Laboratory	0-0-3	3
		15-0-9	**39**

SEMESTER – V			
COURSE NO.	**COURSE NAME**	**L - T – P**	**CREDIT**
EE301	Power Electronics	3-0-0	6
EE303	Electrical Machines-II	3-0-0	6
EE305	Transmission and Distribution	3-0-0	6
EE307	Control System	3-0-0	6
EE309	Electromagnetic Field Theory	3-0-0	6
EE331	Power Electronics Laboratory	0-0-3	3
EE333	Electrical Machines-II Laboratory	0-0-3	3
MA331	Numerical Methods Laboratory	0-0-3	3
		15-0-9	**39**

SEMESTER – VI			
COURSE NO.	**COURSE NAME**	**L - T – P**	**CREDIT**
EE302	Microprocessor and Applications	3-0-0	6
EE304	Power System Protection	3-0-0	6
EE306	Advance Control System	3-0-0	6
EE308	Renewable Energy Resources	3-0-0	6
EE310	Communication System	3-0-0	6
EE332	Microprocessor Laboratory	0-0-3	3
EE334	Power System Laboratory	0-0-3	3
EE336	Control System Laboratory	0-0-3	3
		15-0-9	**39**

SEMESTER - VII			
COURSE NO.	**COURSE NAME**	**L - T - P**	**CREDIT**
EE401	High Voltage Engineering	3-0-0	6
EE403	Power System Analysis	3-0-0	6
EE4XY	Department Elective-I	3-0-0	6
EE4XY	Department Elective-II	3-0-0	6
EE431	Renewable Energy Laboratory	0-0-3	3
EE421	Project - I	0-0-6	6
		12-0-9	**33**

SEMESTER – VIII			
COURSE NO.	**COURSE NAME**	**L - T - P**	**CREDIT**
EE402	Power System Operation and Control	3-0-0	6
EE4XY	Department Elective-III	3-0-0	6
EE4XY	Open Elective/ Department Elective-IV	3-0-0	6
HS404	Professional Ethics	3-0-0	6
EE422	Project - II	0-0-8	8
		12-0-8	**32**

DEPARTMENTAL ELECTIVES

B. Tech. ELECTRICAL ENGINEERING

Department Elective-I				
S. No.	**COURSE NO.**	**COURSE NAME**	**L-T-P**	**Credit**
1.	EE 451	Principles Of Industrial Instrumentation	3-0-0	6
2.	EE 453	Power Station Engineering	3-0-0	6
3.	EE 455	Electrical Engineering Materials	3-0-0	6
4.	EE 457	Ehv Ac Transmission	3-0-0	6
5.	EE 459	Neural Network, Fuzzy Logic And Evolutionary Algorithm	3-0-0	6
6.	EE 461	Discrete And Non-Linear Control Theory	3-0-0	6
7.	EE 463	Illumination Engineering	3-0-0	6
8.	EE 465	Introduction To Digital Signal Processing	3-0-0	6
Department Elective-II				
1.	EE 467	Utilization Of Electric Power	3-0-0	6
2.	EE 469	Electric Traction And Drives	3-0-0	6
3.	EE 471	Numerical Relays	3-0-0	6
4.	EE 473	Advanced Power Electronics	3-0-0	6
5.	EE 475	Hvdc Transmission	3-0-0	6
6.	EE 477	Computer Methods In Power Systems	3-0-0	6
7.	EE 479	Power Quality	3-0-0	6
8.	EE 481	Distribution Systems Planning & Automation	3-0-0	6
Department Elective-III				
1.	EE 452	Surge And Lightning Protection And Safety Devices	3-0-0	6
2.	EE 454	Smart Grid	3-0-0	6
3.	EE 456	Power Market Reforms	3-0-0	6
4.	EE 458	Solar And Wind Power	3-0-0	6
5.	EE 460	Electric And Hybrid Vehicles	3-0-0	6
6.	EE 462	Modern Control System	3-0-0	6
7.	EE 464	Solid State Drives	3-0-0	6
8.	EE 466	Digital Control System	3-0-0	6
Department Elective-IV				
1.	EE468	Energy Harvesting Techniques	3-0-0	6
2.	EE470	Sensors And Transducers	3-0-0	6
3.	EE472	Energy Storage Sysytems	3-0-0	6
4.	EE474	Soft Computing Techniques	3-0-0	6
5.	EE476	Bio-Medical Instrumentation Engineering	3-0-0	6

EE201	NETWORK ANALYSIS	[3-0-0-6]

Network Graphs; Matrices associated with graphs; incidence, fundamental cut set and fundamental circuit matrices. Solution methods: nodal and mesh analysis. Network theorems: superposition, Thevenin and Norton's maximum power transfer, Wye-Delta transformation. Steady State sinusoidal analysis using phasors. Linear constant coefficient differential equations: time domain analysis of simple RLC circuits, Solution of network equations using Laplace transform: frequency domain analysis of RLC circuits. 2-port network parameters: driving point and transfer functions. State equations for network, Transient analysis using transform methods, high pass, low pass, band pass, band stop, all pass filters and frequency dependent negative resistors, Applications of active networks (op-amp, BJT, FET, tunnel diode etc.) and systems, Non-linear network analysis and systems.

Texts:
1. Network Analysis, Van Valkenburg, PHI Pbs, 2010
2. Circuit Theory, Kuriakose-PHI Pbs, 2005

References:
1. Network Analysis, Bakshi & Bakshi, Technical Publications, 2009
2. Network Analysis and Synthesis, Wadhwa, New Age Publications, 2008

EE203	SEMICONDUCTOR DEVICE AND CIRCUITS	[3-0-0-6]

Energy Bands in Silicon, intrinsic and extrinsic silicon. Carrier transport in Silicon: diffusion current, drift current, mobility and resistivity. Generation and recombination of carriers. P-n junction diode, Zener diode, tunnel diode, BJT, JFET, MOS capacitor, MOSFET, LED, p-I-n and avalanche photo diode, Basics of LASERs. Device technology: integrated circuits fabrication process, oxidation, diffusion, ion implantation, photolithography, n-tub, p-tub and twin tub CMOS process 1-D, 2-D, 3-D and 0-D nanostructures, influence of external fields on the nano-devices, quantized systems (magnetic quantization, magneto size quantization, magneto inversion layers), scattering mechanisms for bulk, 0-D, 1-D, 2-D and 3-D systems

Texts:
1. Solid State Electronic Devices by Streetman & Banerjee

References:
1. Semiconductor Devices: Jasprit Singh
2. Integrated Electronics: Millman & Halkis
3. Semiconductor Physics and Devices: Donald Neaman
4. Semiconductor Devices: Kanan Kano
5. Semiconductor Optoelectronic Devices: Pallab Bhattacharaya

EE205	ANALOG CIRCUITS	[3-0-0-6]

Small signal equivalent circuits of diodes, BJTs, MOSFETs and Analog CMOS. Simple diode circuits, clipping, clamping, rectifier. Biasing and bias stability of transistor and FET amplifiers. Amplifiers: single and multi-stage, differential and operational, feedback and power. Frequency response of amplifiers. Single opamp circuits. Filters. Sinusoidal oscillators; criterion for oscillation; single transistor and opamp configurations. Function generators and wave shaping circuits, 555 Timers. Power Supplies. Network synthesis of active analog devices.

Texts:
1. Donald A. Neamen, Electronic Circuit Analysis and Design, Irwin Publications, 1996.

References:
1. Op-AMPS and Lenear Integrated Circuits- Ramakant A. Gayakwad-Prentice Hall of India.
2. Sergio Franco, 'Design with Operational Amplifiers and Analog Integrated Circuits', Tata McGraw Hill Book Company, 3rd Edn., 2002.
3. Jacob Baker R., Li H.W. & Boyce D.E., 'CMOS- Circuit Design, Layout & Simulation', PHI, 2000.
4. VLSI Technology, 2nd edition, S M Sze.
5. Semiconductor Devices & Circuits - B.P. Singh
6. Electronics Devices and Circuits - Allen Mottershead
7. Integrated Electronics - Millman & Halkias

MA201	MATHEMATICS-III	[3-0-0-6]

Matrices- Matrices: Types of Matrices, Symmetric; Hermitian; Skew-symmetric; Skew-Hermitian; orthogonal matrices; Unitary Matrices; rank of a matrix by Echelon form and Normal form, Inverse of Non-singular matrices by Gauss-Jordan method; **Eigen values and Eigen vectors:** Linear Transformation and Orthogonal Transformation: Eigen values and Eigenvectors and their properties: Diagonalization of a matrix; Cayley-Hamilton Theorem (without proof); finding inverse and power of a matrix by Cayley-Hamilton Theorem; Quadratic. **Sequences & Series:** Sequence: Definition of a Sequence, limit; Convergent, Divergent and Oscillatory sequences. Series: Convergent, Divergent and Oscillatory Series; Series of positive terms; Comparison test, p-test, D-Alembert's ratio test;. **Calculus:** Mean value theorems: Rolle's theorem, Lagrange's Mean value theorem with their Geometrical Interpretation and applications, Cauchy's Mean value Theorem. Taylor's Series. Applications of definite integrals to evaluate surface areas and volumes of revolutions of curves (Only in Cartesian coordinates), Definition of Improper Integral: Beta and Gamma functions and their applications.

Texts:

1. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 36th Edition, 2010
2. Erwin kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons,2006.
3. G.B. Thomas and R.L. Finney, Calculus and Analytic geometry, 9th Edition, Pearson, Reprint, 2002.

References:

1. N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2008.
2. Ramana B.V., Higher Engineering Mathematics, Tata McGraw Hill New Delhi, 11thReprint, 2010.

