

Bachelor of Mechanical Engineering

Curriculum

4 Year BME Course

First Year First Semester

Code No	Subject	Periods/week L-T-S	Credit Point	Marks	
				Exam	Sessional
ME/MATH/T/111	Mathematics – I	3-0-0	3	100	
ME/PH/T/112	Physics	3-0-0	3	100	
ME/ET/T/113	Electronics	4-0-0	3	100	
ME/EE/T/114	Basic Electrical Engineering	3-0-0	3	100	
ME/T/115	Engineering Mechanics – I	4-0-0	4	100	
ME/T/116	Engineering Drawing (Drawing board mode)	0-0-0	2	100	
ME/S/111	Engineering Drawing (Drawing board mode)	0-0-4	2		100
ME/S/112	Workshop Practice – I	0-0-3	3		100
ME/S/113	Numerical analysis and computer programming	0-0-4	3		100
	Total	17-0-11	26	600	300

First Year Second Semester

Code No	Subject	Periods/week L-T-S	Credit Point	Marks	
				Exam	Sessional
ME/MATH/T/121	Mathematics-II	3-0-0	3	100	
ME/EE/T/122	Electrical Machines	3-0-0	3	100	
ME/T/123	Engineering Mechanics II	4-0-0	3	100	
ME/T/124	Fluid Mechanics –I	3-0-0	3	100	
ME/T/125	Thermodynamics	4-0-0	4	100	
ME/T/126	Descriptive Geometry and Surface Development	0-0-0	2	100	
ME/S/121	Descriptive Geometry and Surface Development	0-0-3	2		100
ME/S/122	Computer Aided Drafting	0-0-3	3		100
ME/S/123	Workshop Practice II	0-0-3	3		100
ME/EE/S/124	Electrical Technology Lab.-I	0-0-3	3		100
	Total	17-0-12	29	600	400

Second Year First Semester

Code No	Subject	Periods/week L-T-S	Credit Point	Marks	
				Exam	Sessional
ME/MATH/T/211	Mathematics –III	3-0-0	3	100	
ME/T/212	Engineering Mechanics III	4-0-0	4	100	
ME/T/213	Fluid Mechanics-II	3-0-0	3	100	
ME/T/214	Heat Transfer	3-0-0	3	100	
ME/T/215	Material Science and Engineering	4-0-0	4	100	
ME/T/216	Machine Drawing I (Drawing board mode)	0-0-0	2	100	
ME/S/211	Machine Drawing I (Drawing board mode)	0-0-4	2		100
ME/S/212	Workshop Practice III	0-0-3	3		100
ME/EE/S/213	Electrical Technology Lab.-II	0-0-3	3		100
	Total	17-0-10	27	600	300

Second Year Second Semester

Code No	Subject	Periods/week L-T-S	Credit Point	Marks	
				Exam	Sessional
ME/MATH/T/221	Mathematics-IV	3-0-0	3	100	
ME/T/222	Fluid Machinery-I	3-0-0	3	100	
ME/T/223	Engineering Mechanics IV	3-0-0	3	100	
ME/T/224	Kinematic Analysis and Synthesis	4-0-0	3	100	
ME/T/225	Machine Design-I	3-0-0	3	100	
ME/T/226	Manufacturing Processes	4-0-0	3	100	
ME/S/221	Machine Drawing II (Comp terminal Mode)	0-0-3	3		100
ME/S/222	Fluid Mechanics Lab	0-0-3	3		100
ME/S/223	Heat Power Lab.-I (Thermo. & Heat Transfer)	0-0-3	3		100
ME/S/224	Applied Mechanics Lab. - I	0-0-3	3		100
	Total	20-0-12	30	600	400

Third Year First Semester

Code No	Subject	Periods/week L-T-S	Credit Point	Marks	
				Exam	Sessional
ME/T/311	Fluid Machinery-II	3-0-0	3	100	
ME/T/312	Dynamics of Machines	4-0-0	4	100	
ME/T/313	Internal Combustion Engine	3-0-0	3	100	
ME/T/314	Machine Design-II	4-0-0	3	100	
ME/T/315	Machining Technology and Metrology	4-0-0	4	100	
ME/S/311	Workshop Practice IVA	0-0-3	3		100
ME/S/312	Metrology and Metallography Lab. A	0-0-3	3		100
ME/S/313	Applied Mechanics Lab.-II	0-0-3	3		100
	Total	18-0-9	26	500	300

