

**DEPARTMENT OF POWER ENGINEERING  
JADAVPUR UNIVERSITY  
REVISED COURSE CURRICULUM OF 4-YEAR B.E. POWER ENGINEERING**

**FIRST YEAR FIRST SEMESTER**

**PE/Chem/T/111                      CHEMICAL SCIENCE**

Electronic structure of atoms - Chemical bonding and molecular structure organic molecules. The gaseous, solid and liquid states. Chemical thermodynamics. Equilibrium - phase and chemical equilibrium. Acids, bases and salts. Electrochemistry. Kinematics and mechanism of reactions. Carbon compounds- reaction and synthesis. Chemistry of representative elements - water chemistry. Chemistry of semiconductor materials. Chemistry of radioactive materials - nuclear chemistry. Environmental Chemistry.

**PE/Math/T/112                      MATHEMATICS-IQ**

Differential Calculus: Successive differentiation, Rolle's theorem (statement only), Mean value Theorem, Taylors Theorem, Maclaurin's series, Maxima and minima, Indeterminate forms, Functions of two or more variables, Partial derivatives. Integral Calculus: Properties of definite integrals, Fundamental theorem of integral calculus, Improper integrals, Beta and Gamma functions, Multiple integrals, definition and properties, Application Arc length and areas of plane curves. Volumes and surface areas of solids of revolution.

Fundamentals of Vector and Tensor Algebra: Einstein notations, Scalar, vector and dyadic products of vectors, Scalar triple products. Engineering applications of vector and tensor algebra.

**PE/Math/T/113                      MATHEMATICS-IIQ**

Complex numbers: De'Moivre's Theorem, Exponential values of sines and cosines, Elementary knowledge of hyperbolic functions. Determinants and Matrices: Definition and properties, Product of two determinants, Cramer's rule. Addition and Multiplication of matrices. Adjoint and inverse of a matrix. Solution of a system of linear equations by matrix method. Sequence & Infinite series: Convergence and divergence, Comparison test, D' Alembert's ratio test and Cauchy's root test. Fourier Series: Solution of one dimensional wave and diffusion equations and two dimensional Laplace equations. Fourier Transforms.

**PE/T/114                      ENGINEERING MECHANICS-I**

Basic Units and dimensions, Introduction to vector algebra, Free body diagram, Equilibrium equations, trusses and frames, friction forces and their applications, screw and belt friction; Properties of surfaces; Principle of virtual work; Distributed force and center of gravity.

Concept of stress, strain, stress-strain diagrams, tension, compression and shear, thermal stresses, general case of stress; Mohr's circle, thin-walled pressure vessels, torsion in circular shafts.

## **PE/T/115 ENGINEERING DRAWING**

Introduction to drawing instruments & aids. Types of lines; Engineering lettering; Geometric drawing & curves; Scales & dimensioning, I.S. Conventions. Projections of points, lines and surfaces, concept of true length. Orthographic projections, Isometric drawing & Sectional views. Advanced problems on projection drawing, sectional views & auxiliary views.

## **PE/Ph/T/116 PHYSICS**

1. Simple harmonic motion, Composition of simple harmonic motion, Forced vibration and resonance, Wave equation in one dimension and travelling wave solution, Standing waves, Wave velocity and group velocity.
2. Assumption for the kinetic theory of gases, Expression for pressure, Significance of temperature, Deduction of gas laws, Qualitative idea of (i) Maxwell's velocity distribution. (ii) degrees of freedom and equipartition of energy, Specific heat of gases at constant volume and constant pressure.
3. Equation of state of a gas, Andrew's experiment, Qualitative discussion on van der Waal's equation of state, Critical constants, Law of corresponding states.
4. Electric potential and intensity, Electric field, Gauss's law and its application to problems with spherical and cylindrical symmetry, Capacitance and capacitor, Potential and field due to a dipole, Dielectric polarisation, Electric displacement vector, dielectric susceptibility.
5. Biot-Savart law and Ampere's law in magnetostatics and their engineering applications, Faraday's law of electromagnetic induction, Self and mutual inductance, Resonance and oscillation in electrical circuits.
6. Nature of light waves, Interference, diffraction and polarization of light waves, Applied optics: engineering measurements. Lasers.
7. Energy levels of the hydrogen atom and the Bohr atom model, X-ray spectra, X-ray diffraction, Bragg's law, Compton effect. De-Broglie waves, Particle diffraction, Uncertainty principle and its application.

## **PE/Ph/S/111 PHYSICS LABORATORY-I**

(Selected Experiments from the following)

1. Determination of Galvanometer resistance by half - deflection method.
2. Determination of Galvanometer resistance by Thomson's method.
3. To find high resistance by Galvanometer deflection method.
4. To measure mechanical equivalent of heat, J by electrical method (Joule's) using copper calorimeter (radiation correction to be done).
5. To compare to low resistance by drop of potential method.
6. To determine resistance per unit length of wire by using Carey Foster bridge.
7. To estimate strength of a current by using copper voltmeter.
8. a) To compare the EMF's of two cells by using a potentiometer b) To measure current by using a potentiometer
9. To measure the horizontal components of earth's magnetic field intensity using deflection and vibrating magnetometers.
10. Determination of co efficient of linear expansion by optical lever method.
11. Determination thermal conductivity of metal by Searle's method.

12. To determine co-efficient of viscosity by Capillary flow method.
13. Determination of Young's modulus by Flexure method.
14. To draw mutual and anode characteristics of triode and hence too find  $R_p$ ,  $\mu$ , and  $g_m$
15. To draw the transistor characteristics (NPN/PNP) in the given configuration and hence to find  $h_i$ ,  $h_f$
16. Determination of refractive index of the material of the glass prism by prism spectrometer
17. Study of collisions in one dimension using a linear air track
18. Use of an air track for obtaining potential energy curves for magnetic interactions.
19. Study of oscillations under potential wells of various shapes using an air track.
20. Experiments on diffraction in single slit, double slit and plane grating using He-Ne laser
  - a) To find the wavelength of a monochromatic light by single slit.
  - b) To find slit separation of a double slit.
  - c) To find number of rulings per cm of a plane grating
21. To find the wavelength of a monochromatic light by Newton rings.
22. Fabry-Perot interferometry: To find out separation of wavelength of sodium D1 & D2 lines.

**PE/ Chem/S/112      CHEMISTRY LABORATORY**

To supplement the theoretical course on "Chemical Science".

**PE/S/113      ENGINEERING DRAWING**

Introduction to drawing instruments & aids. Types of lines; Engineering lettering; Geometric drawing & curves; Scales & dimensioning, I.S. Conventions. Projections of points, lines and surfaces, concept of true length. Orthographic projections, Isometric drawing & Sectional views. Advanced problems on projection drawing, sectional views & auxiliary views.

**PE/S/114      WORKSHOP PRACTICE-I (Fitting & Carpentry)**

Fitting: Introduction to Fitter's tools, gauge & instruments. Different types of fitting work involving various fitting operations like sawing, marking, chipping, filling, drilling, tapping etc.

Carpentry: Types of wood & identification of wood for engineering purpose. Introduction to Carpenter's tools. Use of wood-working machines. Different types of joint-making, simple pattern-making.

## **FIRST YEAR SECOND SEMESTER**

**Hum/T/B**

**HUMANITIES-B**

English - 2 Pds/week - 50 Marks Sociology - 2 Pds/week - 50 Marks

HUMANITIES

1. Basic writing skills 2. Report, Covering Letter & Curriculum-Vitae writing 3. Reading and Comprehension 4. Selected Short Stories Text Book: ENGLISH FOR ALL

SOCIOLOGY 1. Sociology: Nature and scope of Sociology - Sociology and other Social Sciences - Sociological Perspectives and explanation of Social issues 2. Society and Technology: Impact of Technology on the Society - A case study 3. Social Stratification: Systems of Social Stratification - determinants of Social Stratification - Functionalist, Conflict and Elitist perspectives on Social Stratification 4. Work: Meaning and experience of work: Postindustrial society- Post-Fordism and the Flexible Firm 5. Development - Conceptions of and approaches to development - The Roles of State and the Market in the Development 6. Globalization: The concept of globalization - globalization and the nation state - Development and globalization in post colonial times. 7. Industrial Policy and Technological change in India - The nature and Role of the State in India 8. Technology Transfer: The Concept and Types of Technology Transfer-Dynamics of Technology Transfer 9. Technology Assessment: The Concept - Steps involved in Technology Assessment 10. Environment: Sociological Perspectives on Environment - Environmental Tradition and values in ancient India 11. The Development of Management: Scientific Management - Organic Organization - Net Work organization - Post modern Organization - Debureaucratization - Transformation of Management 12. Technological Problems and the Modern Society: Selected Case Studies - Electric Power Crisis, Industrial and/or Environmental Disaster, or Nuclear Accident.