HS201	ENGINEERING ECONOMICS AND ACCOUNTANCY	[2-0-0-4]

Introduction to Engineering Economics- Basic Principles and Methodology of Engineering Economics – Fundamental Concepts- Demand – Demand Determinants - Law of Demand- Demand Forecasting and Methods- Elasticity of Demand- Theory of Firm – Supply- Elasticity of Supply. Macroeconomic Concepts: National Income Accounting - Methods of Estimation - Various Concepts of National Income - Inflation – Definition – Causes of Inflation and Measures to Control Inflation - New Economic Policy 1991 (Industrial Policy, Trade Policy, and Fiscal Policy) Impact on Industry. Cash Flows and Capital Budgeting: Significance of Capital Budgeting - Time Value of Money- Choosing between Alternative Investment Proposals - Methods of Appraisal Techniques - Pay Back Period - Average Rate of Return – Net Present Value - Internal Rate of Return, Trading and Profit and Loss Account - Balance Sheet. Cost Accounting, Introduction - Classification of Costs - Breakeven Analysis, Meaning and its Application, Limitations. (Simple Problems)

Texts

1. Aryasri, "Managerial Economics and Financial Analysis", TMH, 2'd edition, 2005.
2. Varshney& Maheswari, "Managerial Economics", 5° edition Sultan Chand, 2003

References

1. H. Craig Peterson & W. Cris Lewis, "Managerial Economics", PHI, 4th Edition.
2. Domnick Salvatore, "Managerial Economics In a Global Economy", Thomson, 4°Edition.
3. Raghunatha Reddy & Narasimhachary, "Managerial Economics& FinancialAnalysis", 4th Edition Scitech.
4. S.N.Maheswari & S.K. Maheswari, "Financial Accounting", 6th Edition Vikas.
S. Dwivedi, "Managerial Economics", Vikas, 6th Edition.

EE202	Digital Electronics And Computer Architecture	[3-0-0-6]

Combinational logic analysis and design: logic minimization methods, Combinational design using MSI, LSI and PLDs, Number systems and arithmetic, Logic families, Delay, Hazards. Sequential logic design: latches and flip flops, Setup and Hold time, Clock frequency, Finite state machine design, state minimization, state assignment, synthesis using D-FF and JK-FF, counters, shift registers, MSI devices as state machines. Introduction to computer architecture: Instruction Set Architecture, System Software; Processor Design: Data path, Control unit, Instruction types, addressing modes.

Text Books:

1. J.F.Wakerly, "*Digital Design Principles and Practices*", PH, 1999.

References:

1. D.D. Givone, "*Digital Principles and Design*', TMH, 2002.
2. M. Raffiquzzman & Rajan Chandra, "*Modern Computer Architecture*", Galgotia Publications, 1990.
3. David Patterson and John Hennessy, "*Computer Organization and Design*', Elsevier, 2007.

EE204	ELECTRICAL MACHINES –I	[3-0-0-6]

D.C. Generator-Principle of Operation, Construction of D.C. Machines, E.M.F. equations, Armature reaction, Commutation, interpoles and compensating winding, Types of Generator, Characteristics of self-excited generator and separately excited generators-applications. D.C. Motor- Principle of operation, back E.M.F. torque and speed equations, characteristics of D.C Motors, speed control of series and shunt motors by flux control, armature control and voltage controlled methods- applications, Swinburn's test, brake test, DC motor 3-point starters. Transformer-Construction and principle of operation, E.M.F. equations, phasor diagram, actual and approximate equivalent circuits, open and short circuit tests, voltage regulations, losses and efficiency, Sumpner's test, parallel operation and load sharing. Autotransformer, 3 phase transformer- Scott connection of transformers for phase conversion, on –load and off-load tap changers, induction regulators.

Text Books:

1. Nagrath I. J and Kothari D. P. "*Electric Machines"*, Tata McGraw Hill Publishing Company Ltd,1990.
2. P.S. Bimbhra, "*Electrical Machinery"*, Khanna Publishers, 2003.

References:

1. Fitzgerald. A.E., Charles KingselyJr, Stephen D. Umans, *"Electric Machinery"*, McGraw Hill Books Company, 1992.
2. Hill Stephen, Chapman.J, "*Electric Machinery Fundamentals"*, McGraw Hill Book Co., New Delhi, 4th edition 2005.

EE206	MEASUREMENT & INSTRUMENTATION	[3-0-0-6]

Basic Measurement Techniques: Construction and principle of operation of Moving coil, Moving Iron, dynamometer, Wattmeter, Electro-static Instruments, Thermal and Rectifier type deflecting instruments, extension of instrument ranges using shunts, multipliers and instrument transformers. **Errors in Measurement**: Definition of accuracy, precision, Fidelity, speed of response, non-linearity, techniques of linearization, classification of errors. Statistical analysis. **Measurements of Resistances**: Measurement of low, medium and high resistances, Kelvins double bridge, multimeters, megger, D.C. and A.C. potentiometers. **Localization of cable faults**: Murray and Varley loop methods. *AC Bridges*: measurement of inductances, capacitance and frequency by A.C. Bridges-Maxwell, Schering, Anderson, De-Sauty, Wien. **Measurement of power & Energy**: Measurements of power in polyphase circuits, various wattmeter connections. A.C. and D.C. energy meters. *Cathode Ray Oscilloscope*: C.R.O. construction & principle of operation. **Sensors & Transducers**: piezoelectric sensors, LVDT, Stain Gauges, Actuators A/D, D/A conversion techniques; S/H and multiplexers; isolation amplifiers; Data Acquisition system. **Digital Instrumentation** – Block diagram of Instrumentation schemes, DVM, DMM, frequency counter. **Frequency domain instruments:** Wave analyzer, spectrum analyzer.
Special Purpose Instruments: Signal generators, Q-meter.

Text Books:

1. A. Bell David, '*Electronic Instrumentation & Measurement'*, Reston Publishers, 2003.

References:

1. H.S. Kalsi, "*Electronic Instrumentation*", Tata Mc-Graw Hill, 2010.
2. Sawhney A K, "A *course in Electrical & Electronic Measurements & Instruments*", Dhanpat Rai & Co, 1994.
3. Golding E.W. & Wides F.C, "*Electrical Measuring Instruments & Measurements"*, Wheeler.
4. S. K. Singh, "*Industrial Instrumentation & Control"*, Tata McGraw Hill, New Delhi, 2007.

EE208	SIGNALS AND SYSTEMS	[3-0-0-6]

Definitions and properties of Laplace transform, continuous time and discrete time Fourier series, continuous-time and discrete-time Fourier Transform, DFT and FFT, Z-transform. Sampling theorem. Linear Time-Invariant (LTI) Systems: definitions and properties; causality, stability, impulse response, convolution, poles and zeros, parallel and cascade structure, frequency response, group delay, phase delay. Signal transmission through LTI systems.

Text Books:

1. M.J Roberts, "*Fundamentals of Signals and Systems*", Tata McGraw Hill, 2007.

References:

1. A.V. Oppenheim, A.S. Willsky and H.S. Nawab, "*Signals and Systems*", Prentice Hall of India, 2006.
2. P. Lathi, "*Signal Processing and Linear Systems*", Oxford University Press, 1998.
3. R.F. Ziemer, W.H. Tranter and D.R. Fannin, "*Signals and Systems - Continuous and Discrete*", Prentice Hall of India, 1998.
4. Simon Haykin, Barry van Veen, "*Signals and Systems*", John Wiley and Sons, 1998.

MA204	NUMERICAL METHODS	[3-0-0-6]

Numerical Differentiation and Integration: Introduction, Numerical Differentiation, Numerical Integration, Euler-Maclaurin Formula, Adaptive Quadrature Methods, Gaussian Integration, Singular Integrals, Fourier Integrals, Numerical Double Integration.**Numerical Solution of Ordinary Differential Equations:**Introduction, Solution by Taylor's Picard's Method, Euler's Method, Runge-Kutta Methods, Predictor-Corrector Methods, the Cubic Spline Method, Simultaneous and Higher Order Equations, Boundary Value Problems: Finite-Difference Method, The Shooting Method. **Numerical Solution of Partial Differential Equations:** Introduction, Finite-Difference Approximations, Laplace's Equation: Jacobi's Method, Gauss-Seidel Method, SOR Method, ADI Method, Parabolic Equations, Iterative Methods, Hyperbolic Equations. **System of Linear Algebraic Equations** Introduction, Solution of Centro-symmetric Equations, Direct Methods, LU- Decomposition Methods, Iterative Methods, III-conditioned Linear Systems. **The Finite Element Method:** Functionals- Base Function Methods of Approximation- The Rayleigh –Ritz Method –The Galerkin Method, Application to two dimensional problemsFinite element Method for one and two dimensional problems.

Texts

1. Niyogi, Pradip, "Numerical Analysis and Algorithms", Tata McGraw –Hill
2. Balagurusamy,E., "Numerical Methods", Tata McGraw –Hill

Reference Books:

3. Sastry, S.S., "Introduction Methods of Numerical Analysis", PHI
4. Chapra, S.C. and Canale, R.P., "Numerical Methods for Engineers", Tata McGraw –Hill

EE301	POWER ELECTRONICS	[3-0-0-6]

General Introduction of Power Electronics, Scope and Application,
Power Semiconductor Devices Power diodes - power transistors - SCRs - Triac - GTO - Power MOSFETs - IGBTs- Principles of operation and characteristics, device specifications and ratings, methods of turning on SCR-gate triggering circuit, methods of turning off SCR commutation circuits. Protection and gate drive circuits.
Control rectifiers (AC to DC converter): Single phase converters: Principle of phase control, half wave controlled rectifier load, fully controlled bridge converter, half controlled (semi) converter, Effect of single phase full converter with source inductance, Dual converter, 3-phase half wave controlled rectifier, 3-phase fully controlled bridge converter, 3-phase semi converter.
Inverter: Series inverter, parallel inverter, single phase bridge inverter, concept of VSI and CSI, 3-phase bridge inverter (120° and 180° conduction mode), concept of PWM inverter.
D.C. Choppers: Principle of operation, control techniques, transient analysis of step down chopper, buck, boost & buck-boost regulator, voltage commutated chopper, current commutated chopper, load commutated chopper, jones chopper.
Cyclo converters: Single- phase mid-point type and bridge type cyclo converter, Applications: HVDC transmission, UPS, Zero voltage switch, Zero current switch.
Text Books:
1. P.S. Bimbhra, "*Power Electronics"*, Khanna Publication, 2012.
2. M.H. Rashid, "*Power Electronics"*, Pearson Publication, 2003.
References:
1. P.C. Sen, "*Power Electronics"*, Tata McGraw-Hill, 1987.
2. V.R. Moorthi, "*Power Electronics"*, Oxford University Press, 2005.
3. M.D. Singh & K.B. Khanchandani, "*Power Electronics"*, Tata McGraw-Hill, 2007.