Third Year Second Semester

Code No	Subject	Periods/week L-T-S	Credit Point	Marks	
				Exam	Sessional
ME/T/321	Measurement & Instrumentation	3-0-0	3	100	
ME/T/322	Steam Power Plant	4-0-0	3	100	
ME/T/323	Industrial Management	3-0-0	3	100	
ME/T/324	Machine Design-III	4-0-0	3	100	
ME/T/325	Electrohydraulic Control Systems	3-0-0	3	100	
ME/T/326	Elective I	3-0-0	3	100	
ME/S/321	Workshop Practice IVB	0-0-3	3		100
ME/S/322	Metrology and Metallography Lab. B	0-0-3	3		100
ME/S/323	Machine Design Sessional (Comp terminal mode)	0-0-3	3		100
ME/S/324	Fluid Machinery Lab.	0-0-3	3		100
	Total	20-0-12	30	600	400

Fourth Year First Semester

Code No	Subject	Periods/week L-T-S	Credit Point	Marks	
				Exam	Sessional
ME/T/411	Machine Design-IV	4-0-0	3	100	
ME/T/412	Refrigeration and Air conditioning	3-0-0	3	100	
ME/T/413	Metal Cutting and Machine Tools	4-0-0	3	100	
ME/T/414	Elective - II	3-0-0	3	100	
ME/S/411	Workshop Practice VA	0-0-4	3		100
ME/S/412	Heat Power Lab.-II (Devices)	0-0-3	3		100
ME/S/413	Colloquium	0-0-3	3		100
ME/S/414	Project I	0-0-3	3		100
	Total	14-0-13	24	400	400

Fourth Year Second Semester

Code No	Subject	Periods/week L-T-S	Credit Point	Marks	
				Exam	Sessional
ME/HUM/T/421	Humanities	4-0-0	3	100	
ME/ECO/T/422	Engineering Economics and Costing	3-0-0	3	100	
ME/T/423	Material Handling	3-0-0	3	100	
ME/T/424	Elective III	3-0-0	3	100	
ME/T/425	Comprehensive Viva Voce on Mechanical Engg.	0-0-0	3	100	
ME/S/421	Workshop Practice VB	0-0-4	3		100
ME/S/422	Machine Elements Lab	0-0-3	3		100
ME/S/423	Project II	0-0-3	3		100
	Total	13-0-10	24	500	300

First Year, First SemesterME/MATH/T/111 **Mathematics-I****Module 1****Differential Calculus of Single Variables: (Marks: 30)**

Sequence; Infinite series and their convergence and divergence; Cauchy's general principle of convergence; Comparison test; D'Alembert's ratio test and Cauchy's root (statement and their applications only); Successive differentiation; Rolle's theorem*; Mean value theorems; Taylor's theorem*; Maclaurin's theorem*; Expansion of elementary functions; Indeterminate form; Curvature and Asymptote; Concavity, convexity and points of inflexion.

Differential Calculus of Several Variables: (Marks: 20)

Limit; Continuity and Differentiability; Directional derivatives; Partial derivatives; Differentials; Euler's theorem on homogeneous functions; Implicit Functions; Jacobian; Taylor's theorem*, Maxima; Minima and Lagrange's method of undetermined multipliers.

* Proof not required.

Module 2**Integral Calculus: (Marks: 50)**

Riemann integration (Definition and properties); Fundamental theorem of integral calculus; First Mean value theorem of integral calculus; Improper integrals (Definitions and examples); Gamma and Beta functions; Multiple integrals; Rectification; Quadrature; Volume and surface areas of solids of revolution; Numerical integration by trapezoidal and Simpson's 1/3 rule.