**PE/Math/T/122**

**MATHEMATICS-IIIQ**

Vector Calculus: Vector and scalar function and fields, Vector differential calculus: The 'del' operator, Gradient Divergence, Curl, and Laplacian, Vector Integral Calculus: Line, surface and volume integrals, Green's Theorem, Divergence theorem of Gauss, Stokes's theorem. Applications of vector calculus in fluid mechanics and electrodynamics.

Ordinary Differential equations: Linear differential equations of 1st order, second order and higher order linear differential equations. Series solution of Bessel and Legendre Equations. Recurrence relations. Orthogonal property of Legendre polynomial. Geometry of Three Dimensions: Cartesian coordinates in three dimension. Direction cosines. Equations of planes and straight lines. Shortest distance between two skew lines. Standard equations of sphere, cylinders and cones. Applications of Calculus: Tangent, normal and asymptotes.

Partial Differential Equation: Method of separation of variables. Application in 2-dimensional Laplacian heat equation and wave equation.

**PE/T/123**

**ENGINEERING MECHANICS-II**

Kinematics of rectilinear motion. Curvilinear motion, projectile, relative motion, Newton's laws of motions, inertia force, central force motion, momentum and impulse, work, power & energy, impact, undamped free vibration of spring-mass system with single degree of freedom.

Shear force and bending moment diagram, shear and bending stresses in beams, Buckling of columns, Strain energy in tension, compression, bending and torsion, Castiglione's theorem.

#### **PE/T/124 PRINCIPLE OF ELECTRICAL ENGINEERING**

Units and dimensions of electrical and magnetic quantities, conversion between various system of units, analysis of DC electric circuits, Kirchoff's laws, fundamental relations of electrostatic field - Coulomb's law, Gauss's law, electric flux, flux density and field intensity, line charge, potential function, stored energy in electric field - capacitance calculation for simple geometries, electro-magnetism, Ampere's law, magnetic flux, flux density and field intensity, magnetic force, Faraday's law, inductance calculation for simple geometries. AC fundamentals - sinusoidal waves and their phasor representation, concept of impedance and admittance, analysis of R-L-C series and parallel circuits – resonance, Q-factor. Concept of polyphase circuits - relation between 3-phase voltage, current and power in different passive circuits, analysis of balanced 3-phase circuits, 3-phase power measurement, single line diagram, relation between voltage, current and power unbalanced 3-phase circuits.

#### **PE/T/125 ENGINEERING GRAPHICS**

Screw threaded forms, bolts and nuts, studs & their uses, keys, splines, etc. riveted and welded joints. Pulleys, rigid coupling & joints for rods, pipes, etc. Development of common surfaces (Cube, Prism, Cylinder, Truncated Cone, pyramid) Intersection of surfaces (Intersecting cylinders, Intersection of Cone and cylinder, Intersection of two prisms).

##### **COMPUTER AIDED DRAFTING**

Introduction : Cartesian and Polar Co-ordinate system, Absolute And Relative Co-ordinates; Basic editing Commands : Line, Point, Trace, Rectangle, Polygon, Circle, Arc, Ellipse, Polyline; Basic editing Commands : Basic Object Selection Methods, Window and Crossing Window, Erase, Move, Copy, Offset, Fillet, Chamfer, Trim, Extend, Mirror; Display Commands : Zoom, Pan, Redraw, Regenerate; Simple dimensioning and text, Simple exercises.

#### **PE/T/126 CIRCUIT THEORY**

Elementary electrical network - basic definition -formulation of network equations, basic network theorems, superposition theorem, Thevenin's -Norton's, maximum power transfer, reciprocity, Milman's theorem and Telegen's theorem, elementary network topology - graph of networks, concepts of tieset, cutset and incidence matrix, loop and node variable analysis, formulation of equilibrium equation on the loop and node basis, source transformation, two-port networks, y-parameters and z-parameters and their equivalent circuits, h-parameters and ABCD parameters, cascade and parallel connection of 2-port networks, relationship between 2-port parameters, frequency response of networks, Bode plot, Fourier and Laplace transforms application for transient analysis, the time series representation of signals, time domain analysis of transient using the initial and final value theorem, introduction to network synthesis.

**PE/Hum/S/121      LANGUAGE LABORATORY**

Basic forms of communication, Development of positive personal attitudes, Removing miscommunication (barriers); Improving communication, Practices in business communication; Group discussions; Mock interviews; Seminars; Individual and group presentations and report writing. Principles of effective communication. Planning business messages; Rewriting and edition; the first draft; reconstructing the final draft; Principles of oral presentation, speeches to motivate, effective presentation skills. Non-verbal communications, Body-languages: meanings. Effective listening: principles of effective listening; factors affecting listening exercises.

**PE/S/122      APPLIED MECHANICS LABORATORY**

Experiments on mechanics and strength of materials, moment of inertia of flywheel, tension, torsion, bending tests; Hardness and impact test; Static and dynamic balancing test, governing apparatus, natural frequency of vibration of a beam, critical speed of a rotor.

**PE/S/123      ENGINEERING GRAPHICS**

Screw threaded forms, bolts and nuts, studs & their uses, keys, splines, etc. riveted and welded joints. Pulleys, rigid coupling & joints for rods, pipes, etc. Development of common surfaces (Cube, Prism, Cylinder, Truncated Cone, pyramid) Intersection of surfaces (Intersecting cylinders, Intersection of Cone and cylinder, Intersection of two prisms).

**COMPUTER AIDED DRAFTING**

Introduction : Cartesian and Polar Co-ordinate system, Absolute And Relative Co-ordinates; Basic editing Commands : Line, Point, Trace, Rectangle, Polygon, Circle, Arc, Ellipse, Polyline; Basic editing Commands : Basic Object Selection Methods, Window and Crossing Window, Erase, Move, Copy, Offset, Fillet, Chamfer, Trim, Extend, Mirror; Display Commands : Zoom, Pan, Redraw, Regenerate; Simple dimensioning and text, Simple exercises.

**PE/S/124      WORKSHOP PRACTICE-II (Welding & Machining)**

Introduction to different welding techniques and related shop works, e.g. arc welding, gas welding, TIG welding, MIG welding, Brazing etc. Joining Plates by arc welding. Introduction to machine tools - lathes, drilling machines, Work involving various operations with lathe, e.g. turning, facing, drilling, boring etc.

## **SECOND YEAR FIRST SEMESTER**

### **PE/T/211      ENGINEERING THERMODYNAMICS-I**

Concept of thermodynamic system, surrounding, state, property, process and cycle. Path function and point function. Zeroth law of thermodynamics, quasistatic process. Energy: Different energy forms-stored energy, energies in transition. Heat and work.

Perfect gas laws, Vapor formation at constant pressure, properties of vapor, vapor chart and table.

The First law of thermodynamics: Statement of the First law for closed systems. PMM I. Corollaries: concept of internal energy and enthalpy, Analysis of different non-flow processes with perfect gases. First law analysis for control volumes for steady state and unsteady states.

The Second law of thermodynamics: Limitations of the first law of thermodynamics. Statements of the second law of thermodynamics. Heat engine, Heat Pump and Refrigerator. Thermal efficiency. Coefficient of Performance. Carnot cycle. Corollaries of the Second law, Clausius inequality, Reversibility and Irreversibility, Concept of Entropy. Second law analysis of closed and open systems, Entropy generation. Reversible work. Concept of Thermodynamic Availability, Irreversibility. Availability analysis for open and closed systems, 2nd law efficiency.

### **PE/CSE/T/212      NUMERICAL METHODS & COMPUTER PROGRAMMING**

Part A (Numerical Methods) : Iterative methods, Method of false position, Solution of non-linear equations by Newton-Raphson method, Finding roots of algebraic equations, Solution of simultaneous algebraic equations - Gaussian elimination, Gauss-Siedel method, Matrix inversion, Sparse Matrix.

Interpolation - Newton's forward and backward difference formulae, Lagrange's method for unequal intervals. Least square methods of curve-fitting -trend line, Numerical differentiation and integration. Solution of ordinary differential equations - Picard's method of successive approximation, Euler's method, modified Euler's method, Runge-Kutta method - 2nd & 4th order.

Part-B (Computer Programming): The structure and nature of algorithms. FORTRAN programming, problems of engineering interest, C programming with special emphasis on the use of data structures.

### **PE/T/213      FLUID MECHANICS**

Properties of fluid, Different types of fluid, Newton's law of viscosity, Fluid Static, Force on submerged plane and curved plates, Stability of submerged and floating bodies, Static fluid subjected to uniform acceleration in horizontal and vertical direction, Fluid rotation – free vortex and forced vortex.