EE303	ELECTRICAL MACHINES-II	[3-0-0-6]

Synchronous Generator: Constructional details – Types of rotors – emf equation – Synchronous reactance – Armature reaction – Voltage regulation – EMF, MMF, ZPF and A.S.A method – Synchronizing and parallel operation – Synchronizing torque - Change of excitation and mechanical input – Two reaction theory – Determination of direct and quadrature axis synchronous reactance using slip test – Operating characteristics - Capability curves.
Synchronous Motor: Principle of operation – Torque equation – Operation on infinite bus bars -V-curves – Power input and power developed equations – Starting methods – Current loci for constant power input, constant excitation and constant power developed.
Three Phase Induction Motor: Constructional details – Types of rotors – Principle of operation – Slip – Equivalent circuit – Slip torque characteristics - Condition for maximum torque – Losses and efficiency – Load

test - No load and blocked rotor tests - Circle diagram – Separation of no load losses – Double cage rotors – Induction generator – Synchronous induction motor. Single phase induction motor, single phase synchronous motor, single phase commutator motors. Special purpose Machine.

Text Books:

1. D.P. Kothari and I.J. Nagrath, "*Electric Machines",* Tata McGraw Hill Publishing Company Ltd 2002.
2. P.S. Bhimbhra, "*Electrical Machinery"*, Khanna Publishers, 2003.

References:

1. A.E. Fitzgerald, Charles Kingsley, Stephen. D. Umans, "*Electric Machinery",* Tata McGraw Hill publishing Company Ltd, 2003.
2. J.B. Gupta, "*Theory and Performance of Electrical Machines"*, S. K. Kataria and Sons, 2002.
3. K. Murugesh Kumar, "*Electric Machines",* Vikas Publishing House Pvt. Ltd, 2002.

EE305	TRANSMISSION AND DISTRIBUTION	**[3-0-0-6]**

Introduction: Structure of electric power systems – one-line diagram – Two wire DC, AC single phase and three phase systems- Recent Trends in transmission systems, comparison of EHVAC and HVDC systems. **Transmission line parameters:** Resistance, inductance and capacitance of single phase transmission lines – stranded and bundled conductors – symmetrical and unsymmetrical spacing –transposition of conductors– Double circuit line Application of self and mutual GMD – Skin and Proximity effect –Corona loss.

Performance of transmission lines: Equivalent circuits for short, medium and long lines – transmission efficiency and voltage regulation – Real and reactive power flows in lines –power angle diagram – power circle diagrams for receiving and sending end, limiting factors for transmission line load ability– Ferranti effect. **Mechanical design of Transmission line:** Factors affecting mechanical design, line supports, sag.

Insulators and cables: Insulators - Types, voltage distribution in insulator string and grading, improvement of string efficiency. Underground cables - Introduction-Types of cables, Capacitance of Single-core cable, Grading of cables.

Distribution System: Types of distribution system – Radial and Ring main system. Current and voltage calculation in distributors with concentrated and distributed loads- Kelvin's law for the design of feeders and its limitations - Substation design-Types of Substation- Bus-bar Arrangement- Substation Bus Schemes-Substation Location- Substation Equipments.

Text Books:

1. C.L.Wadhwa, *"Electrical Power System"*, New Age International Pvt. Ltd., 2007.
2. J Nagrath and D P Kothari, "*Power System Engineering",* Tata McGraw Hill

References:

1. J Nagrath and D P Kothari, "*Power System Engineering",* Tata McGraw Hill
2. B R Gupta, "*Power System Analysis and Design",* Wheelers Publishers
3. Ashfaq Hussain, "*Electrical Power Systems",* CBS publishers and distributor.
4. S.N. Singh, "*Electric Power*

EE307	CONTROL SYSTEM	**[3-0-0-6]**

Introduction- feedback and its effects-linearization Mathematical Modelling of Physical Systems- Block diagram Concept and use of Transfer function. Signal Flow Graphs Mason's gain formula. Time Domain Analysis of Control Systems - BIBO and absolute stability, Routh-Hurwitz Criterion. P, PI and PID controllers, State Variable Analysis of Linear Dynamic Systems- controllability and observability Root Locus Techniques- zero and pole. Frequency Domain Analysis of Control Systems- polar plots, Nyquist stability criterion, Bode plots, application M&N circles, Nichols charts Design of Compensators.

Text Books:

1. I .J. Nagrath, M. Gopal, "*Control Systems Engineering*", New Age International Publishers, 2008.
2. K. Ogata, "*Modern Control Engineering",* Prentice Hall, 2010.

References:

1. Samarjit Ghosh, "*Control System: Theory & Applications",* Pearson Education, 2007.
2. B. C. Kuo, Farid Golnaraghi, "*Automatic Control Systems",* John Wiley and Sons, 2003
3. D. Roy Choudhury, "*Modern Control Engineering",* Prentice Hall, 2005.

EE309	ELECTROMAGNETIC FIELD	**[3-0-0-6]**

Vector algebra, Cartesian, Cylindrical and Spherical co-ordinate system. Transformation of variables from Cartesian to cylindrical and spherical coordinate system. Coulomb's law, Electric field intensity, Field of 'n' point charges, Field of line and sheet of charge. Electric flux density, Gauss's law and its applications. Divergence and Divergence theorem. Definition of potential difference and potential, Potential of point charge and system of charges. Potential gradient, Energy density in electrostatic field. Poisson's and Laplace's equations. Current and current density, Continuity of current. Biot-Savart and Amperes circuital laws and their applications, Curl, Stoke's theorem. Magnetic flux density, Scalar and Vector magnetic potential. Maxwell's equations in steady electric and magnetic fields. Force on moving charge and differential current element, Force and torque on a closed circuit. Time
varying fields and Maxwell's equations. Uniform plane waves, wave motion in free space, perfect dielectric, lossy dielectric and good conductor, skin effect. Poynting vector and power considerations. Reflection of uniform plane waves, Standing ratio.

Text Books:

1. William H.Hayt Jr. and John A. Buck, "*Engineering Electromagnetics"*, Tata McGraw-Hill, 2011.
2. K. K. Shah, "*Introduction to Electromagnetic's"*, Dhanpat Rai, 2006.
3. Mathew N. O. Sadiku, "*Elements of Electromagnetics"*, Oxford University Press, 2007.
4. Ashutosh Pramanik, "*Electromagnetism – Theory and Applicatio*ns", Prentice-Hall, 2008.

References:

1. Joseph. A. Edminister, "*Theory and Problems of Electromagnetics"*, Schaum
Series, Tata McGraw Hill, 1993.
2. Kraus and Fleish, "*Electromagnetics with Applications"*, McGraw Hill International Editions, 1999.

EE302	MICROPROCESSOR AND APPLICATIONS	**[3-0-0-6]**

Microprocessors: Introduction to 8085; architecture; 8085 addressing modes; instruction sets; assembly language programming; timing diagram; interrupts; interrupt service routine; stack and subroutine; counters and time delays.

Interfacing the 8085 - memory interfacing- I/O interfacing- types of IO data transfer; interfacing matrix keyboard; seven segments display-interfacing DAC and ADCs. Programmable peripheral devices 8255 - interfacing ADC and printer to 8085 through 8255; 8254 programmable interval timers- timing diagrams; Design of a real time clock using 8254; DMA controller 8237; Universal synchronous asynchronous receiver transmitter (USART) 8251; programmable interrupt controller 8259.

Text Books:

1. R. S. Gaonkar, "*Microprocessor Architecture, Programming and Applications with the 8085*",
Penram International Publishing (India), 2000.
2. A.K. Roy & K.M. Bhurchandi, "*Advanced Microprocessor and Peripherals (Architecture, Programming & Interfacing"*, Tata McGraw-Hill Publication,

References:

1. D. V. Hall, "*Microprocessors and Interfacing: programming and hardware"*, Tata McGraw-Hill, 1995.
Ghosh & Sridhar, "*Introduction to Microprocessor for Scientists & Engineers"*, Prentice Hall of India Pvt. Ltd,

EE304	POWER SYSTEM PROTECTION	**[3-0-0-6]**

Introduction to protection scheme: Need for Protective systems - Nature and causes of Faults -Types of faults - Effect of faults - fault statistics - Evolution of protective relays - Zones of protection - Primary and Back –up Protection - Essential qualities of Protection -Classification of Protective schemes -Automatic reclosing - current transformer for Protection - potential transformer - basic relay terminology.

Relays: General considerations - sensing of faults - construction of electro-magnetic attraction and induction types relays - Buchholz and negative sequence relay -concept of reset, pick up, inverse time and definite time characteristics, over current, over voltage, directional, differential and distance relays on R-X diagram - Static Relays: Introduction, advantage and limitation of static relays, static over current, directional, distance and differential relays. Electronic relays - static relays functional circuits: comparators, level detectors, logic and training circuits, microprocessor and computer based protection schemes.

Protection: Types & detection of faults and their effects, alternator protection scheme – Power transformer protection, generator-transformer unit protection scheme, bus bar protection - Transmission line protection, Pilot relaying schemes, power line carrier protection.

Switchgear: Theory of current interruption- energy balance and recovery rate theory, arc quenching, recovery and restriking voltages - Types of circuit breakers - Rating selection and testing of circuit breakers/operating mechanisms - LT switchgear, HRC fuses, types construction and applications.

Text Books:

1. Badriram & Vishwakarma, "*Power System Protection*", Tata McGraw-Hill Education, 2011.
2. Paithankar Y. G., S. R. Bhide., "*Fundamentals of power system protection*", PHI Learning Pvt. Ltd., 2004.

References:

1. Ravindra Nath.B, and Chandar.M, "*Power systems protection and switchgear*", New age international (P) Ltd. 2005.
2. Rao Sunil.S, "*Switchgear and protection".* Khanna Publishers, 1999.
3. Paithankar.Y.G," *Transmission Network Protection: Theory and Practice*", Marcel Deicker, Inc.1998.

EE306	ADVANCE CONTROL SYSTEM	**[3-0-0-6]**

Introduction, concept of state, state variables and state Model, state modeling of linear systems, linearization of state equations. State space representation using physical variables, phase variables & canonical variables. Derivation of transfer function from state model, diazotization, Eigen values, Eigen vectors, generalized Eigen vectors. Solution of state equation: state transition matrix and its properties, computation using Laplace Transformation, power series method, Cayley-Hamilton method, concept of controllability & observability, methods of determining the same.