ME/PH/T/112 **Physics**

1. Simple Harmonic motion, free vibration, damped and forced vibration, resonance. Wave motion, Superposition principle, phase velocity and group velocity. (4)
2. Motion of fluid, Bernoulli's theorem, Poiseuille's equation for the flow of liquid through narrow tube, motion of a body through viscous medium, Stoke's law. (4)
3. Overview of Coulomb's law, Gauss's law, dielectric polarization, Displacement Vector, Overview of Biot Savart law and ampere's circuital law. (4)
4. Time –varying field, Farady's law of electromagnetic induction, Transient phenomena in electric circuits.(Series L-R, Series C-R) (4).
5. Maxwell's equations, wave equation, plane electromagnetic waves, energy momentum , Poynting's theorem, electromagnetic boundary conditions, reflection and refraction. (10).
6. Interference of light waves, Young's experiment, Spatial and temporal coherence, diffraction due to single slit and plane diffraction grating, Polarization of light waves , Polarization by reflection,Brewster's law. (9).
7. Wave particle duality, de Broglie waves and uncertainty principle, Concept of wave function and its physical interpretation. Normalization. I-D Schrodinger equation -1-D (infinite) potential well. (7)

ME/ET/T/113 **Electronics**

Review of the basics of semiconductor physics; N and P- type semiconductors; P-N junction and its V-I characteristics; Rectifier and filter circuits; Zener diodes, its V-I characteristics and applications. (5 periods)

Junction transistors (NPN and PNP types); Symbolic representation of these transistors; Biasing of transistors; Their Input and out characteristics; DC load line, determination of Q-point and application of sinusoidal input signal, Common base, common emitter and common collector configurations; Voltage gain and power gain, Transistors as amplifiers, small signal analysis of BJT circuits (12 periods)

Introduction to JFET and MOSFET characteristics	(3 Periods)
General theory of feedback, negative feed back and its advantages, Darlington connection	
Positive feed back, Requirement for oscillation; Phase shift oscillator R-C types.	(8 periods)
Transistor as a switch, Introduction to astable, monostable and bi-stable multivibrators, Schmitt Trigger	(4 periods)
Introduction to linear integrated circuits, Operational amplifiers and its applications including inverting and non-inverting amplifiers, adders, subtractors, integrators etc.	(4 periods)
Combinational digital circuits; Logic systems and basic logic gates, truth table of each gate and their implementations,	(4 periods)
Introduction to non-linear integrated circuits, flip-flops, clock pulses.	(2 Periods)

Reference: Electronic Devices and Circuits An Introduction - Allen Mottershead; PHI

ME/EE/T/114 **Basic Electrical Engineering**

DC circuits: Superposition theorem, Kirchoff's Laws and Thevenin's theorem, Maximum power transfer, applications; delta-star and star-delta transformations. (6 Lectures)

Electromagnetism: Review of magnetic flux, force on current carrying conductors, Fleming's right hand rule and Lenz's law. (3 lectures)

Magnetic circuit: MMF, Flux, reluctance, B-H loop, Hysteresis and eddy current loss; Magnetic circuit analysis with an air gap. (6 lectures)

Alternating voltage and current: Generation of alternating emf, average value, RMS value, Form factor, peak factor, representation of an alternating quantity by a phasor, addition and subtraction of phasors. Single phase circuits with R, L and C in parallel and series, resonance, power and power factor, complex notations, j-operator, resistance, reactance and impedance, power and reactive volt-ampere. (10 lectures)

Electrical Measurements: Measurement of resistance and inductance by using bridges, Principle of operation of moving coil and moving iron type instruments; DC and AC ammeters and voltmeters, Power factor meter and frequency meter, DC and AC Power measurement, Introduction to error analysis (6 lectures)

Introduction to Primary sensing elements and transducers, Thermistors, opto-electronic devices like photo-diodes, photo-voltaic cell (8 lectures)

Introduction to Power system components, Switches, relays and circuit breakers (4 lectures)

ME/T/115 **Engineering Mechanics-I**

Statics:

Vectors, Equivalent systems, Free body diagrams and equilibrium (2d and 3d), Analysis of structures – truss, frame and cable, Friction-basics, wedge, screw and belt, Principle of Virtual work and its application to rigid body statics, Properties of surfaces – Centroid, Area moment of inertia and Product of inertia including rotation of axes and Mohr's circle.

Dynamics:

Differentiation of vectors (Derivative of vectors of constant magnitude and constant direction), Kinematics and kinetics of particles in 2d using Newton's law, Energy principle and Momentum method in rectangular, natural and polar co-ordinates.