Fluid Kinematics, Different types of fluid motion, stream line, pathline and streakline, Reynolds transport theorem, Equation for conservation of mass, momentum and energy in 1- 2- and 3-dimensions, Euler's equation of motion, Integration of equation of motion, Bernoulli's equation.

Study of viscous flow – Pipe line flow, laminar and turbulent flow through circular and non-circular conduits, Losses in pipe flow – Darcy-Weisbach equation, Hagen-Poiseuille's

equation, friction factor, pipe network, Pipes in series and parallel, Power transmission through pipeline.

Open channel flow – Chezy's equation, most economical rectangular and trapezoidal section of a channel.

Flow measurement in pipes and open channel – manometer, venturimeter, orificemeter, flow nozzle, Pitot tube, V-notch and rectangular weir.

Dimensional analysis, Buckingham pi-theorem, non-dimensional numbers, similitude.

Boundary layer, Von-Karman momentum integral equation.

Compressible flow – velocity of sound, Mach number, different types of compressible flow, compressibility correction factor, Stagnation pressure, temperature, density ratio.

### **PE/T/214                      ELECTRICAL MACHINES-I**

Transformers - 1-ph Transformers, Construction and Types, Types of Cooling, Principle of Operation, emf Equations, Phasor diagrams, Equivalent Circuits, P.U. system, Open circuit and Short circuit tests, Voltage regulation, Losses, Efficiency, All-day efficiency, Auto Transformers, Parallel Operation of 1-ph Transformers.

DC Machines - Construction, Principle of Operation, Methods of excitation and classifications, Torque, emf and speed equations, Armature reaction, Commutation, Interpoles, Back emf in DC machines, Motor Starter, Speed Control, Torque speed characteristics, Losses, Efficiency, Testing, Swinburn Test, Hopkinson Test.

Poly-phase Induction Motors -, Construction, Principles of working, Slip, Equivalent circuit, Performance equations, No load and blocked tests, determination of equivalent circuit parameters, Torque speed characteristics, Circle diagram, Speed control, Starting methods, applications.

1-ph Induction Motors - Construction, Principle of operation, Starting and classification, Revolving field theory, Equivalent circuit, determination of equivalent circuit parameters, Applications.

### **PE/IEE/T/215                      ELECTRONICS**

Semiconductor Devices: Intrinsic/Extrinsic semiconductors, PN junction diode - characteristics, diode equation, forward bias, reverse bias.

Diode circuits: DC analysis: piecewise linear model, AC analysis - small-signal equivalent circuit. Zener diode - Zener mechanism, characteristics, Zener as voltage regulator.

Transistor: BJT -structures, current flow mechanism, basic transistor equation, npn and pnp transistors, forward active mode current-voltage characteristics - modes of operation (CE, CB, CC) - DC analysis of Transistors circuits ( CE circuit ), load line. Transistor biasing, stability of Q-point. Small signal voltage amplifier. Small signal hybrid-pi model of BJT; AC load line, classification of amplifiers; CE amplifier circuit; Emitter follower amplifier. Multistage amplifier.

JFET, MOSFET: Biasing techniques, common source amplifier. Source follower amplifier. Frequency response. Large signal amplifiers. - Power amplifiers: Class A, Class B, Class AB - load coupling methods.



Operational amplifiers: Ideal and practical; Inverting, non-inverting amplifiers. Other applications - voltage followers, current-to-voltage and voltage-to-current converters, summing amplifiers, difference amplifier, Instrumentation amplifier. Adder/ Subtractor, Integrator, differentiator. Oscillators; Introduction to Filters.

Feed back in amplifiers: positive and negative feedback, feed back topologies (series-shunt-voltage amplifier, shunt-series-current amplifier, series-series- transconductance amplifier, shunt-shunt transresistance amplifier) using op-amplifier configurations.

Introduction to Digital Electronics: Number systems, binary, octal, hexadecimal system, BCD code. Logic gates: AND, OR, NAND, XOR. Boolean theorems, DeMorgan's theorem, Adder, Subtractor and some typical combinational circuits, K-maps, Sequential circuits : Latches/flip-flops, registers, counters.

### **PE/T/216 MATERIALS AND PROCESSES**

Structure and properties of materials, defects in materials and plastic deformation, stress-strain curves and theories of failure, phase transformations and phase diagrams, Iron-carbon system, Heat treatment of steel, Electronic materials. Material standards – Indian and other major International standards.

Casting: Pattern, different types of casting and cast products, gating system and riser design.

Welding: Different types of welding— arc welding, gas welding, MIG and TIG welding.

Metal forming: Hot and cold working, forging, rolling, extrusion, drawing and press working.

Machinery: Introduction to turning, milling, drilling, boring, shaping, tool geometry and tool angles, tool life and cutting force calculations, Introduction to some non-conventional machinery processes and their applications.

Introduction to Layered Manufacturing. Cost of manufacturing process and selection of proper process-brief concept.

### **PE/CSE/S/211 PC LABORATORY-I**

Introduction to micro-computers and microcomputer components, overview of operating system- WINDOWS, LINUX. Programming in FORTRAN and C- simple problems in array operation, matrix operation, sorting, elementary concepts of objects oriented programming etc.

### **PE/S/212 BASIC ELECTRICAL ENGINEERING LABORATORY**

- 1) Verification of Thevenin's and Superposition theorem.
- 2) Verification of Norton's and Maximum power transfer theorem
- 3) R-L-C series and parallel circuits and resonance effects.
- 4) Studies on balanced 3-phase circuits
- 5) Studies on unbalanced 3-phase circuits- Phase sequence meters.
- 6) Characteristics of fluorescence lamps- measurements of power and power factors.
- 7) Measurements of armature and field resistance of D.C. machines
- 8) Magnetic circuit principles.
- 9) Calibration of ammeters and voltmeters
- 10) Series parallel operation of dc source.

**PE/IEE/S/213            ELECTRONICS LABORATORY**

1. Familiarization with Circuit Components like R, L, C and discrete devices and Integrated circuits.
2. Familiarization with Electronic Workshop Tools and their use. Soldering Practice.
3. Study of the Characteristic of PN-Junction Diode, Clipper, Clamper, Rectifier circuits and Zener regulators.
4. Characteristics of BJT (CE mode).
5. Study of a CE Amplifier.
6. Studies on the applications of operation amplifier - voltage follower, summer, integrator, differentiator.
7. Timer-555 : Monostable and astable multivibrator using 555.

**PE/S/214            WORKSHOP PRACTICE-III (Machining)**

Machining operation: thread cutting, knurling, taper turning etc. Shaping, Grinding, Milling. Introduction to advanced machining processes.

## **SECOND YEAR SECOND SEMESTER**

### **PE/T/221 ENGINEERING THERMODYNAMICS-II**

Vapor Power cycles: Performance parameters of cycles, Heat rate, Work ratio, Specific vapor consumption. Carnot vapor cycle, Rankine cycle, Reheat cycle, Ideal regenerative cycle.

Gas Power Cycles: Air Standard Cycles – Otto, Diesel, Dual, Stirling, Brayton cycles; Use of air tables for gas power cycle analysis.

Vapor compression and absorption refrigeration cycle. P-h Chart, Air Refrigeration cycle.

Thermodynamic property relations, Maxwell Relations, Clausius Clapeyron Equation, Joule Thomson Coefficient, Compressibility and expansion coefficient.

Thermodynamics of Mixtures: Mixture of ideal gases, Mixture of ideal gas and vapor, Laws of thermodynamics for gas-vapor mixtures, Psychrometry, Thermodynamic analysis of psychrometric processes, Thermodynamic relations for multi-component systems.

Thermodynamics of reacting systems: Fuels, Air requirements, Analysis of Combustion products, enthalpy of formation, Calculation of enthalpy of combustion and adiabatic flame temperature, HHV and LHV of fuels, Second law analysis of chemically reacting systems.

### **PE/T/222 HEAT TRANSFER**

Basic concepts of Heat Transfer,

Conduction: General heat conduction equation, Steady state one-dimensional conduction, Conduction through plane walls, cylinder, sphere and composite walls, Concept of film coefficients and thermal resistance, Network problems, Critical thickness of insulation, Extended surfaces, 2-D conduction, Transient conduction in 1-D.

Convection: Thermal boundary layer equation and its integral solution, Heat transfer in fully developed flows through pipes, Heat transfer over flat plates. Relation between fluid friction and heat transfer, forced convection correlation, Free convection, laminar free convection on vertical flat plates, empirical correlation.

Heat exchangers: LMTD and NTU methods of computation of heat transfer in heat exchangers.