Frequency response design: Design of lag, lead, lag-lead and PID controllers, the Nyquist criterion, analysis and design, relative stability and the Bode diagram, closed-loop response, sensitivity, time delays; Root locus design: construction of root loci, phase-lead and phase-lag design, PID controller design; Modern design: controllability and observability, state feedback with integral control, reduced order observer. Digital controllers: Use of z-transform for closed loop transient response, stability analysis using bilinear transform and Jury method, deadbeat control, Digital control design using state feedback.

Text Books:

1. M. Gopal, "*Digital Control and State Variable Methods*", Tata McGraw Hill, 2003.
2. M. Gopal, "*Control Systems*", Tata McGraw Hill, 2008.

References:

1. G. F. Franklin, J. D. Powel and A. E. Emami-Naeini, "Feedback *Control of Dynamic Systems*", Prentice Hall Inc. 2002.
2. K. J. Astrom and T. Hagglund, "*Advanced PID Control*", ISA, Research Triangle Park, NC 27709, 2005.

EE308	RENEWABLE ENERGY RESOURCES	**[3-0-0-6]**

Introduction-Fossil fuel based systems, Impact of fossil fuel based systems, Non-conventional energy - seasonal variations and availability. Renewable energy - sources and features, Hybrid energy systems, Distributed energy systems and dispersed generation (DG), Other sources of energy- Solar energy, Wind energy system, Wave energy, Energy from biomass, Energy from OTEC, Geothermal energy system,

The Sun -The Solar constant, Solar radiation spectrum, Solar radiation measurement, Solar radiation at earth's surface, Solar radiation data, radiation geometry, empirical relations predicting availability of solar radiation, radiation on horizontal and tilted surface, Flat plate collectors, Basic energy balance equation and its principle, concentrating collectors, It's classification and working principle, Application of solar thermal technologies- Heating, cooling, Drying, Distillation, Power generation, Solar PV system, it's principle and application,

Wind Energy – Introduction, Basic principle of wind energy conversion, wind data and energy estimation, site selection, basic component of wind energy conversion system, wind turbines and their analysis, wind-electrical generation. Stand-alone and grid connected wind-electrical power system, various applications of wind energy.

Text books

1. Rai.G.D, "*Non-conventional resources of energy*", Khanna publishers, Fourth edition, 2010.
2. Khan.B.H, "*Non-Conventional Energy Resources*", The McGraw Hills, Second edition, 2009.
3. S.P. Sukhatme, "Solar energy: Principles of Thermal storage", Tata McGraw Hill.

References:

1. Godfrey Boyl, *"Renewable Energy: Power sustainable future*", Oxford University Press, Third edition, 2012.
2. Rao.S. & Parulekar, *"Energy Technology"*, Khanna publishers, Fourth edition, 2005.

EE310	COMMUNICATION SYSTEM	**[3-0-0-6]**

Analog Communication: Introduction to communication systems, signals and spectra, electromagnetic spectrum and its usage, communication channels and propagation characteristics, amplitude modulation and demodulation - spectra, circuits and systems, frequency modulation/demodulation, frequency division multiplexing, radio transmitters and receivers, sampling theory, pulse modulation and demodulation - spectra, circuits & systems, circuit noise, performance of analogue communication systems in AWGN and fading channels.
Digital Communication: Introduction to digital signals and systems, spectra and bandwidth. A-D conversion and quantization. PCM, Log- PCM, DPCM, ADPCM, DM, ADM, and LPC for speech signals, time division multiplexing, digital hierarchy and standards, baseband transmission, data regenerators and clock recovery, inter-symbol interference, equalizers, digital modulation and demodulation - binary and M-ary ASK, FSK, GMSK, PSK, DPSK and their spectra, circuits and systems, carrier recovery, performance of digital modulation systems, elements of information theory and coding.

Text books

1. S. Haykin, "Communication Systems", 3rd edition, John Wiley, 1994
2. H. Taub and D. Schilling, "Principles of Communication Systems", 3rd edition, Tata McGraw Hill

References:

1. W. Stallings, "Data and Computer Communications", 6th edition, Pearson education Asia (IPE), 2000
2. F. Halshall, "Data Communications, Computer networks and Open Systems", 4th edition, Pearson Education Asia (IPE), 1996
3 B.A. Forouzan, "Data Communications and Networking", 3rd edition, Tata McGraw Hill, 2003
4 D. Bertrekas and R. Gallagar, Data Networks, 2nd edition, Prentice Hall (EEE), 1992

EE401	HIGH VOLTAGE ENGINEERING	**[3-0-0-6]**

Breakdown Phenomenon: Breakdown in gases - Mechanism of breakdown in gases, breakdown theory. Breakdown in liquids - suspended solid particle mechanism, Cavitation and bubble mechanism, Stressed Oil volume mechanism, etc. Breakdown in solids - Intrinsic breakdown, Electromechanical breakdown, breakdown of solid dielectrics in practice, Chemical and Electrochemical deterioration and breakdown, breakdown due to treeing and tracking, breakdown due to internal discharges. Overvoltage Phenomenon, Protection & Insulation Coordination Natural causes for overvoltage - lightning phenomenon, over voltage due to switching surges and due to arching ground. Line design based on lightning. Basic idea about protection against overvoltage - lightning arresters, surge absorbers, Ground wire, grounding practices etc. BIL, SIL of the equipments, V-T curve, Concepts of Insulation coordination. Generation of High AC & DC voltageHigh AC voltage generation - Testing transformer and its cascaded connections. Single phase resonant circuits. High DC voltage generation - Single stage and Multi stage voltage multiplier circuits.Impulse Voltage and Current generation.Measurement of High Voltage and Current High Voltage Testing.

Text Books:

1. High Voltage Engineering , 'C. L. Wadhwa ',New Age International Pub. (P) Limited, New Delhi.
2. High Voltage Engineering, 'M.S Naidu & V Kamaraju' , Tata Mc Graw Hill Publishing company, New Delhi,

References:

1. High Voltage Engineering Fundamentals, ' E. Kuffel & W. S. Zaengl' , Butterworth-Heinemann, 2000

EE403	POWER SYSTEM ANALYSIS	**[3-0-0-6]**

Power system overview: Power scenario in India, Power system components, Representation. Single line diagram, per unit quantities, p.u. impedance diagram, Network graph, Bus incidence matrix, Primitive parameters, Bus admittance matrix using singular method, Formation of bus admittance matrix of large power network, Representation of off nominal transformer.
Power flow analysis: Bus classification, Formulation of Power Flow problems, Power flow solution using Gauss Seidel method, Handling of Voltage controlled buses, Power Flow Solution by Newton Raphson method, Fast Decoupled Power Flow Solution.
S**ymmetrical fault and Unsymmetrical Faults:** Symmetrical short circuit on Synchronous Machine, Bus Impedance matrix building algorithm, Symmetrical fault analysis through bus impedance matrix, Symmetrical components, Sequence impedance, Sequence networks, Analysis of unsymmetrical fault at generator terminals, Use of bus impedance matrix for analyzing unsymmetrical fault occurring at any point in a power system**.**
POWER SYSTEM STABILITY: Introduction to stability studies, Swing equation, Swing curve, Equal area

criterion, Critical clearing angle and time, Modified Euler's method, Fourth order Runge-Kutta method, Multi-machine transient stability.

Text Books:

1. John.J.Grainger, William D. Stevenson, "*Power System Analysis*", Tata Mc Graw Hill Publishing company, New Delhi, 2003.
2. Nagarath I.J. and Kothari D.P. "*Modern Power System Analysis*", Fourth Edition, Tata Mc Graw Hill Publishing Company, New Delhi, 2011.

References:

1. Hadi Sadat, "*Power System Analysis"*, Tata Mc Graw Hill Publishing company, New Delhi, 2002.
2. Pai M.A. "*Computer Techniques in Power System Analysis*", Tata Mc Graw Hill Publishing Company, New Delhi, 2003.
3. Abhijit Chakrabarti and Sunita Halder, "*Power System Analysis Operation and Control*", PHI Learning Private Limited, New Delhi, 2011.
4. Arthur R and Vijay Vittal, "*Power Systems Analysis*", Dorling Kinderley (India) Private Limited, New Delhi, 2012.

EE402	POWER SYSTEM OPERATION AND CONTROL	**[3-0-0-6]**

Introduction: Basic concepts of operation and control of power system - necessity of voltage and frequency regulation in power systems-real power-frequency and reactive power- voltage control loops-system load variation, load curves and basic concepts of load dispatching, load forecasting, unit commitment, load shedding and islanding.

Real power frequency control: Plant and system level control - basics of speed governing mechanisms and modeling-speed load characteristics-regulation of two generators in parallel-Concept of control area-LFC of single area system-static and dynamic analysis of uncontrolled and controlled cases- integration of economic dispatch controller with LFC-LFC of two area system-tie line modeling-block diagram representation of two area systemstatic and dynamic analysis-state variable model.

Reactive power voltage control: Basics of reactive power control- Excitation system requirement-elements of excitation system-static and dynamic analysis-stability compensation-generation and absorption of reactive power-methods of voltage control-control by tap changing transformer-shunt and series compensation, phase angle compensation.

Economic operation of power system:

Statement of economic dispatch problem-incremental cost curve-input and output characteristics of thermal and hydro plants-system constraints-hydrothermal. Scheduling of long and short terms-optimal operation of thermal units without and with transmission losses using penalty factor, incremental transmission loss, and transmission loss formula (no derivation)-base point and participation factors-Statement of unit commitment-constraints in unit commitment-solution methods using priority list and dynamic programming.

Computer control of power systems:

Concept of energy control centre and functions-need of computer control of power systems-system monitoring, data acquisition and controls-System hardware configurations-SCADA.

Text Books:

1. Olle.I.Elgerd, "*Electric energy systems theory-An introduction*", Tata McGraw Hill publishing Ltd, New Delhi, 2008.
2. Prabha Kundur, "*Power system stability and control*", Tata McGraw Hill publishing Ltd, New Delhi, 5th reprint, 2008.

References:

1. Allen J.Wood, Bruce F.Wollenberg, "*Power Generation*", *Operation and Control*", 2nd Edition, John Wiley and sons, 1996.
2. I.J.Nagrath and D.P.Kothari, "*Power System Engineering*", 2nd Edition, Tata McGraw Hill publishing Ltd, New Delhi, 2008.
3. S.Sivanagaraju, G.Sreenivasan, "*Power System Operation and Control*", Pearson Education, 2010.