ME/T/116

ME/S/111

Engineering Drawing

(Drawing Board Mode)

(Sessional: 100 marks, Examinaton: 100 marks, Examination Duration: 4 hours)

Introduction and uses of drawing instruments, Different types of lines, IS conventions (BIS SP46: 1988), Engineering Lettering, Home assignment	(4 hours)
Standard practices and principles of dimensioning. Concept of scale, use of diagonal scale and scale of chord, Home assignment	(4 hours)
Geometrical Constructions: Regular polygons, conic sections, spirals, Sine Curve, Involutives, Rolling Curves, Home assignment	(4 hours)
Principles of orthographic projection: planes of projection (principal & auxiliary), object & viewer, lines of projection etc., angles of projection. Projections of points, lines and solids, Home assignment	(4 hours)
Orthographic projection drawing of simple objects: prisms, pyramids & sphere with and without auxiliary views.	(8 hours)
Orthographic projection of combination of simple objects with and without auxiliary views.	(4 hours)
Orthographic projection of machine parts	(4 hours)
Isometric projection: Isometric scale, Isometric drawings	(8 hours)
Third view development.	(8 hours)
Sectional views.	(8 hours)

ME/S/112

WORKSHOP PRACTICE-I

(CARPENTRY AND PATTERN MAKING)

Introduction to types of Indian woods used for engineering purposes and carpenter's tools; use of wood working machines; making of selected joinery;
Introduction to different phenomena arising out of shrinkage of castings and pattern maker's rule; making of wooden patterns from supplied drawings and samples of patterns; making of core boxes.

ME/S/113

NUMERICAL ANALYSIS AND COMPUTER PROGRAMMING

A. Computer Programming:

1. Introduction to modern digital computers: organisation of digital computer – hardware and software, Flow charts and their use (4 hours).
2. High level programming languages: Fortran, C++, MATLAB, etc. (4 hours).
3. General programming concepts:
 - i). statement, numerical input/output; (4 hours).
 - ii). character variables, logical variables and operators, (4 hours).
 - iii). transfer of control; do loops, (4 hours).
 - iv). array, subscripted variable, (4 hours).
 - v). functions and sub routines, (4 hours).

B. Numerical Analysis and its implementation through computer programming:

- a. Solution of polynomial equation and simultaneous non-linear equations using iterative techniques. (2x4 hours).
- b. Solution of simultaneous algebraic equations using Gauss elimination method and various iterative methods. (4 hours).
- c. Numerical differentiation and integration using various rules and formulae. (2x4 hours).
- d. Numerical solution of differential equations using various methods like Runge Kutta method, Taylor series method, Predictor-Corrector method etc. (2x4 hours).

First Year, Second Semester

ME/MATH/T/121

Mathematics – II

Linear Algebra: (Marks: 30)

Matrix Determinant; Inverse of a square matrix ; Elementary row and column operations; Echelon form; rank of a matrix; Solution of a system of linear equations; Cramer's rule; matrix inversion method. Characteristic equations; Eigenvalues and Eigenvectors; Cayley-Hamilton theorem.

Geometry of Three Dimensions: (Marks:20)

Cartesian co-ordinates in three dimension; Direction cosines; Angle between two lines; Equation of planes and Straight lines; Skew lines; Shortest distance between skew lines; Condition of co-planarity; Standard equation of spheres.

Vector Algebra :(Marks:15)

Basics of vector algebra; Dot and Cross products of two vectors; Products of three or more vectors; Volume of tetrahedron; Work done; Moment; Angular Velocity.

Vector Calculus: (Marks:35)

Vector functions of a scalar variable; Limit; Continuity and Derivative of vector functions; Applications to mechanics ; Partial Derivatives of vector function of more than one variables; Directional derivative; Gradient; Divergence and Curl; Vector integration; Line integrals; Surface integrals and volume integrals; Green's theorem in the plane; Gauss theorem; Stokes's theorem and their applications; Tangent, Normal and Binormal of space curve; Serret-Frenet formulae; Normal plane; Rectifying plane and oscillating plane.

ME/EE/T/122

Electrical Machines

Direct current machines: Operating principle of DC generator and motor, Construction and winding, Ring wound armature, commutator, lap and wave winding, emf equation, armature reaction, Losses in DC machines and efficiency determination by brake, Swinburne and Hopkinson methods.