Radiation: Basic laws e.g. Planck's law, Stefan-Boltzmann law etc., intensity of radiation, view factor, radiation exchange between surfaces and enclosures, luminous and non-luminous radiation,

Application of heat transfer in power plants, Mixed mode of heat transfer, Heat transfer over rows of tube etc.

### **PE/T/223 ELECTRICAL MACHINES - II**

Transformers - 3-ph Transformers, Construction, Connection and phasor groups, Harmonics and suppression of harmonics, Parameter estimation, Voltage regulation, Open delta and Scott connection, 3-ph and multiphase conversions, Testing of transformers, Parallel operation of 3-ph Transformers.

Synchronous Machines - Construction, Principle of working, Excitation, Phasor diagrams, Synchronous reactance, Voltage Regulation, determination of regulation by

different methods, Two reaction theory, Phasor diagram of salient Pole Machines, Power angle characteristics, Parameter Estimation, Efficiency, Transient Analysis, Sudden Short Circuit, Loading & Load rejection, , Transient reactances, Synchronizing, Synchronizing power and torque, Parallel Operation, V-curves, Starting of Synchronous Motors, Current locus, Hunting, Damper winding, Applications.

#### **PE/T/224      THEORY OF MACHINES AND MACHINE DESIGN**

Planar mechanisms, four bar linkage, quick-return mechanism, velocity and acceleration analysis, kinematics of gears and gear trains, vibrations, balancing of rotating and reciprocating masses, gyroscopic motion, fly wheels, cam and cam follower design, inertia force analysis of reciprocating systems, design for variable and dynamic load, design of shaft, screws; bolted, riveted and welded joints, pulley, clutch and brake design, spur gear design, design of bearings, selection of bearings.  
Concept of limits, fits and tolerance.

#### **PE/T/225      ENGINEERING ECONOMICS AND COSTING**

Basics of demand and supply - elasticity of demand - concept and measurement. Theory of costs - short run and long run cost curves. Industrial development in India - trends - problems prospects - economic reforms and Indian industry - foreign direct investment and foreign collaboration in Indian industry. International environment - an overview of international trading environment - trends in World Trade and the problems of developing countries - International Economic Institutions - GATT, WTO, World Bank, IMF. Industrial Record Keeping - Double entry - concepts and conventions - Journal, Ledger, Trial Balance, Cash Book, Final Accounts. Nature, Scope, Objectives and Functions of cost accounting and management accounting - costs and its classifications - preparation of cost sheet - accounting for material - pricing of material issues - ABC analysis - Just-in-time - concepts of overheads - allocation and apportionment of overhead - absorption of overheads - marginal costing. Capital budgeting - methods of appraisal - average rate of return - pay back period - discounted cash flow (net present value, internal rate of return). Management - definition - functions - organization - definition and principles - other functions of management.

#### **PE/IEE/T/226      POWER ELECTRONICS**

Power Semiconductor Devices: Power diodes: characteristics, types, series /parallel connected diodes. Power Transistors: BJT, MOSFET; characteristics & Base/Gate Drives, series Parallel operation, di/dt, dv/dt limitation. Thyristors: Types, characteristics, Two- transistor model turn - on, turn- off, di/dt, dv/dt protection series / parallel operation. Triggering circuit. Triac, Diac, Commutation of thyristors, GTOs.

Uncontrolled rectifiers: Single-phase, 3-phase bridge rectifiers, analysis & performance evaluation.

Controlled rectifiers: single-phase, 3-phase half wave, full wave bridge circuits, Dual converters - analysis & performance evaluation. Freewheeling diodes, inductive load & transformer ratings.

AC voltage controllers: Principles (on-off, phase control), single-phase, 3-phase controllers, operation & analysis.

Cycloconverters: single-phase, 3-phase, Blocked group operation, circulating current mode - operation & analysis.

DC choppers: step down, step up operation classification, switching mode Regulators, transistor chopper circuits - operation & analysis.

Inverters: single phase, 3 phase - operation, performance parameters, voltage Control of single phase, 3 phase inverters, forced commutated inverters, current source inverters, - (PWM - inverters); Resonant pulse inverter.

### **PE/S/221 FLUID MECHANICS LABORATORY**

Fluid Mechanics Laboratory – Viscosity measurement, study on flow visualization techniques, study of characteristics of laminar and turbulent flow (Reynolds experiment), Flow measurement in pipes and open channel (venturimeter, orificemeter, V-notch and rectangular notch), measurement of losses in pipe flow – major and minor losses, boundary layer measurement, study on submerged axisymmetric jet.

### **PE/S/222 ELECTRICAL MACHINE LABORATORY I**

- 1) Studies of Electrical Machines.
- 2) Saturation characteristics of a D.C. machine.
- 3) External characteristics of a D.C. machine (Shunt and Compound)
- 4) Study of a D.C. Motor starter and speed control
- 5) Parallel operation of D.C. Generators and load sharing.
- 6) Coil connection and polarity test of a single phase transformer
- 7) Parallel operation of two single phase transformer
- 8) Open circuit and short circuit test of a transformer and parameter calculation,
- 9) Three phase transformer connection - Star, Delta and Zigzag- Effect of unbalanced load.

### **PE/IEE/S/223 DIGITAL CIRCUIT LABORATORY**

1. Study of basic Logic gates.
2. Study of a 2-to-4 line decoder.
3. Realization of a 2:1 digital multiplexer
4. Study of different Flip Flops.
5. Study of a 4-bit binary up-counter.
6. Study of a 4-bit ring-counter.
7. Realization of a 1-digit decimal counter.

### **PE/S/224 PC LABORATORY-II**

Review of C and FORTRAN programming, C++ concepts of object oriented programming, class, objects, etc., C++ builder. Programming with MATLAB: numerical solution of transcendental equations, algebraic linear simultaneous equations and ordinary differential equations. Working with Linux, share programming, introduction to assemblers.

## **THIRD YEAR FIRST SEMESTER**

### **PE/T/311 STEAM GENERATOR**

Classification and application of boilers, fire and water tube boilers, Boiler layout: Two pass boiler and tower type (Benson) boiler, Utility steam generator fundamentals; types of coal firing- stoker, PF, cyclone and fluidized bed firing; Boiler furnace, furnace design, types and arrangement of coal and oil burners, flame scanners and ignitors; Boiler draft and air flow control. Boiling heat transfer, nucleate and film boiling, DNB; Circulation principles, Features of forced circulation and critical pressure boilers, once through and super-critical pressure boilers, Boiler mountings and accessories, Steam drum & drum internals, Steam water separation; Waterwall, superheater, reheater, economizer, heat transfer and fluid flow through different elements, disposition and calculations of heating surfaces, air preheaters, boiler casing and insulations, Superheater steam temperature adjustment and control, Boiler losses, Performance and heat balance. Waste Heat Recover Boilers, Supplementary Firing System, Pressurized Fluidized Bed Combustion Boilers.

### **PE/T/312 STEAM AND GAS TURBINES**

Principle of action of rotary turbines; relative merits of steam turbine and gas turbine as prime mover, classification of turbines, components of steam and gas turbine and their functions.

Ideal and Actual flow of compressible fluid through nozzle, critical pressure ratio, maximum rate of discharge, under expansion and over expansion in nozzle. Nozzle efficiency & velocity coefficient of nozzles. Supersaturated flow through nozzle.

Flow through simple impulse turbine blading, velocity diagram, blade efficiency, Gross stage efficiency, net stage efficiency, optimum velocity ratio. Degree of admission. Multistaging or compounding of impulse turbine, velocity compounding, pressure compounding, velocity and pressure compounding,

Reheat factor, internal efficiency, state point locus etc. in relation to steam turbine.

Flow through Reaction turbine, velocity diagram, Degree of reaction, blade height, stage efficiency, optimum velocity ratio, axial thrust in reaction turbine.

Comparisons of impulse & reaction turbine, Losses in turbines, Partial admission loss, gland leakage loss,

Blades in turbine: Material, manufacturing, fixing and cooling, Erosion of turbine blades.

Turbine bearing and lubrication, Principle of turbine governing.

Fundamental concept of gas turbine control and monitoring system.

### **PE/T/313 FLUID MACHINERY**

Conservation of linear momentum and its application, Impact of jet on flat and curved plates.

Conservation of angular momentum, Euler head equation, Different types of turbomachines.

Hydraulic turbine – Impulse turbines, its constructional features and characteristics (Pelton turbine and turgo impulse turbine), Design of impulse turbine, Reaction turbine, its constructional features and its characteristics (Francis turbine) and design criteria, Draft tube.

Centrifugal pump and its characteristics, Design components of centrifugal pump, pumps in series and parallel, losses in pumps, Axial flow pumps, Stodola's slip factor.