EE4XY	DEPARTMENTAL ELECTIVE-I	**[3-0-0-6]**

EE 451 PRINCIPLES OF INDUSTRIAL INSTRUMENTATION 3-0-0-6

Pre-requisite: Basic Electrical Engineering

Characteristics of Measurement System: Functional Units, Classification and Performance characteristics, Dynamic Calibration, Errors: An Overview, Statistical Error Analysis and Reliability.
Pressure, Temperature and Flow Measurement: Pressure Measurement: Electrical types, Vacuum Measurement, Sound pressure level measurement, Temperature Measurement: Electrical Types temperature sensors. Flow Measurement: Electrical type flow meters, Open Channel flow measurement; Level Measurement: Hydrostatic type, Thermal effect type, Solid level measurement.
Instruments for Analysis: Introduction, Gas Analysers, Liquid Analysers, X-ray Methods, Chromatography, Mass spectrograph.
Telemetry: Introduction, Pneumatic Means, Electrical Means, Frequency Telemetering, Multiplexing, Modulation, Modulation of Digital Data, Transmission Channels, Briefing of a Telemetry System in Operation.
Power Plant Instruments: Introduction, Power Plant Scheme, Vibration and Expansion, Analysis, Flue Gas Analysis. Turbine–Monitoring and Control: Turbine measurements: electrical, mechanical and process parameters. Turbine control systems: safety and process. Lubrication system for Turbo Alternator and its control. Turbo Alternator cooling system.
Display, Recording, Alarm: Introduction, Display methods, Recorders, Alarm annunciation, Data logging system.

Text Book

1. Principles of Industrial Instrumentation, D Patranabis, Third Edition, Tata McGraw Hill Education Private Limited, New Delhi
2. Power Plant Instrumentation – K.Krishnaswamy, M.Ponnibala, PHI publications,2009.

Reference Book

1. Power Plant Engineering - P.K Nag, Tata McGraw-Hill,2010.

EE 453 Power Station Engineering 3-0-0-6

COAL BASED THERMAL POWER PLANTS Rankine cycle – improvisations, Layout of modern coal power plant, Super Critical Boilers, FBC Boilers, Turbines, Condensers, Steam & Heat rate, Subsystems of thermal power plants – Fuel and ash handling, Draught system, Feed water treatment. Binary Cycles and Cogeneration systems. DIESEL, GAS TURBINE AND COMBINED CYCLE POWER PLANTS Otto, Diesel, Dual & Brayton Cycle–Analysis & Optimisation. Components of Diesel and Gas Turbine power plants. Combined Cycle Power Plants. Integrated Gasifier based Combined Cycle systems. NUCLEAR POWER PLANTS Basics of Nuclear Engineering, Layout and subsystems of Nuclear Power Plants, Working of Nuclear Reactors: Boiling Water Reactor (BWR), Pressurized Water Reactor (PWR), Canada Deuterium- Uranium reactor (CANDU), Breeder, Gas Cooled and Liquid Metal Cooled Reactors. Safety measures for Nuclear Power plants. POWER FROM RENEWABLE ENERGY Hydro Electric Power Plants – Classification, Typical Layout and associated components including Turbines. Principle, Construction and working of Wind, Tidal, Solar Photo Voltaic (SPV), Solar Thermal, Geo Thermal, Biogas and Fuel Cell power systems. ENERGY, ECONOMIC AND ENVIRONMENTAL ISSUES OF POWER PLANTS Power tariff types, Load distribution parameters, load curve, Comparison of site selection criteria, relative merits & demerits, Capital & Operating Cost of different power plants. Pollution control technologies including Waste Disposal Options for Coal and Nuclear Power Plants.

TEXT BOOKS:

1. A Course in Power Plant Engineering:/Arora and S.Domkundwar/Dhanpat Rai Publisher
2. Power Plant Engineering / P.C.Sharma / S.K.Kataria Publisher
3. A Text Book of Power Plant Engineering / R.K.Rajput / Laxmi Publications

REFERENCE BOOKS:

1. Power Plant Engineering/ P.K.Nag II Edition /TMH Publishers
2. An Introduction to Power Plant Technology / G.D. Rai/Khanna Publishers
3. Power plant Engg /Elanchezhian/I.K. International Publishers

EE 457 EHV AC Transmission 3-0-0-6

UNIT-I: Necessity of EHV AC transmission – advantages and problems–power handling capacity and line losses-mechanical considerations – resistance of conductors – properties of bundled conductors – bundle spacing and bundle radius- Examples.Line and ground reactive parameters**:** Line inductance and capacitances – sequence inductances and capacitances – modes of propagation – ground return – Examples.
UNIT- II: E.H.V.A.C. Transmission line trends and preliminary aspect standard transmission voltages – Estimation at line and ground parameters-Bundle conductor systems-Inductance and Capacitance of E.H.V. lines – positive, negative and zero sequence impedance – Line Parameters for Modes of Propagation.
UNIT- III: Electrostatic field and voltage gradients – calculations of electrostatic field of AC lines – effect of high electrostatic field on biological organisms and human beings – surface voltage gradients and maximum gradients of actual transmission lines – voltage gradients on sub conductor.
UNIT- IV: Electrostatic induction in unenergized lines – measurement of field and voltage gradients for three phase single and double circuit lines – unenergized lines. Power Frequency Voltage control and over voltages in EHV lines: No load voltage – charging currents at power frequency-voltage control – shunt and series compensation – static VAR compensation.
UNIT – V: Corona in E.H.V. lines – Corona loss formulae- attention of traveling waves due to Corona – Audio noise due to Corona, its generation, characteristic and limits. Measurements of audio noise radio interference due to Corona – properties of radio noise – frequency spectrum of RI fields – Measurements of RI and RIV.
UNIT- VI: Design of EHV lines based on steady state and transient limits – EHV cables and their characteristics.
TEXT BOOKS:

- R. D. Begamudre, "EHVAC Transmission Engineering", New Age International (p) Ltd. 3rd Edition.
- K.R. Padiyar, "HVDC Power Transmission Systems" New Age International (p) Ltd. 2nd revised Edition, 2012.

REFERENCES:

- S. Rao "EHVAC and HVDC Transmission Engineering. Practice" Khanna publishers.
- Arrillaga. J "High Voltage Direct Current Transmission" 2nd Edition (London) Peter Peregrines, IEE, 1998.
- Padiyar. K.R, "FACTS Controllers in Power Transmission and Distribution" New Age International Publishers, 2007.
- Hingorani H G and Gyugyi. L "Understanding FACTS-Concepts and Technology of Flexible AC Transmission Systems" New York, IEEE Press, 2000.

EE 463 Illumination Engineering 3-0-0-6

UNIT 1: Fundamentals of illumination engineering: Radiant energy, Nature of light, Plane angle, Solid angle, Relation between plane angle and solid angle, Luminous flux, Luminous intensity, Lumen, Candle power, Brightness or Luminance, Illumination, Uniform diffuse source, Mean horizontal candle power (M.H.C.P.), Mean spherical candle power (M.S.C.P.), Mean hemi-spherical candle power (M.H.S.C.P.), Reduction factor, Lamp efficacy, Specific consumption, Utilization factor, Space-height ratio, Coefficient of utilization, Maintenance factor, Depreciation factor, Waste light factor, Absorption factor, Beam factor, Reflection factor, Glare. Measurement and analysis of artificial lighting: Laws of Illumination: inverse square law; cosine law; Lambert's law, Polar curves, Photometry: Photometer bench, Photometer heads, Lummer-bodhun photometer head, Flicker photometer, Integrating sphere, Illumination photometer, Energy radiation and luminous efficiency. Incandescent lamp: heat radiation; filament materials; filament dimension measurement; coiled-coil filament; lamp characteristics, Arc lamp: carbon arc lamps; flame arc lamps; magnetic arc lamps, electric discharge lamps: excitation; ionization; lamps characteristics, Hot cathode lamp, Cold cathode lamp, Neon lamp, Sodium vapour lamp, Mercury vapour lamp, Halogen lamps, Fluorescent lamp: phosphor; starters; chokes; stroboscopic effect; its operation on DC, LEDs, LEDs in communication. Lighting fittings and schemes: Requirements of good lighting, symmetrical fittings: A type fitting; B type fitting; C type fitting; D type fitting; E type fitting, Asymmetrical fittings, Factory lighting, Flood lighting, Street lighting: diffusion principle; specular reflection principle, Recommended illumination levels for different purposes.

Text books:

1. D.C. Pritchard, “Lighting”, 6th Edition, Routledge, 2016
2. Jack L. Lindsey, “Applied Illumination Engineering”, PHI, 1991

EE 465 Introduction To Digital Signal Processing 3-0-0-6

EE4XY	DEPARTMENTAL ELECTIVE-II	**[3-0-0-6]**

EE 467 Utilization of Electric Power 3-0-0-6

Module 1

Heating and welding: Electric Heating, Resistance ovens, Radiant Heating, Induction Heating, High frequency Eddy Current Heating, Dielectric Heating, The Arc Furnace, Heating of Buildings, Air -Conditioning, Electric Welding, Modern Welding Techniques. Electrolytic Electro-Metallurgical Process:Ionization, Faraday’s Laws of Electrolysis, Definitions, Extraction of Metals, Refining of Metals, Electro Deposition.

Module 2

Illumination: Introduction, Radiant Energy, Definitions, Laws of Illumination, Polar Curves, Photometry, Measurement of Mean Spherical Candle Power by Integrating Sphere, Illumination Photometer, Energy Radiation and luminous Efficiency, electric Lamps, Cold Cathode Lamp, Lighting Fittings, Illumination for Different Purposes, Requirements of Good Lighting.

Module 3

Module 4

Braking: Introduction, Regenerative Braking with Three Phase Induction Motors, Braking with Single Phase Series Motors, Mechanical braking, Magnetic Track Brake, Electro-Mechanical Drum Brakes. Electric Traction Systems and Power Supply: System of Electric Traction, AC Electrification Transmission Lines to Sub-Stations, Sub-Stations, Feeding and Distribution System of AC Traction Feeding and Distribution System for DC Tramways, Electrolysis by Currents through Earth, Negative Booster, System of Current Collection, Trolley Wires. Trams, Trolley Buses and Diesel-Electric Traction: Tramways, The Trolley-Bus, Diesel Electric Traction.