Speed-torque characteristics of DC motors, starting and speed control by rheostats and thyristors. Testing and selection of DC machines (10 lectures)

Single phase transformer; Principle of operation, types of transformer, construction, emf equation, equivalent circuits, phasor diagram, losses and efficiency, open circuit and short circuit tests, auto transformer (8 Lectures)

Three phase circuits: Introduction to 3-phase systems, relationship between line and phase voltages in star-connected and delta connected systems, measurement of power in 3-phase systems. Introduction to 3-phase transformer. Two-wattmeter method for star connection and delta connection, Three-wattmeter method for 3-phase 4-wire circuit, Energy meter (4 Lectures)

Synchronous machines: Production of rotating magnetic field; concept of synchronous speed, Synchronous motors and generators (8 Lectures)

Induction machines: Principle of operation of 3-phase induction machine, Single phase induction motors, slip, Starting and speed control of 3-phase induction motor, Testing (10 Periods)

Recommended books:

1. AC machines by M. G. Say
2. Electrical Machines by P. S. Bimbra
3. Problems on electrical engineering by Parker and Smith

ME/T/123

Engineering Mechanics-II

Dynamics:

Revision of Newton's laws, Energy principle and Momentum method, Application of kinetics to problems of Collision, Central force motion and free vibration of single-degree-of-freedom systems (inclusive of damping).

Deformable Mechanics:

Uniaxial stress field, Hooke's law, Introduction to elastic constants, Thin pressure vessel, Torsion of circular shafts, Close-coiled helical spring, Shear force and Bending Moment in beams, Normal and shear stresses in beams, Plane stress and Plane strain, Mohr's circle, Combined bending and twisting.

ME/T/124

FLUID MECHANICS-I

Definition of fluid, continuum hypothesis, different properties of fluid, classification (like Newtonian/non-Newtonian, ideal/real etc.). (2 hrs.)

Fluid Statics: pressure at a point, Pascal's law, variation of pressure within a static fluid – equation of hydrostatic pressure distribution, variation of properties in static atmosphere; measurement of pressure; hydrostatic thrust on plane and curved surfaces; buoyancy, stability of submerged and floating bodies. (5 hrs.)

Fluid Kinematics: preliminaries of Eulerian and Lagrangian description of fluid flow; velocity and acceleration of fluid particles in rectilinear and curvilinear co-ordinates; different types of flow – steady and unsteady flow, uniform and non-uniform flow, one- two and three dimensional flow, rotational and irrotational flow, laminar and turbulent flow; stream line, streak line and path line; stream filament and stream tube; principle of conservation of mass – equation of continuity for a stream tube and for unsteady three dimensional flow; deformation of a fluid particle – linear and angular deformation and rotation; vortex motion; relative equilibrium of fluids. (8 hrs.)

Fluid Dynamics: principle of conservation of linear momentum, Euler's equation of motion along a stream line and for unsteady three dimensional flow; derivation of Bernoulli's equation and physical significance of different terms; applications of Bernoulli's equation in flow measurement devices: stagnation tube, pitot tube, venturi meter, orifice meter, triangular and rectangular weir. (7 hrs.)

Application of Linear Momentum to Control Volume: linear momentum equation; analysis of force exerted by a fluid stream on a solid boundary – jet impingement, thrust on pipe bends etc. (2 hrs.)

Principle of Conservation of Angular Momentum and its application. Steady Flow Energy Equation and its application. (2 hrs.)

Characteristics of Laminar and Turbulent Flow: Reynolds experiment, critical Reynolds number; laminar flow through pipe – Hagen Poiseuille equation. (3 hrs.)

Flow Through Closed Conduits: Darcy Weisbach equation, friction factor of closed conduits, flow through non-circular ducts, Moody's diagram and its use; minor losses – at sudden expansion, at sudden contraction, at bends, at valves and fittings etc; analysis of simple pipe network problems. (6 hrs.)

Free Surface Flow: flow in open channel, Chezy's equation, Manning's equation, economical cross section, specific energy, hydraulic jump. (5 hrs.)