Positive displacement pumps – reciprocating pump, gear pump, axial piston pump, etc.-- their constructional features and performance curves.

Axial flow fan, blower and compressor – their constructional features and performance curves.

NPSH, Cavitation – its cause and remedies, Thoma's cavitation parameter, runaway speed, Unit quantities and dimensional similarity – model and prototype, specific quantities.

Fluid coupling, torque converter, hydraulic lift, crane, accumulator, etc. – elementary description and performance.

### **PE/T/314      TRANSDUCERS AND MEASUREMENT**

Classification of electrical measuring instruments, General features of indicating instruments- controlling, damping and balancing of moving systems; Static and dynamic characteristics. Construction and principle of moving coil, moving iron, rectifier, electrostatic and induction type instruments for measuring voltage, current, power, energy, frequency and power factor. Extension of instrument range, shunt multiplier.

C.T. and P.T., Measurement of resistances, measurement of inductance and capacitance by A.C. bridges, Potentiometers, Magnetic measurements, Galvanometers- D' Arsonval, ballistic and vibration type, CRO and digital instruments.

Definition, Classification of transducers. Measurement of vibration, displacement, discharge, pressure, temperature, pH, rotation and strain. Photoelectric transducers, Hall-effect transducers. Signal conditioning and signal transmission. Microprocessor-based Measurements of Electrical parameters, Multifunction Meters for Industrial Application, Microprocessor based Energy Meters, Energy Management System(EMS) and Data acquisition, Large Video screens and application in Power plant

### **PE/T/315      POWER TRANSFER SYSTEMS**

Electrical power transfer, its necessity and superiority. Basic network structure for electrical power transfer, Overhead lines, Underground cables- Mechanical and Electrical aspects, selection of economic voltage, suitable conductors and insulators, high voltage transmission, Transmission line parameters, skin and proximity effects, bundle conductors, transposition, P.U. system, Representation of short, medium and long lines for performance analysis, Power transfer equations, regulation and efficiency, line voltage regulators, reactive power compensation – FACTS devices, Interconnected power systems, Power system transients and line surges, Stability considerations, Equal area criteria, Corona, primary and secondary distribution systems, feeders and distributors, Radial and mesh systems, loading and its effect on voltage profile, , Power factor improvement and its importance, distribution, Deregulation of Electricity industry, Tariff, HVDC transmission, transmission and distribution through High Temperature Superconducting cables.

### **PE/T/316 CONTROL SYSTEMS**

Introduction to feed back control - concept of a system, excitation and response of a system, Mathematical modeling of dynamic systems, Control system components – servomotors, synchros, stepper motors, tacho-generator, positions sensor, Block diagram and signal flow graph, transfer functions, continuous and discrete data system. Time domain analysis of 1st and 2nd order systems, Proportional integral and derivative control, error constants. Stability analysis: frequency domain techniques - Bode plot, Routh and Nyquist criterion, gain and phase plot, stability margin. Root locus techniques - lag, lead and lag-lead compensation, introduction to state variable analysis, Actuators. Introduction to discrete and sampled data system. Fundamental Concept on Integrated Control system for Power Plant Application, Identification of Analog and Binary Drives of Power Plant.

### **PE/S/311 TRANSDUCER AND MEASUREMENT LABORATORY**

- 1) Calibration of energy meters.
- 2) Kelvin's double bridge for measurement of low resistance.
- 3) Measurement of inductance and capacitance by Bridge method.
- 4) Measurement of voltage and resistance by D.C. potentiometer.
- 5) Measurement of resistance by Wheatstone bridge and Megger.
- 6) Three voltmeter and three ammeter method of measuring single phase power.
- 7) Measurement of flame temperature using thermocouple and data acquisition.
- 8) Measurement of magnetic flux density using Gaussmeter.
- 9) Measurement of liquid level using ultrasonic level sensor
- 10) Measurement of Flow using ultrasonic flowmeter
- 11) Measurement of pH and electrical conductivity of water, KCl, etc.
- 12) Signal conditioning.
- 13) Microprocessor based Multifunction Meter with PC Interface.
- 14) Microprocessor Based Energy meters with PC Interface.
- 15) Level Measurement by Radar Type Instrument.
- 16) Proximity Sensor and application for Speed Measurement.
- 17) Proximity sensor for Vibration Monitoring of Turbine, Generator and concept of Vibration Analysis.

### **PE/S/312 COMPUTATIONAL LABORATORY**

Computer aided numerical analyses of problems: (i) load flow analysis and ELD, (ii) fluid flow and heat transfer. Introduction to graphic postprocessing using MATLAB or other software. Modeling of simple dynamic systems using MATLAB Simulink. Introduction to commercial CFD software.

### **PE/S/313 MICROPROCESSOR LABORATORY**

Study of 8-bit and 16-bit microprocessors, Architecture, Assembly Language programming, Typical interfaces, Assembler, Microcontrollers



**PE/S/314 HEAT TRANSFER LABORATORY**

Study of conduction heat transfer and determination of thermal conductivity; Study of heat transfer through a fin and determination of fin performance parameters; Study of forced convective heat transfer and determination and validation of heat transfer coefficient and Nusselt number; Study of free convective heat transfer and determination and validation of heat transfer coefficient and Nusselt number; Study of various types of heat exchangers, like shell and tube heat exchanger, plate heat exchanger, tubular heat exchanger etc. Determination of heat exchanger performance parameters; Study of radiative heat transfer: determination of emissivity of gray surface, determination of Stefan-Boltzmann coefficient.

## THIRD YEAR SECOND SEMESTER

### **PE/T/321 COMBUSTION & IC ENGINE**

Review of thermochemistry, chemical equilibrium, fundamentals of mass transfer and chemical kinetics.

Flames: Premixed and non-premixed flames, laminar and turbulent flames, flame quenching, flammability, flame stability.

Liquid fuel combustion: Spray formation, fuel injectors, droplet evaporation and burning. Principle of solid fuel combustion.

IC Engines: classification, two stroke & four stroke engines, different parts of IC Engine and their functions, fuel air cycle and actual cycle analysis.

Carburetion in SI engine, fuel injection in SI Engines. Ignition systems in SI engine, battery ignition, Magneto-ignition and electronic ignition systems, Fuel injection in CI engines.

Combustion in SI and CI engines. Detonation and knock. Performance and testing of IC engines

Supercharging, turbo charging & scavenging in IC engines. Lubrication and cooling systems in IC Engines. New developments in IC engines: HCCI and GDI engines,

### **PE/T/322 POWER PLANT CYCLES & SYSTEMS**

Properties of ideal working fluid for vapor power cycles. Practical losses in Rankine and Reheat cycles. Practical Regenerative cycles with open and closed feed water heaters, choice of heaters, heater arrangements and optimum degree of regeneration. Supercritical pressure cycle. Heat Balance Diagram and its utility. First and Second Law analyses of practical vapor power cycles.

Effects of operating parameters on plant performance.

Gas turbine cycles with intercooling, reheating and regeneration.

Combined Cycles: Definition and classification, simple thermodynamic analyses of coupled cycles. Binary vapor power cycle, Gas Turbine Combined Cycle, STIG, IGCC, Cogeneration, CHP applications

Layout of a thermal power plant. Familiarization with different systems of thermal power plant: fuel, air and flue gas systems, Condensate and feedwater system, Construction and functioning of condenser, deaerator and closed feed water heaters, HP - LP By-pass systems, Auxiliary Steam System, Turbine gland steam system. CW system. Cooling Towers—principle of operation and types, performance of cooling towers.

### **PE/T/323 NON CONVENTIONAL POWER GENERATION**

Introduction, Global & National energy scenarios, Forms & characteristics of renewable energy sources, Importance of non-conventional Power Generation, different types. Solar Power Generation - Solar Energy, Extraterrestrial and Terrestrial Solar Radiation, Solar-Thermal conversion, collectors, Heliostat, Heat transport system. Solar ponds. Wind Power Generation, Principles of wind power, Maximum & Actual Power, Wind Turbine operation Small and Large Wind Turbines, recent developments.

Energy from biomass, municipal solid wastes, biogas and its applications

Ocean Thermal, Wave Thermal and Geothermal Power Generation.

Direct Energy Conversion system - M.H.D, Fuel cells  
Variability in non-conventional power generation level  
Energy Storage systems

#### **PE/T/324 HYDRO POWER GENERATION**

Hydro power scenario in India and world, its development and future prospect, Hydrology – hydrological cycle, precipitation, run-off and its measurement, hydrograph, unit hydrograph, flow duration and mass curve.

Site selection – Preparation of DPR, Clearance from various agencies, funding agencies, government rules and subsidies for SHP.