Module 5

Electric Vehicles: Configurations of Electric Vehicles, Performance of Electric Vehicles, Tractive Effort in Normal Driving, Energy Consumption. Hybrid Electric Vehicles: Concept of Hybrid Electric Drive Trains, Architectures of Hybrid Electric Drive Trains.

EE 469 Electric Traction and Drives 3-0-0-6

Introduction to Traction: General features of Electric traction, Measurement of train movement.
Tractive Effort: Calculation of tractive effort, Electrical Motors for traction, Modern Power Electric converters in modern traction.
AC Drives in Electric Traction: Diesel electric traction, reference of Indian Standards, AC drives in Electric Traction.
Vector Controller Induction Motor Drive: Dynamic d-q model of 3 phase induction motor d-q equivalent circuit (stator, rotor, synchronously rotating reference frames model), equation of flux linkage, small signal equations of induction motor, dynamic model state space equations, Principles of vector control, direct vector control, implementation with voltage source, Derivation of indirect vector control scheme.
Parameter Compensation: Parameter sensitivity of the indirect vector-controlled induction motor drive, Parameter Sensitivity compensation, Speed- Controller design for an indirect vector controller induction motor drive, Sensor less vector control.

Text Book

1. Fundamentals of Electric Drives by G K Dubey Narosa publishing House , 3rd Edition , 2002
2. Bimal K. Bose, Power Electronics and Motor Drives: Advances and Trends, Academic Press, 2006.

Reference Book

1. S. K. Pillai : A First Course On Electrical Drives, 2nd Edition, New Age International Publishers,2007.
2. N. K. De, P. K. Sen: Electric Drives, 7th Edition, PHI Learning Pvt. Ltd., 2004

EE 471 Numerical Relays 3-0-0-6

UNIT – I Introduction to Computer Relaying Introduction to DSP, Use of computer relay, Analog to Digital Converters, Sampling, Anti – aliasing filters. Evolution of power system relaying from electromagnetic to static to computer relaying; Relay operating principles for computer relaying; Expected benefits of computer relaying, Computer relay architecture.

UNIT – II Protection of Transmission Line using Computer Relaying Three zone protection of transmission line, algorithms for impedance calculations- Mann-Morrison algorithm . Three sample technique - Two sample technique - First and second derivative algorithms - Numerical integration methods.

UNIT –III Protection of power system equipment using Frequency domain techniques Problems associated with differential protection of transformer and bus-bar, magnetic inrush current, LSQ algorithm, Fourier analysis of transformer protection.

UNIT –IV Phasor Measurement Units Introduction to Phasor measurement units (PMUS), global positioning system (GPS), Functional requirements of PMUs and PDCs, phasor estimation of nominal frequency inputs

UNIT –V PMU Applications Wide Area Measurement Systems (WAMS), WAMS Applications in Smart Grid, WAMS Based Protection Concepts, Adaptive Relaying, State estimation.

Reference Books:

1. John G. Prokis and Dimitris G. Hanolakis, 'Digital Signal Processing, Principles, Algorithms & Applications' 4th Edition, Pearson Education, 2006
2. A.G. Phadke, J.S. Thorp, 'Computer Relaying for Power Systems', John Wiley and Sons Ltd., Research Studies Press Limited, 2nd Edition, 2009
3. A.G. Phadke, J.S. Thorp, 'Synchronized Phasor Measurements and Their Applications', Springer Publications, 2008

EE 473 Advanced Power Electronics 3-0-0-6

Switching Voltage Regulators, Introduction; Linear power supply (voltage regulators); Switching voltage regulators; Review of basic dc-dc voltage regulator. configurations -Buck, Boost, Buck-Boost converters and their analysis for continuous and discontinuous mode; Other converter configurations like Flyback converter, Forward converter, Half bridge, Full bridge configurations, Push-pull converter, Cuk converter, Sepic Converter; Design criteria for SMPS; Multi-output switch mode regulator. Resonant Converters Introduction, Need of resonant converters, Classification of resonant converters, Load resonant converters, Resonant switch converters, zerovoltage switching dc-dc converters, zero current switching dc-dc converters, clamped voltage topologies Multi-level converters Need for multi-level inverters, Concept of multi-level, Topologies for multi-level: Diode Clamped, Flying capacitor and Cascaded H-bridge multilevel Converters configurations; Features and relative comparison of these configurations applications, Introduction to carrier based PWM technique for multi-level converters, Multipulse Converters

Reference Books:

1. Ned Mohan, Tore M. Undeland and William P. Robbins, "Power Electronics – Converters, Applications and Design", John Willey & sons, Inc., 3rd ed., 2003.
2. Muhammad H. Rashid, "Power Electronics - Circuits, Devices and Applications", Prentice Hall of India, 3rd ed., 2009.
3. Bin Wu, "High Power Converters and AC Drives", John Willey & sons, Inc., 2006.
4. Derek A. Paice "Power Electronic Converter Harmonics – Multipulse Methods for Clean Power", IEEE Press, 1996.
5. Muhammad H. Rashid , "Power Electronics Handbook", Elsevier, 3rd ed., 2011.
6. P.C.Sen, "Modern Power Electronics ", S. Chand and Co. Ltd., New Delhi, 2000.
7. Vijay K. Sood, "HVDC and FACTS Controllers Applications of Static Converters in Power Systems", Kluwer Academic Publishers, Boston, 2004.
8. L. Umanand, "Power Electronics Essentials and Applications", Wiley India Ltd., 2009

EE 475 HVDC Transmission 3-0-0-6

DC power transmission technology: Introduction, Comparison of HVAC and HVDC transmission system, Applications of DC transmission, Description of DC transmission system, Configurations, Modern trends in DC transmission.
Analysis of HVDC converters: Pulse number, Choice of converter configuration, Simplified analysis of Graetz circuit, Converter bridge characteristics, Characteristics of a twelve-pulse converter, Detailed analysis of converters with and without overlap.
Converter and HVDC system control: General, Principles of DC link control, Converter control characteristics, System control hierarchy, Firing angle control, Current and extinction angle control, Starting and stopping of DC link, Power control, Higher level controllers. **Converter faults and protection:** Converter faults, Protection against over-currents, Overvoltages in a converter station, Surge arresters, Protection against over-voltages.
Smoothing reactor and DC line: Introduction, Smoothing reactors, DC line, Transient over voltages in DC line, Protection of DC line, DC breakers, Monopolar operation, Effects of proximity of AC and DC transmission lines.
Reactive power control: Reactive power requirements in steady state, Sources of reactive power, Static VAR systems, Reactive power control during transients, Harmonics and filters, Generation of harmonics, Design of AC filters, DC filters.
Component models for the analysis of ac/dc systems: General, Converter model, Converter control, Modelling of DC network, Modelling of AC networks.
Power flow analysis in AC/DC systems: General, Modelling of DC links, Solution of DC load flow, Discussion, Per unit system for DC quantities

Text Books / Reference Books

1. Arrillaga, J., HVDC Transmission, IEE Press (2007).
2. Edwart, K., Direct Current Transmission (Vol. 1), John Wiley and Sons (2008).
3. Padiyar, K.R., HVDC Power Transmission System, New Age International (P) Limited,
4. Publishers (2008).
5. Arrillaga, J. and Smith, B.C., AC to DC Power System Analysis, IEE Press (2008)

EE 477 Computer Methods in Power Systems 3-0-0-6

Elementary linear graph theory: Incidence and network matrices. Calculation of Z-Bus, Y-Bus, Z-Loop by singular and non-singular transformations. Algorithm for the calculation of Z-Bus of singular and three phase network. Short circuit studies using Z-Bus, Y-Bus.
Different methods of solution of Linear and non-linear algebraic equations: Gauss-Scidel, Gront relaxation, Newton-Raphson and iterative methods. Load flow studies by different methods, solution of the swing equations. Representation of off-load and on-load tap changing and phase-shifting transformers for the purpose of load flow studies.
Central Computer Control and Protection: Data collection and manipulation, supervisory control relay target logging, state estimation program, Operating procedure recommendations, automatic fault study and relay setting, power system stability monitoring, corrective action for stability problem. Automatic generation control, economic dispatch, generation schedule, optimum unit commitment interchange negotiation, volt/ VAR dispatch, weather forecast analysis, load forecast – future, evaluation of proposed operation, system security, load flow calculations, environmental monitoring.
Reference books:

1. Stagg and Al Albiad, Computer Application in Power System, McGraw Hill
2. M.A. Pai., Computer Techniques in Power System Analysis, TMH
3. George L. Kusic, Computer aided power system analysis , PHI
4. Wood and Wollenberg, Power generation and Control, John Wiley

EE 479 Power Quality 3-0-0-6

UNIT I: INTRODUCTION TO POWER QUALITY
Terms and definitions & Sources – Overloading, under voltage, over voltage - Concepts of transients - short duration variations such as interruption - long duration variation such as sustained interruption - Sags and swells - Voltage sag - Voltage swell - Voltage imbalance – Voltage fluctuations - Power frequency variations - International standards of power quality – Computer Business Equipment Manufacturers Associations (CBEMA) curve

UNIT II: VOLTAGE SAG AND SWELL

Estimating voltage sag performance - Thevenin's equivalent source - Analysis and calculation of various faulted condition - Estimation of the sag severity - Mitigation of voltage sag, Static transfer switches and fast transfer switches. - Capacitor switching – Lightning - Ferro resonance - Mitigation of voltage swell.

UNIT III: HARMONICS

Harmonic sources from commercial and industrial loads - Locating harmonic sources – Power system response characteristics - Harmonics Vs transients. Effect of harmonics – Harmonic distortion - Voltage and current distortions - Harmonic indices - Inter harmonics – Resonance Harmonic distortion evaluation, IEEE and IEC standards.

UNIT IV: PASSIVE POWER COMPENSATORS

Principle of Operation of Passive Shunt and Series Compensators, Analysis and Design of Passive Shunt Compensators Simulation and Performance of Passive Power Filters- Limitations of Passive Filters Parallel Resonance of Passive Filters with the Supply System and Its Mitigation. Fundamentals of load compensation – voltage regulation & power factor correction.