ME/T/125

THERMODYNAMICS

1. Introduction: Microscopic and Macroscopic viewpoints in thermodynamics. Fundamental concepts of System, Control volume, State, Property, Equilibrium, Processes. etc. 2 hours

2. The Zeroth law of thermodynamics: Thermal equilibrium. Temperature. Principle of thermometry. International practical temperature scale. 2 hours

3. Energy: Different energy forms-stored energy, energies in transition (J-Icat & Work). Definitions. 2 hours

4. Properties of pure substances: Thermodynamics' properties of pure substances in solid, liquid and vapour phases. P- V - T behaviour of simple compressible substances. Phase rule. State postulate. Thermodynamic property tables and charts. Ideal and Real gases. Equations of state. Compressibility factor. Generalised compressibility chart. Problems. 8 hours

5. The First law of thermodynamics: The first law of thermodynamics for systems. Corollaries. Internal energy and enthalpy. First law for control volumes. Steady state and unsteady state applications, Process calculations for ideal and real gases using equations, tables and charts. Problems. 6 hours

6. The Second law of thermodynamics: Limitations of the first law of thermodynamics. Steadily operating systems-Heat engine, Heat Pump and refrigerator. Introduction to power and refrigeration cycles. Thermal efficiency. Coefficient of Performance. Carnot cycle. Statements of the second law of thermodynamics. Equivalence of Kelvin Planck and Clausius statements of the second law of thermodynamics. Corollaries. Entropy. Reversibility and Irreversibility. Problems. Mollier Chart and its use. Second law analysis of control volume. Entropy generation. Reversible work. Availability. Irreversibility. 12 hours

7. Thermodynamic relationships: Tds relations. Maxwell equations. Clapeyron equation, Clausius Clapeyron

- equation. Joule-Thompson coefficient. Compressibility and expansion coefficient. Problems. Development of property data in graphical and tabular form. 4 hours
8. Psychrometry: Thermodynamics of ideal gas and condensable mixture. Psychrometric chart and its use. Different psychrometric processes. 6 hours
9. Fuels and Combustion: enthalpy of formation, Calculation of enthalpy of combustion and adiabatic flame temperature, Second law analysis of chemically reacting systems. 6 hours
10. Chemical and Phase Equilibrium: Criteria for equilibrium, Equilibrium between multi-component and multi-phase systems, Gibbs phase rule, Meta-stable equilibrium, Chemical equilibrium. 8 hours

ME/T/126

ME/S/121

Descriptive Geometry and Surface Development

(Sessional: 100 marks, Examinator: 100 marks, Examination Duration: 4 hours)

- Introduction to the concept of Descriptive Geometry: points, lines, surfaces and their classifications. Projection of points and lines, and their projections on principal and auxiliary planes. Relation of the coordinate axes and the planes of projections. Methods of finding true shape of different lines and different surfaces. (3 hours)
- Revolution method & Auxiliary view method of finding the true shape of different types of lines. (3 hours)
- Determining the true shape of a plane. (3 hours)
- Determination of the Relations (perpendicular distance, foot of perpendicular, angle, line of intersection etc.) among point, line and plane. (3 hours)
- Intersection of a line with curved surfaces: a cylinder, cone and sphere, (3 hours)
- Concept and definition of Trace of points and lines, Trace of different types of lines: (3 hours)
- Traces of planes. To determine the line of intersection and the angle between the edge views of two planes by the method of trace. (6 hours)
- Surface Development of simple objects (both right angled and oblique): cylinders, prisms, pyramids and cones. (6 hours)
- Surface development of objects cutting each other, Intersection of different surfaces. (6 hours)
- Surface development of objects for transition of shapes with maximum utilization of surface. (6 hours)

ME/S/122

Computer Aided Drafting

- Introduction to a computer aided drafting software, Basic commands of 2D drafting, Drafting assignment (9 hours).
- Concept of Layer, Layout, Model space, Paper space, Viewport, Drafting assignment (9 hours).
- Dimensioning, Blocks, Attributes, Accessing internal and external database files, Drafting assignments (9 hours).
- Isometric drawing using iso-planes, Drafting assignment (3 hours).
- Surface and Solid Modelling: top down and bottom up approach, Drafting assignment (12 hours).

ME/S/123

WORKSHOP PRACTICE-II

(FITTING AND WELDING)

- Introduction to fitter's tools, gauges, measuring instruments etc.; marking of jobs; fitter's job involving chipping, filing, sawing, drilling; use of taps and dies; pipe fittings and plumbing.
- Introduction to and practice of different welding processes- gas, SMAW, TIG, MIG, SAW, resistance welding etc.; introduction to gas cutting and its application; soldering, brazing etc.; making welded joints using different welding processes.