Classification of hydro electric power plants, pondage and storage, Operating principles of different types hydro plants like run-off river, dam toe type and canal base type, Design, construction and operation of different components of a hydro plant like dam, spillways, canals (power canal), penstocks (economical diameter, embedded and exposed type, short and long penstock), surge tank, draft tubes, etc.

Power house structure, overhead crane, auxiliary power supply, selection of prime mover, Kaplan, Bulb/tubular, cross flow and Deriaz turbine, speed and pressure regulation, Methods of governing of impulse and reaction turbine, starting and stopping of water turbines, operation of hydro turbines, machine loading and frequency control, maintenance of hydropower plants.

Need for testing of SHP, testing methodology and instruments.

#### **PE/T/325 POWER PLANT INSTRUMENTATION AND CONTROL**

Introduction – overview of power plant control loops, control loops, complex control schemes, PID controller, multivariable control. Instrumentation- General concepts and objectives, instrumentation of complex systems, different types of power plants and role of instrumentation in controlling and monitoring the power production, optimization and adaptation, Thermal power plant instrumentation, controlling and monitoring of boilers, turbines and generators, Transformers, condensers and power plant auxiliaries. Furnace draft and temperature control, combustion control, drum and feed water level control, emergencies and actions, alarm and annunciation, safety, interlock and supervisory schemes, salient features of instrumentation of hydro-electric, nuclear and non-conventional power plants, Monitoring generation and load flow, plant efficiency, Excitation control and temperature profile, DCS, Fire Detection and Protection system, Plant Communication system. Study of P&I Diagram and presentation of Instrumentation on P&ID.

#### **PE/T/326 ELECTRICAL MACHINE AND POWER CONTROL**

Concept of Electrical Drives -4-quadrant operation, Braking Schemes.

DC Motors Control - 1-ph Converter Drives, Semi-converter drives, 3-phase Converter Drives, Chopper-fed Drives. DC closed loop control.

Schemes for Induction Motors speed control - Rotor resistance control, Chopper controlled, Slip power recovery Scheme, Variable frequency control, Control of

Induction Motors by PWM Inverter, Constant v/f operation, Cyclo-converter driven Induction Motors by AC closed loop control.

Excitation Control of Synchronous M/Cs, Load Frequency Control, Control of Voltage and Reactive Power Stability analysis of Power Systems, Load Flow Studies, Economic Load dispatch - Unit Commitment, Load Scheduling

### **PE/S/321 ELECTRICAL MACHINES AND POWER SYSTEM LAB-I**

- 1) Starting of Synchronous motors and determination of V-curves
- 2) Parameter estimation of a 3 phase alternators
- 3) High Voltage test of transformers and Electrical Machines
- 4) Study of Micro-processor based Excitation Control
- 5) Back to back test of single phase transformer
- 6) Parameter estimation and voltage regulations of a three winding transformer
- 7) No load and blocked rotor test of three phase induction motor and construction of Circle diagram.
- 10) Starting and loading of three phase induction motor.
- 11) Three phase to two phase (Scott) and V-V connection of transformer.

### **PE/S/322 FLUID MACHINES LABORATORY**

Fluid machines laboratory – study on the performance test on centrifugal pump, gear pump, reciprocating pump, pumps in series and parallel operation, Performance test on Pelton, Francis and Kaplan turbine in off-grid and on-grid condition. Performance test on centrifugal blower, fan and compressor, Study on pump cavitation, study on oil hydraulic system including the characteristic of fluid power components such as pressure control valve, sequence valve, flow control valve, pressure relief valve, etc. Use of various instruments for SHP and fan testing,

### **PE/S/323 FUELS AND COMBUSTION LABORATORY**

Determination of Hardgrove Grindability Index (HGI) of coal, Proximate analysis of coal, CHNS analysis of coal, determination of calorific value of coal using bomb calorimeter. Determination of flash point of liquid fuels.

Study of flames: Premixed, non-premixed and partially premixed flames, laminar and turbulent flames.

Determination of burning velocity of flame using tube method and burner method.

Flame stability study and determination of stability diagram of burners

Determination of temperature distribution across flames and analysis of flame structures.

### **PE/S/324 NONCONVENTIONAL POWER LABORATORY**

1. Performance study of solar photovoltaic cell
2. Performance study of solar thermal collector
3. Performance study of wind turbine
4. Characterization of biomass fuel
5. Study of biomass gasification

## **FOURTH YEAR FIRST SEMESTER**

### **PE/T/411 POWER PLANT AUXILIARIES & MATERIAL HANDLING**

Boiler Auxiliaries: Pulverizers and their types, principle of operation, performance. ID, FD and PA Fans – types and performance. Dust collectors, Electrostatic Precipitators – principle of operation and performance. Soot blowers – types and principle of operation.

Boiler Feed Pumps and CW Pumps – construction, operation and performance.

DM Water Plant, Condensate polishing unit, HP and LP dosing system.

Coal Handling System in Power Plants, Pneumatic System Overview, various types, conveying characteristics, various components. Fuel oil storage and handling systems.

Ash Handling System in Power Plants, collection and removal of flyash.

Various types of material handling equipment – Cranes and Hoists, Conveyors, surface and overhead material handling equipment – types, terminologies, classification, operation drives, speed, brake. Belt Conveyers – Application, various types, belt conveyor components, calculations. Hydraulic Transport, Two Phase flow and various flow regime, jet pump, centrifugal slurry pumps. Fundamental Concept of Control and Monitoring of Ash handling Plant, Coal handling Plant and DM Plant.

### **PE/T/412 POWER SYSTEM PROTECTION**

Over voltage and over current phenomenon in power system, arc phenomena in circuit breakers, power system transients, restricting and recovering voltages, technology of small capacity and inductive current interruptions, circuit breakers, material for contacts and medium, different types of circuit breakers, plane brake and control brake, oil, air vacuum and sulphur hexafluoride circuit breakers, protective relays, basic philosophy, principle of over current, earth fault, directional and differential relaying, desirable quality of relaying and annunciation schemes, protection schemes of generators, transformers, transmission line, buss bars and motors, fault current calculation and selection of CB ratings, lightening arresters, surge absorbers and suppressors, automatics devices for protections, automatics reclosure devices, automatic connections of backup power, automatics frequency load shedding, earthing schemes and earthing codes. Fundamental Concept of Digital Protection Relays, Substation Automation System.

### **PE/T/413 ENERGY AND ENVIRONMENTAL MANAGEMENT**

Sources of energy, Classification of energy sources, Energy-environment interaction, Environmental issues related to harnessing energy from fossil fuels — acid rain, global warming and greenhouse gases, Ozone layer depletion. Local, regional and global implications, Environmental degradation, Primary and secondary pollutants. Thermal/radioactive pollution, Air & water pollution. Environmental pollutions from different power plants and their control mechanisms – ESP, FGD, SCR, etc. Continuous emission monitoring system (CEMS). Micro climatic effects of pollution, Pollution from stationary and mobile sources, Biological effects of radiation, Heat and radioactivity disposal,.

Approaches to mitigate environmental emissions from energy sector, Global Protocols, Clean development mechanism.

Statutory requirements for Environment Management, Environment and Social Impact Studies, Protection of Coastal Zone and Aquatic Life, Concepts of ISO 14000 – Environmental Audit.

Evaluation of energy conserving opportunities and environmental management, Environmental norms and laws, Energy conservation through controls, Electric energy conservation in building heating and lighting, Energy Efficient Motors, Energy savings in boilers and Furnaces, Energy conservation in domestic appliances, Energy conservation in agriculture, transport, Energy auditing concepts.

### **PE/T/414 ELECTIVE I**

- A. FLUIDIZED BED BOILER
- B. HIGH PRESSURE UTILITY BOILER
- C. FLUID POWER AND CONTROL
- D. FLUID FLOW AND GAS DYNAMICS
- E. EXPERIMENTAL TECHNIQUES & MEASUREMENTS
- F. FINITE ELEMENT METHODS
- G. SYSTEM DESIGN AND OPTIMIZATION IN THERMAL ENGINEERING
- H. HEAT EXCHANGERS
- I. ADVANCED TOPICS IN FLUID MECHANICS
- J. HEATING VENTILATION & AIR-CONDITIONING
- K. POWER PROJECT ENGINEERING AND MANAGEMENT
- L. COMPUTATIONAL FLUID DYNAMICS

### **PE/T/414A FLUIDIZED BED BOILER**

Definition of particle diameter, sphericity, etc, powder classification, pressure drop through fixed and fluidized beds, minimum fluidization velocity, elutriation and transport disengagement height, two phase theory of fluidization, bubble diameter, bubble rise velocity, etc, Bubbling fluidized boiler, merits over conventional types, features of fluidized boiler, basic design consideration, start up and operation of fluidized boilers, combustion and heat transfer in fluidized boilers, regimes of fluidization from bubbling to pneumatic transport, basic thermodynamics of circulating fluidized beds, features of circulating fluidized boilers, design aspects start up, operation, etc. merits of CFB over bubbling beds, national Na international status of fluidized boilers, pressurized fluidized boilers and using in combined cycle plants.