UNIT V: POWER QUALITY MONITORING & CUSTOM POWER DEVICES

Monitoring considerations - Monitoring and diagnostic techniques for various power quality problems - Quality measurement equipment - Harmonic / spectrum analyzer - Flicker meters Disturbance analyzer - Applications of expert systems for power quality monitoring. Principle& Working of DSTATCOM – DSTATCOM in Voltage control mode, current control mode, DVR Structure – Rectifier supported DVR – DC Capacitor supported DVR -Unified power quality conditioner.

TEXT BOOKS:

1. Roger. C. Dugan, Mark. F. Mc Granagham, Surya Santoso, H.Wayne Beaty, "Electrical Power Systems Quality", McGraw Hill,2003
2. J. Arrillaga, N.R. Watson, S. Chen, "Power System Quality Assessment", (New York:Wiley),2000.
3. Bhim Singh, Ambrish Chandra, Kamal Al-Haddad, "Power Quality Problems & Mitigation Techniques" Wiley, 2015.

EE 481 Distribution Systems Planning & Automation 3-0-0-6

Distribution System Planning: Planning and forecasting techniques – Present and future – Role of computers-Load Characteristics Load forecasting using ANN – Load management – tariffs and metering of energy.

Distribution Transformers: Types – Three phase and single phase transformers – connections – causes and types of failures in distribution transformers.

Primary distribution systems and Distribution Sub–Stations: Distribution substations –Bus schemes – comparison of switching schemes- Substation location and rating- Types of feeders – voltage levels.

Voltage Drop and Power Loss Calculations: Three phase primary lines – Copper loss – Distribution feeder costs – Loss reduction and Voltage improvement in rural networks.

Capacitors in Distribution Systems: Effects of series and shunt capacitors – justification for capacitors – Procedure to determine optimum capacitor size and location.

Distribution System Automation: Reforms in power sector – Methods of improvement – Reconfiguration – Automation – Communication systems – Sensors –Basic architecture of Distribution automation system – software and open architecture – RTU and Data communication – SCADA requirement and application functions – Communication media for distribution system automation- Communication protocols for Distribution systems – IEC 61850 and IEEE 802.3 standards.

Distribution system management: Integrated sub–station metering system – Revenue improvement – issues in multi–year tariff and availability based tariff.

Text books:

1. Turan Gonen : Electric Power Distribution Engg., Mc-Graw Hill,1986.
2. James A Momoh: Electric Power Distribution, Automation, Protection and Control, CRC press.
3. A. S. PABLA : Electric Power Distribution, TMH,2000.

REFERENCES:

1. G.T. Heydt, "Electric Power Quality", 2nd Edition. (West Lafayette, IN, Stars in a Circle Publications, 1994.
2. M.H.J Bollen, "Understanding Power Quality Problems: Voltage Sags and Interruptions", (New York: IEEE Press), 2000

EE4XY	DEPARTMENTAL ELECTIVE-III	**[3-0-0-6]**

EE 452 Surge and Lightning Protection And Safety Devices 3-0-0-6

UNIT 1: Modern Trends in Power System Protection, Need for Protective Systems, Nature and Causes of Faults, Types of Faults, Effects of Faults, Fault Statistics.
UNIT 2: Fuse Characteristics, Types of Fuses, Applications of HRC Fuses, Selection of Fuses, Discrimination.
UNIT 3: Protection Against Overvoltages, Causes of Overvoltages, Lightning Phenomena, Wave Shape of Voltage Due to Lightning, Overvoltages Due to Lightning, Klydonograph and Magnetic Link, Protection of Transmission Lines against Direct Lightning Strokes, Protection of Stations and Sub-stations from Direct Strokes, Protection Against Travelling Waves, Peterson Coil, Insulation Coordination, Basic Impulse Insulation Level (BIIL).
UNIT 4: Circuit Breakers, Fault Clearing Time of a Circuit Breaker, Arc Voltage, Arc Interruption, Restriking Voltage and Recovery Voltage, Resistance Switching, Current Chopping, Interruption of Capacitive Current, Classification of Circuit Breakers High Voltage DC (HVDC) Circuit Breakers, Rating of Circuit Breakers.
UNIT 5 : Relay Construction and Operating Principles, Electromagnetic Relays, Static Relay.

Reference Books:

1. Lewis Blackburn, J., 'Protective Relaying – Principles and Applications', Marcel Dekkar, INC, New York, 2006.
2. The Electricity Training Association, 'Power System Protection Vol1-4', The IEE, U.K., 2005. 3. C. Russeil Mason, 'The art and Science of Protective Relaying', GE Publishers, 1962.
3. T. Johns and S. K. Salman, 'Digital Protection for Power Systems', Peter Peregrinus Ltd.,1997.
4. Arun G Padkye and James S Thorp, 'Computer Relaying for Power Systems', John Wiley publications, 2nd Edition, 2009.
5. P M Anderson, 'Power System Protection', IEEE Press, 2012.

EE 454 Smart Grid 3-0-0-6

Basic Power Systems: Load Modeling and generation systems for conventional and restructured power system. Power Flow Analysis.
Renewable Generation : Renewable Resources: Wind and Solar, Micro-grid Architecture, Distributed Storage and Reserves, Dealing with short term variations, stochastic models based on price forecasting.
Power System Economics: Power system generation economics, Modeling of Consumers and producers, Electricity market structures, Marginal price, Optimal Power Flows, Distribution systems basics under new environment etc.
Smart Grid: Definition, Various components, Application and standards, Impacts of Smart Grid on reliability, Impacts of Smart Grid on air pollutant emissions reduction.
Smart Grid Communications: Two-way Digital Communications Paradigm, Network Architectures, IP-based Systems Power Line Communications, Advanced Metering Infrastructure.
Demand Side Management: Definition, Applications, Load characteristics, load curve and load duration curve, Energy Consumption Scheduling, Controllable Load Models, Dynamics, and Challenges, Plug-in-hybrid Vehicles and smart appliances.
Wide Area Measurement: Sensor Networks, Phasor Measurement Units, Communications Infrastructure, Fault Detection and Self-Healing Systems, Applications and Challenges.
Security and Privacy: Cyber Security Challenges in Smart Grid, Load Altering Attacks, False Data Injection Attacks, Defense Mechanisms, Privacy Challenges.

Reference:

1. D.S. Kirshen, Fundamentals of Power System Economics, John Wiley & Sons
A. J. Wood, B. F. Wollenberg, Power Generation Operation and Control , John Wiley & Sons
2. G. M. Masters, Renewable and Efficient Electric Power Systems, John Wiley & Sons
3. S. Stoft, Power System Economics: Designing Markets for Electricity, Wiley-Interscience

EE 456 Power Market Reforms 3-0-0-6

Overview of key issues in electric utilities restructuring: Introduction, restructuring models, independent system operator, power exchange, market operations, market power, stranded costs, transmission pricing , congestion pricing, management of inter zonal/ intra zonal congestion

Open Access Same Time Information System: Introduction, structure of OASIS, implementation of OASIS phases, posting of information, transfer capability of OASIS, transmission services, methodologies to calculate ATC, experience with OASIS in some restructuring models.

Tagging Electricity Transactions: Introduction, definition of tagging, historical background on tagging, how does a tagging process work? Identify tags, data elements of a tag, communication during failure recovery, transaction states, implementations, curtailment and cancellation of transactions.

Electric energy trading: Introduction, essences of electric energy trading, energy trading framework, derivative instruments of energy trading, portfolio Management, energy trading hubs, brokers in electricity trading, green power trading,.

Hedging tools for managing risk in electricity markets: Introduction, risk, definition of hedge, sources of electricity market risks, value at Risk, counterparty risk, risk evaluation in electricity trading, hedging weather risk.

Books:

1. Wood A and Wollenberg B, Power generation, Operation and control, Second Edition John Wiley & Sons Inc.
2. A Chambers, Merchant Power: A basic Guide, Pennwell Publishers
3. D Pilipovic, Energy Risk: Valuing and Managing Energy Derivatives, MC Graw-Hill
4. Fusaro P, Energy Risk Management: Hedging Strategies and Instruments for the international Energy Markets, McGraw-Hill, New York
5. Jorion P, Value at Risk, McGraw Hill, New York

EE 460 Electric And Hybrid Vehicles 3-0-0-6

Introduction to Hybrid Electric Vehicles, Conventional Vehicles, Hybrid Electric Drive-trains, Electric Propulsion unit, Configuration and control of DC Motor drives, Induction Motor drives, Permanent Magnet Motor drives, switched reluctance motor, Energy Storage Requirements in Hybrid and Electric Vehicles, Sizing the drive system, Design of a Hybrid Electric Vehicle, Energy Management Strategies.

Text books:

1. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.

References:

1. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.
2. Mehrdad Ehsani, YimiGao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.

EE 462 Modern Control System 3-0-0-6

System representation-introduction to state and state variable- transformations- state transition matrix properties and methods of valuation - time response of linear systems - state diagrams - resolvent matrix controllability and observability-state variable feedback - pole placement-stability-stability in the sense of lyapunov, stability of linear systems and non-linear systems-optimal control-formulation of the optimal control problem - use of Hamiltonian method - continuous time linear state regulator matrix riccati equation-state variable feedback design.

TEXTS:

1. Katsuhiko Ogata : Modern Control Engineering, 5th Edition, Prentice-Hall of India, 2010.
2. M. Gopal : Modern Control Systems Theory, 2nd Edition, New Age Intl. Pvt. Ltd., 1993.

EE 464 Solid State Drives 3-0-0-6

DRIVE CHARACTERISTICS: Electric drive – Equations governing motor load dynamics – steady state stability – multi quadrant Dynamics: acceleration, deceleration, starting & stopping – typical load torque characteristics – Selection of motor, CONVERTER / CHOPPER FED DC MOTOR DRIVE: Steady state analysis of the single and three phase converter fed separately excited DC motor drive– continuous conduction – Time ratio and current limit control – 4 quadrant operation of converter / chopper fed drive-Applications, INDUCTION MOTOR DRIVES: Stator voltage control–V/f control– Rotor Resistance control-qualitative treatment of slip power recovery drives-closed loop control— vector control- Applications, SYNCHRONOUS MOTOR DRIVES: V/f control and self-control of synchronous motor: Margin angle control and power factor control- Three phase voltage/current source fed synchronous motor- Applications, DESIGN OF CONTROLLERS FOR DRIVES: Transfer function for DC motor / load and converter – closed loop control with Current and speed feedback– armature voltage control and field weakening mode – Design of controllers; current controller and speed controller- converter selection and characteristics.