ME/EE/S/124

Electrical Technology Lab – I

To supplement ME/EE/T/114 and be provided by Electrical Engg Dept.

Second Year, First Semester

ME/MATH/T/211

Mathematics – III

Fourier series and Integral Transforms: (Marks:50)

Fourier series; Periodic functions; Trigonometric series of sine and cosines; Euler's formula; Even and odd functions; Dirichlet's conditions; Half range sine and cosine series; Fourier transform, definitions and properties; Inverse Fourier transform; Convolution; Laplace transform, properties; Inverse Laplace transform; Convolution; Z transform and properties.

Ordinary Differential Equation (ODE) and Series Solution : (Marks:30)

First order exact differential equation and first order linear differential equation; Second and higher order linear differential equations with constant coefficients; Euler and Cauchy equation; Method of variation of parameters; Ordinary point and regular singularity of a second order linear differential equation; Series solutions; Solution of Legendre and Bessel's equations; Generating functions; Recurrence relations and their Orthogonal properties

Partial Differential Equation (PDE): (Marks:20)

First order PDE; Lagrange method; Second order PDE with constant coefficients and their classifications to Elliptic, Parabolic and Hyperbolic type. Solution of PDE by method of separation of variables; Solution of one-dimensional wave and diffusion equation; Laplace equation of two dimensions.

ME/T/212

Engineering Mechanics-III

Dynamics:

Dynamics of system of particles – force equation, energy equation, linear and angular momentum equations, Classification of rigid body motions, two-dimensional rigid body kinematics (absolute motion, instantaneous centre, relative velocity, scalar concept of rotation), two-dimensional rigid body kinetics - application of $T = I \alpha$ for plane motion, fixed axis rotation and translation, Energy and momentum methods in 2d.

Deformable Mechanics:

Stresses in compound beams, Deflection of beams, Statically indeterminate beams, Elastic stability with reference to columns, Energy principles (Castigliano's theorems).

ME/T/213

FLUID MECHANICS-II

Basic concept of turbulence and turbulent flow.

(1 hrs.)

Equation of motion for viscous flow – two-dimensional laminar flow between flat parallel plates and annulus

(2 hrs.)

Boundary Layer Theory: concept of boundary layer, boundary layer thickness, displacement thickness, momentum thickness, growth of boundary layer; Prandtl's boundary layer equations, Von Karman's momentum integral equation for a boundary layer, skin friction drag coefficient for laminar and turbulent boundary layer, hydraulically smooth and rough surfaces; boundary layer in pipe flow, friction velocity; separation of boundary layer, form drag, method of drag reduction; lift and drag on submerged bodies, aerofoils, stalling of aerofoils.

(10 hrs.)

Compressible Flow: review of thermodynamic principles for perfect gases, adiabatic and isentropic relations; steady flow energy equation; speed of propagation of a small disturbance through a compressible fluid, sonic velocity, Mach number, Mach cone and Mach wave; isentropic flow, stagnation properties of a compressible flow, isentropic pressure, temperature and density ratios; compressibility correction factor in the measurement of air speed; area – velocity relationship for compressible flow through a variable area duct, mass flow rate through a duct, critical condition and choking; flow through convergent-divergent nozzle, over expansion and under expansion, performance of propulsive nozzles; normal shock, normal shock relations, wave drag.

(10 hrs.)

Ideal Fluid Flow: rotation of a fluid particle, vorticity, rotational and irrotational motion; velocity potential function, circulation, stream function, flownet; governing equation for two dimensional irrotational motion,

simple two dimensional irrotational flows like uniform flow, plane source, plane sink etc; superimposition of simple irrotational flows, combination of a source and a sink, combination of uniform flow and a source (Rankine half body), combination of a uniform flow and a source-sink pair (Rankine oval), doublet and its strength, superimposition of an uniform flow and a doublet (flow past a stationary cylinder); vortex motion – free and forced vortex, strength of a vortex; combination of a uniform flow, a doublet and a free vortex (flow over a rotating cylinder), Magnus effect, Kutta-Joukowski's theorem. (12 hrs.)

Dimensional analysis and Buckingham Pi theorem; similarity and model studies. (3 hrs.)

Unsteady flow – water hammer. (2 hrs.)