### **PE/T/414B HIGH PRESSURE UTILITY BOILER**

Types and features of High Pressure Boiler. Specification of a Power Station Boiler. Sub and Supercritical Pressure Large Boiler features, Comparison, Advantages and Disadvantages. Heat Loss and Efficiency calculation. Economizer, Superheater, Reheater Heat Transfer, Pressure Drop calculation. Boiler performance and problems of part load operation. Circulation, Natural, Forced, Assisted. Furnace Design, Heat Input. Materials of Boiler Tubes, Drum, Header. Thickness calculation of Superheater, Drum, Headers. Water Chemistry of High Pressure Boiler. Effect of Coal & Ash Quality on Boiler design and performance. Internal and External deposits of Boiler. ID, FD, PA Fan specification &

selection. Boiler Mountings. Boiler Insulation. Thermal expansion of Boiler. Boiler structure & supports.

#### **PE/T/414C FLUID POWER AND CONTROL**

Properties of industrial fluids, fluid reservoir for liquids and gases, fluid power units - pumps, compressors & blowers, accumulators & intensifiers, valves - one, two & three way valves, pressure control, flow control & sequence valves, master control valves, flexible piping & fittings, seals & packing, filtration of liquids, moisture control of gases, industrial hydraulic & pneumatic circuits - pressure regulating circuits, counterbalance circuits, sequence operation circuits, speed control circuits, meter-in-meter-out circuits, regenerative circuits, circuits using accumulators & intensifiers, fluid logic & control system - principles of fluid logic & application, open loop & closed loop system, block diagram, root locus method, steady state error & stability, system performance, optimization & reliability, feedback control system, analogue technique - application to hydraulic & pneumatic system.

#### **PE/T/414D FLUID FLOW AND GAS DYNAMICS**

Introduction and definitions, equations of motion for 3-D flow, Navier-stokes equations, circulation and vorticity, potential flow, flow around bodies (cylinders and aerofoil), transformation of circle into aerofoil. Introduction to compressible flow, velocity of sound and Mach number, isentropic flow, flow with friction and heat transfer, Rayleigh line and Fanno line, analysis of flows with normal and oblique shock waves, supersonic flows, unsteady flows.

#### **PE/T/414E EXPERIMENTAL TECHNIQUES & MEASUREMENTS**

Basic principles of experimental analysis, strain gauges and strain gauge circuits, Rosettes, photo elasticity, brittle coating methods, Moire fringe methods, holograph, etc. Flow visualization techniques, measurement of pressure, velocity, discharge, temperature in fluid flow, hot-wire anemometry, hot-film anemometry, LDA, PIV, solid transformation.

#### **PE/T/414F FINITE ELEMENT METHODS**

Methods of weighted residuals and variational approach for solving differential equations, Galerkin and Rayleigh-Ritz methods, finite element methods and implementation, convergence criterion, finite element formulation for linear elastic continuum and extended Laplace equation including inertia and dissipative terms, subtracting, co-elements including isoparametric elements, plate bending and C elements, non-conforming elements and patch test, dynamic and non-linear problems.

#### **PE/T/414G SYSTEM DESIGN AND OPTIMIZATION IN THERMAL ENGINEERING**

Introduction to thermal design, Regression Analysis and Equation Fitting, Basics of Fluid Flow and heat transfer required for design of thermal systems, Modeling of thermal equipment, e.g. Heat Exchangers, evaporators, Condensers, turbo-machines, etc. System simulation (Successive substitution, Newton Raphson method)- examples. Optimization, search methods, linear programming, dynamic programming, geometric programming, Lagrangian multipliers, examples applied to thermal systems such as power plants. Basics of second law analysis in heat and fluid flow, applications in thermal designs.

#### **PE/T/414H HEAT EXCHANGERS**

Review of Heat transfer: conduction, Convection and Radiation. Classification of heat exchangers, Tubular heat exchangers, Parallel flow, Counter flow and cross flow arrangements, Design and analysis of heat exchangers, LMTD and NTU methods and their applications, Shell and Tube heat exchangers, Flow arrangements for increased heat recovery, Application of extended surfaces. Heat exchanger with two phase mixtures, Condensers, evaporators - their design and analysis. Direct contact type heat exchangers - Cooling Towers.

#### **PE/T/414I ADVANCED TOPICS IN FLUID MECHANICS**

Reviews of basic laws of fluid flow in integral and differential form, Kinematics, ideal fluid flow, Newtonian fluid flow and applications, creeping flow, transition and turbulence, modeling and dimensional analysis, Boundary layer concept and its formulation in different situations, Blasius solution and similar solutions, thermal boundary layer.

#### **PE/T/414J HEATING VENTILATION & AIR-CONDITIONING**

Industrial needs for heating, ventilation and air-conditioning. Psychrometric overview: Physical properties of moist air, mixing processes, processes with varying enthalpy and moisture content of air.

Analysis and design of heating and air-conditioning systems: Review: Principles of psychrometry; psychrometric processes and their analysis; psychrometric charts. Heat load estimation. System design for an air conditioning system: Design for capacity of AHU, coil.

Major air conditioning Equipment: Chillers; Air handling units; cooling towers; cooling coils.

Types of AC system. Comfort chart. Ducting systems: four systems of ducting design. Control: HP/LP cutout switches; oil safety switch; Thermostat; Humidistats and antifreeze thermostats.

Purpose of ventilation, methods of ventilation, determining quantity of contaminants and air change. Aerodynamics principles of air interchange, air jets, interaction of jets, thermal currents, air outlets, suction data, circulation in isothermal conditions, surplus heat and other impurities – surplus heat; humidity; gases and vapours, dust, methods of processing and removal. Main ventilation methods – air change, effect of wind, control of natural ventilation, calculation of air change, air douches, applications, standards, calculation, air curtains; local exhaust systems. Fundamental Concept of Control and Monitoring of HVAC.

#### **PE/T/414K POWER PROJECT ENGINEERING AND MANAGEMENT**

Major project activities: from concept to commissioning, project planning, feasibility, project approvals, project funding, regulatory requirements, project tariff, contracting, competitive bidding, specifications, procurement, quality controls, project implementation.

Project Engineering: Basic concepts of Owner's Engineers, EPC Contractor's Engineers and Lender's Engineers – their roles in feasibility study, detailed project report, EPC specification, basic engineering, detailed engineering, procurement support, review



engineering, inspection and testing, pre-commissioning activities, acceptance tests, reliability runs, performance guarantee tests – plants and equipment, codes and procedures, liquidated damages, uncertainty analysis, calculation and report making.

Project Management: Project Network – monitoring & control, software based management techniques, project handover.

Residual life assessment of main plant and auxiliaries. R&M of power plants: major stages and their execution.

### **PE/T/414L COMPUTATIONAL FLUID DYNAMICS**

Types of Partial Differential Equation: parabolic, elliptic and hyperbolic equations; boundary conditions – well posed and ill posed problems.

Reynolds transport theorem, Conservation equations in fluid flow and heat and mass transfer.

Finite Difference discretization of conservation equations. Explicit and Implicit methods, Stability, convergence, consistency and transportiveness, Solution of heat conduction problems using finite difference Method. Stream function-vorticity formulation of viscous fluid flow and its discretization; Viscous flow modeling using the primitive variables approach using finite difference and finite volume algorithms – SOLA and SIMPLE.

Introduction to turbulence modeling.

### **GRAND VIVA-VOCE**

#### **PE/S/411 SEMINAR**

#### **PE/S/412 POLLUTION MEASUREMENT & CONTROL LAB**

1. Demonstration of the measurement techniques of stack gas emission using flue gas analyzer.
2. Measurement of Particulate fractions ( $PM_{10}$ ,  $PM_{2.5}$ , NRPM & TSPM) using air samplers.
3. Chemical determination of  $SO_2$  and  $NO_2$  employing Spectrophotometer.
4. Measurement of Ground Level Ozone using Photometric Ozone Analyzer.
5. Measurement of Carbon Monoxide using Gas Filter Correlation CO Analyzer.
6. Measurement of  $NO_X$  ( $NO/NO_2$ ) using Chemiluminescence  $NO_X$  Analyzer.
7. Determination of Aerosol Optical Thickness (AOT) employing Hand held Sunphotometer.
8. Determination of C-H-N-S using C-H-N-S Analyzer.