Text books:

1. Gopal K.Dubey, Fundamentals of Electrical Drives, Narosa Publishing House, 1992.
2. Bimal K.Bose. Modern Power Electronics and AC Drives, Pearson Education, 2002.
3. R.Krishnan, Electric Motor & Drives: Modeling, Analysis and Control, Pearson, 2001.

References:

1. Vedam Subramanyam, " Electric Drives Concepts and Applications ", 2e, McGraw Hill, 2016
2. Shaahin Felizadeh, "Electric Machines and Drives", CRC Press (Taylor and Francis Group), 2013.
3. John Hindmarsh and Alasdain Renfrew, "Electrical Machines and Drives System," Elsevier 2012.

EE 466 Digital Control System 3-0-0-6

Discrete-time system representations: modeling discrete-time systems by linear difference equations and pulse transfer functions, time responses of discrete systems; discrete state-space models, stability of discrete-time systems. Finite settling-time control design: deadbeat systems, inter sample behaviour, time-domain approach to ripple-free controllers, limitations and extensions of the deadbeat controller.
State-feedback design techniques: linear system properties, state feedback using Ackermann's formula, tracking of known reference inputs. Output-feedback design techniques: observer design,
observer-based output feedback design.

Texts:

1. B. C. Kuo, Digital Control Systems; Oxford University Press, 2/e, Indian Edition, 2007.
2. K. Ogata, Discrete Time Control Systems; Prentice Hall, 2/e, 1995.
3. M. Gopal, Digital Control and State Variable Methods; Tata Mcgraw Hill, 2/e, 2003.
4. G. F. Franklin, J. D. Powell and M. L. Workman; Digital Control of Dynamic Systems; Addison Wesley, 1998, Pearson Education, Asia, 3/e, 2000.
5. K. J. Astroms and B. Wittenmark, Computer Controlled Systems - Theory and Design; Prentice Hall, 3/e, 1997.

EE4XY	OPEN ELECTIVE/DEPARTMENTAL ELECTIVE-IV	**[3-0-0-6]**

EE468 Energy Harvesting Techniques 3-0-0-6

Wind Energy harvesting: Fundamentals of Wind energy, Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces, and grid interconnection topologies, Ocean Energy: Ocean Energy Potential against Wind and Solar, Wave Characteristics and Statistics, Wave Energy Devices. Tide characteristics and Statistics, Tide Energy Technologies, Ocean Thermal Energy, Osmotic Power, Ocean Bio-mass, Geothermal Energy: Geothermal Resources, Geothermal Technologies, Hydro Energy: Hydropower resources, hydropower technologies, environmental impact of hydro power sources, Piezoelectric Energy harvesting: Introduction, Physics and characteristics of piezoelectric effect, materials and mathematical description of piezoelectricity, piezoelectric parameters and modeling piezoelectric generators, piezoelectric energy harvesting applications,

Human power Electromagnetic Energy Harvesting: Linear generators, physics mathematical models, recent applications, Carbon captured technologies, cell, batteries, power consumption. Environmental issues and Renewable sources of energy, sustainability.

References:

1. Non-conventional energy sources - G.D Rai - Kh^nna Publishers, New Delhi
2. Solar energy - M P Agarwal - S Chand and Co. Ltd.
3. Solar energy - Suhas P Sukhative Tata McGraw - Hill Publishing Company Ltd.
4. Godfrey Boyle, "Renewable Energy, Power for a feustainable future", 2004, Oxford University Press, in association with The Open University.
5. Dr. P Jayakumar, Solar Energy: Resource Assesment Handbook, 2009
6. J.Balfour, M.Shaw and S. Jarosek, Photovoltaics, Lawrence J Goodrich (USA).

EE470 Sensors And Transducers 3-0-0-6

General concepts and terminology of measurement systems, transducer classification, general input-output configuration, static and dynamic characteristics of a measurement system, Statistical analysis of measurement data. Resistive transducers: Potentiometers, metal and semiconductor strain gauges and signal conditioning circuits, strain gauge applications: Load and torque measurement, Digital displacement sensors. Self and mutual inductive transducers- capacitive transducers, eddy current transducers, proximity sensors, tacho-generators and stroboscope. Piezoelectric transducers and their signal conditioning, Seismic transducer and its dynamic response, photoelectric transducers, Hall effect sensors, magneto strictive transducers. Introduction to semiconductor-sensor, materials, scaling issues and basics of micro fabrication. Smart sensors.

Text Books

1. John P. Bentley, Principles of Measurement Systems, Pearson Education, 4th Edition, 2005.
2. Doebelin E.0, Measurement Systems - Application and Design, McGraw-Hill, 4th Edition,2004.
3. S.M. Sze, Semiconductor sensors, John Wiley & Sons Inc., 3rd Edition, 2006.

Reference Books

1. Murthy D. V. S, Transducers and Instrumentation, Prentice Hall, 2nd Edition, 2011
2. James W.Dally, Instrumentation for Engineering Measurements, Wiley, 2nd Edition, 1993
3. John G.Webster, Sensors and Signal Conditioning, Wiley Inter Science, 2nd Edition, 2008
4. Neubert H.K.P, Instrument Transducers - An Introduction to their Performance and Design, Oxford University Press, 2nd Edition, 1999.
5. Patranabis, Sensors and Transducers, Prentice Hall, 2nd Edition, 2003.
6. Waldemar Nawrocki, Measurement Systems and Sensors, Artech House, 2005

EE472 Energy Storage Systems 3-0-0-6

Battery technology Overview: Battery definitions, terms and terminology, Battery types and their properties, Introduction to lithium ion battery, Components, functions, advantages and disadvantages of lithium-ion batteries, Growth & development of Li-Ion batteries, charging procedures, Safety of lithium-ion batteries, Lifetime, Types of lithium ion battery: Lithium Cobalt Oxide (LCO), Lithium Iron Phosphate Battery (LFP), Lithium Manganese Oxide (LMO), Lithium Nickel Cobalt Aluminium Oxide (LNCA), Lithium Nickel Manganese Cobalt Oxide (LNMC), Lithium Polymer Battery, Lithium Polymer Battery technology, Difference between the lithium ion and lithium polymer, Applications of Li-ion battery: Battery Requirements- Electrical Requirements, Thermal Requirements, Mechanical Requirements. Automotive Applications- Drive Cycles, SLI (starting, lighting and ignition) batteries, Start-Stop (Micro) Hybrids, Power Assist Hybrids, Plug-In Hybrids, BEVs, Fuel Cells: Introduction to fuel cells, components of fuel cells, Types of fuel cells: Alkaline fuel cells, proton exchange membrane fuel cell, phosphoric acid fuel cell, molten carbonate fuel cell, Solid oxide fuel cell, Types of solid oxide fuel cells: High temperature, intermediate temperature Single chamber solid oxide fuel cells, Working Principle and Application of fuel cells: working principle of fuel cell, performance characteristics of fuel cells,

efficiency of fuel cell, fuel cell stack, description of some commercially available fuel cell stacks, fuel cell cars and buses, overview on research activities.

Text Books:

1. Lithium-Ion Batteries Basics and Applications by Reiner Korthauer, Springer.
2. Lithium-Ion Batteries Science and Technologies by Ralph J. Brodd (auth.), Masaki Yoshio, Ralph J. Brodd, Akiya Kozawa (eds.), Springer.
3. Lithium-ion Batteries Fundamentals and Applications. by Wu, Yuping, CRC Press, Taylor and Francis.
4. O'hayre, S.W. Cha, W.G. Colella, F.B. Prinz, Fuel Cell Fundamentals, 3rd edition, Wiley publisher.
5. High-temperature Solid Oxide Fuel Cells for the 21st Century, Second Edition Fundamentals, Design and Applications by Kendall, Kevin Kendall, Michaela.
6. Fuel cells from fundamentals to applications by Supramaniam Srinivasan, Springer.

References:

1. Handbook of lithium-ion battery pack design chemistry, components, types and terminology by Warner, John T, Elsevier.
2. Fundamentals and Application of Lithium-ion Battery Management in Electric Drive Vehicles by San Ping Jiang, Wiley.
3. Lithium ion rechargeable batteries by edited by Kazunori Ozawa, Wiley.
4. E. Lipman, A. Z. Weber, Fuel Cells and Hydrogen Production, A Volume in the Encyclopedia of Sustainability Science and Technology, Second Edition, Springer reference.
5. Modern electric, hybrid electric, and fuel cell vehicles fundamentals, theory, and design by Mehrdad Ehsani, Yimin Gao, Sebastien E. Gay, Ali Emadi, CRC press

EE476 Bio-Medical Instrumentation Engineering 3-0-0-6

Introduction: Generalized Medical Instrumentation System, Roles of Engineering in Healthcare systems, Biometrics, Problems encountered in measuring physiological parameters. Physiological transducers: Various types of transducers for measurement of temperature, pressure, flow etc. and their selection for medical applications, Different types of electrodes. Electric signals and electronics: Origin of bio-electric signals, Bioelectric potentials, Biopotential electrodes, Measurement of electrical activities in heart, muscles and brain: Electrocardiograph, Electroencephalograph, Electromyograph and their interpretations. Cardiovascular measurement: Electrocardiograph, Measurement of ECG, ECG electrodes, ECG Amplifiers, Common mode interference reduction circuits, Cardiac pacemaker, Phonocardiograph, Measurement of heart rate, Plethysmography Different physiological parameters measurement and monitoring systems: Blood pressure measurement, Electromagnetic blood flow meter, Ultrasonic blood flow meter, Doppler flow meter, Measurement of temperature, Respiratory System Measurement: Respiration rate measurement, Blood pH Measurement, Pulse oximeter, Coulter counters, Automatic recognition and differential counting of cells, Ultrasonography, X-ray.

Text books:

1. Leslie Cromwell, Fred J. Weibell and Erich A. Pfeiffer, "Biomedical Instrumentation and Measurements", 2nd Edition, Prentice Hall, New Delhi.
2. R. S. Kandpur, "Handbook of Biomedical Instrumentation", Tata McGraw Hill, New Delhi.