#### **PE/S/413 POWER PLANT FAMILIARIZATION CAMP**

Each student will have to undergo this sessional course in one or more power plants and load dispatch centers for a total period of at least three weeks. The students will have to bear expenses for their board and lodging. Assessment will be made on the basis of Viva-voce and report submitted by each student by the training department of the concerned Power Plants / Load Dispatch Centers.

#### **PE/S/414 HEAT POWER LABORATORY**

1. Study of IC engines,

2. Determination of valve timing diagram of a single cylinder CI Engine,
3. Performance test of single cylinder CI engines test rig,
4. Performance test of a variable compression ratio SI engine,
5. Performance test of a refrigeration unit,
6. Performance test of a wet cooling tower test rig,
7. Performance test on air compressor,
8. To study and conduct Morse Test on four-cylinder four-stroke Petrol Engine,
9. Tests on boilers and turbines.

**PE/S/415      PROJECTS-I & II**

Project I: Any topic related to power engineering (mechanical) - 2 semesters

Project II: Any topic related to power engineering (electrical) -- 2 semesters

## **FOURTH YEAR SECOND SEMESTER**

### **PE/T/421 POWER PLANT OPERATION & MAINTENANCE MANAGEMENT**

Operation of feed pumps, condensate pumps and feed water heaters, Operation of FD, ID and PA fans, coal feeders and mills, coal, oil and gas burners. Bringing a boiler on load, Cold and Hot start-up and shutdown of turbogenerators, normal and emergency operation of power plants.

Automatic voltage and frequency control, VAR-compensation during peak and off-peak hours and the voltage profile, Generator capability curve. Relay setting operation, Setting of under-voltage and under-frequency relays, Voltage collapse due to cascaded tripping and emergency measures, Automatic load-shedding, Resynchronization and Self-synchronization, Load scheduling and load dispatch.

Maintenance organization, routine and emergency maintenance of boilers, turbines and auxiliaries, like pumps, heat exchangers, mechanical shaft seals, ejectors etc. Economic operation of a plant, Optimization procedure for boiler and turbine operation, Maintenance records.

Operation and maintenance of captive power plants, Maintenance of generators, transformers, Main and Transfer buses, Relay and circuit breakers and the drives, charging and discharging of storage cells and their maintenance.

### **PE/T/422 NUCLEAR POWER GENERATION**

Introduction to nuclear physics, Nuclear power generation in general, Reactor fuel system, Fuel cycle, Production of reactor fuels, Fuel enrichment, Properties of fuel materials, Fuel management, Reprocessing of spent fuels etc. Non-fuel reactor materials, different materials used as moderator, Material for fuel cladding, etc. Reactor types, different power reactor systems, PWR, BWR, PHWR, Fast breeder reactors, gas cooled reactors, etc. Core vessel and coolant system of different reactors, description of reactor in India. Reactor safety, general principles of safety, Safety features, Reactor safety analysis, Design basis, Accidents, Loss of Coolant Accident etc., Reactor control, general control features, control devices, control rods and their driving mechanisms, control in reactor operation, radiation protection, radiation hazards, different units of radiation, protection standards, biological effects, radioactive, Biological effects, radioactive waste treatment systems etc.

### **PE/T/423 INDUSTRIAL ADMINISTRATION AND MANAGEMENT SCIENCE**

Production management., project management - CPM, PERT, application of network strategies, scheduling & line balancing investment & cost benefit analysis, present worth & breakeven analysis inventory & material control management - m. r. p, linear & dynamic programming, transportation problems., assignment problems., sequencing, introduction to queuing theory., theory of games, forecasting., correlation & regression., replacement, reliability & maintenance strategies, statistical quality control, work study & work management, total quality management, management information system.

Behavioral science concepts & objectives of management, managerial control system, organization - authority & responsibility. managerial leadership, communication, delegation, decision making, motivation, transactional analysis, time management.

**PE/T/424 ELECTIVE II**

- A. MICROCOMPUTERS AND DIGITAL SYSTEMS
- B. ADVANCED TOPICS IN ELECTRICAL MACHINES
- C. POWER PLANT SIMULATION AND MODELING
- D. COMPUTER AIDED POWER SYSTEM ANALYSIS & OPERATION
- E. CONTROL AND REGULATION OF POWER PLANTS
- F. HYBRID ENERGY SYSTEMS
- G. GREEN ENERGY

**PE/T/424A MICROCOMPUTERS AND DIGITAL SYSTEMS**

Introduction to 8086 based systems- organization and architecture. Memory and I/O. Micro-computer interfaces- Interrupts and IRQ. Interfacing serial ports- UARTS, RS 232 and RS 485 . Parallel Port and USB interfaces. Micro-computer based instrumentation systems for power plants- Data Acquisition Systems, SCADA, GPIB. Concepts of Field-Bus

**PE/T/424B ADVANCED TOPICS IN ELECTRICAL MACHINES**

Generalized theory of electrical machines, linear transformations - matrix model of dc, inductive & synchronous machines - motional impedance matrix, effects of saturation, harmonics & solid iron rotor/pole shoe on the performance of synchronous machines, stability assessment in terms of generalized machine model, Asynchronous operation of synchronous machines – resynchronization, self synchronization, heating & cooling of large power transformers & turbine-generators, effects of surge voltage on electrical machines, industrial testing of electrical machines - types tests & routine tests - IS specifications.

**PE/T/424C POWER PLANT SIMULATION AND MODELING**

Concept of a model- their classifications - concept of similarity and simulation - physical vs mathematical simulation - analog, digital and hybrid simulation, stochastic models - sampling techniques - data storage & data handling, identification & estimation of system parameters - on-line & off-line techniques, model validation - accuracy of simulation verses cost, modeling of power network & load, mathematical models of one-machine, two-machines & multi-machines problems, liberalization of models under small perturbation, reduced order models , time domain vs frequency domain analysis, computer methods of system analysis - stability assessment, simulation experiments - micro-machine model of power system.

**PE/T/424D COMPUTER AIDED POWER SYSTEM ANALYSIS & OPERATION**

Introduction, operational problems of electrical power system, load-fore-casting, unit-commitment, load scheduling, network modeling & load flow studies - functions of load-dispatch centers, concept of optimal load flow, load-frequency control - one area & two

area systems, short-circuit, asynchronous operation & stability analysis using computer programs, transient & dynamic overvoltage, reliability of system & generation planning.

#### **PE/T/424E CONTROL AND REGULATION OF POWER PLANTS**

Introduction, discrete data system and Z-plane analysis, state space analysis, observability and controllability, performance specification and compensation, analysis of non-linear systems, face plane, and D-partition methods, concept of adaptive control, power plant system and sub-systems and their mathematical models, identification of control objectives, coordination of different control units, application of solid state devices, excitation control, microprocessor and PLC control of excitation and drives, digital and hybrid control scheme. Power system stabilizers, automatic control of frequency, voltage generation and load flow, automatic re-closure, automatic load shedding on loss of generation, optimality concept, dynamic optimization of multivariable system.

#### **PE/T/424F HYBRID ENERGY SYSTEMS**

Introduction- concept of stand alone and distributed generations. Generation and storing technologies, Hybrid energy systems – concepts, elements, operation, control. Introduction to electric grid- integration of renewable energy into grid- operation, control, protection, reliability and security. National and international norms for grid connections. Concepts of smart grid development- components, control and instrumentation, protection. Techno economic optimization- design, performance evolution, feasibility assessment.

#### **PE/T/424G GREEN ENERGY**

Introduction – Global energy scenario- Green energy and Brown energy sources. Scientific principles of renewable energy- technical and social implications. Solar thermal systems- radiation spectrum, radiation measurement, technologies Applications-heating, cooling, drying, distillation, power generation

#### **PE/S/421 PROJECT I**

#### **PE/S/422 PROJECT II**

#### **PE/S/423 ELECTRICAL MACHINES AND POWER SYSTEM LABORATORY -II**

- 1) Study of Active and Reactive Power Transfer.
- 2) Measurement of ABCD parameters of a transmission line.
- 3) Power frequency test with porcelain insulator.
- 4) Impulse withstand and power-frequency tests of pin insulators.
- 5) Di-electric test of transformer oil and insulating material.
- 6) Synchronization and Parallel operation of alternators.
- 7) Studies of SOLAR cells.

- 8) Performance study of induction type relay.
- 9) Performance study of attraction type relay.

**PE/S/424      INSTRUMENTATION AND CONTROL LABORATORY**

- 1) Study of synchro
- 2) Study of Stepper Motor
- 3) Study of an AC position control system
- 4) Study of a DC position control system
- 5) Study of waveforms using a signal generator and a CRO
- 6) Study of a PID controller module
- 7) Study of a Compensation Design module
- 8) Micro-processor based servo motor speed control
- 9) Micro-processor based voltage control using a SCR