ME/T/214

Heat Transfer

1. Introduction: Modes of heat transfer - (1 lecture)
2. Conduction: Fourier law of heat conduction for isotropic material. Thermal conductivity. Derivation of general heat conduction equation. Non-dimensionalisation- thermal diffusivity and Fourier number. Types of boundary conditions. Solution of steady one dimensional conduction problem with and without heat generation. Analogy with electrical circuits. Critical thickness of insulation. Fins-rectangular and pin fins. Fin effectiveness and efficiency. Lumped parameter approach and significance of time constant. Biot number Solution of I-D transient heat conduction equation without generation using product solution. - (10 lectures)
3. Radiation: Physical mechanism of thermal radiation. Laws of radiation. definition of black body, emissive power. radiation intensity.reflectivity. transmissivity. irradiation, radiosity.Radiation exchange between black bodies Concept of grey- ditluse-isotropic (OD!) surface. Exchange between **GDI** surfaces by radiation network method. Radiation shielding. - (8 lectures)
4. Convection: Introduction. Newton's law of cooling and significance of heat transfer coefficient. Momentum and energy equation in two-dimensions. Non-dimensionalisation and significance of non-dimensional quantities. Scale analysis for flow over flat-plate. Velocity and thermal boundary layer thickness by integral method. Natural convection-effect of coupling on the conservation equation. One dimensional solution for Collette and Poiseulli flow.Concept of developing and developed How. Correlations-forced convection for external and internal flows. natural convection over a vertical flat-plate.- (15 lectures)
5. Heat exchangers: Types of heat exchangers. Introduction to UVITD. Correction factor. Fouling factor Effectiveness-NTU method for heat exchangers, rating and sizing. - (4 lectures)
6. Boiling and condensation: Pool boiling curve. D.N.B, critical heat nux. drop and filmwise condensation, laminar film condensation on a vertical plate- (4 lectures)

ME/T/215

MATERIALS SCIENCE AND ENGINEERING

Structure: Crystal structure of materials, crystal systems, unit cells and space lattices, miller indices of planes and directions, packing geometry in metallic, ionic and covalent solids. Imperfections in crystalline solids and their role in influencing various properties.

Diffusion: Fick's laws and application of diffusion in sintering, doping of semiconductors and surface hardening of metals.

Mechanical Properties: stress-strain diagrams of metallic, modulus of elasticity, yield strength, tensile strength, toughness, elongation, plastic deformation, viscoelasticity, hardness, impact strength, creep, fatigue, ductile and brittle fracture.

Electronic Properties: Concept of energy band diagram for materials – conductors, semiconductors and insulators, electrical conductivity effect of temperature on conductivity, intrinsic and extrinsic semiconductors, dielectric properties.

Metals and Alloys: Solid solutions, solubility limit, phase rule, binary phase diagrams, intermediate phases, intermetallic compounds, iron-iron carbide phase diagram, heat treatment of steels; cold and hot working of metals; recovery, recrystallization and grain growth; microstructure, properties and applications of ferrous and non-ferrous alloys.

Ceramics: Structure, properties, processing and applications of traditional and advanced ceramics.

Polymers: Classification, polymerization, structure and properties, additives for polymer products, processing and applications.

Composites: Powder Metallurgy; Properties and applications of various composites.

Introduction to Advanced Materials and Tools: Smart materials, exhibiting ferroelectric, piezoelectric, optoelectric, nanomaterials , synthesis, properties and applications, biomaterials, superalloys, shape memory alloys. Materials characterization techniques.

Environmental Degradation: Corrosion and oxidation of materials, prevention.

ME/T/216

ME/S/211 **Machine Drawing I** (drawing board mode)

(Sessional: 100 marks, Examination: 100 marks, Examination Duration: 4 hours)

Screw threads, Screwed fastenings - Nuts, Bolts, Set screws, Foundation bolts etc.	(2x4 hours)
Rivettted joints and welded joints	(2x4 hours)
Keys, Cotter joint/ Knuckle joint/ Pipe joints	(2x4 hours)
Pulleys	(2x4 hours)
Shaft coupling: Rigid/ Flanged/ Flexible	(2x4hours)
Plummer block	(2x4hours)
Stuffing box	(2x4hours)

ME/S/212

WORKSHOP PRACTICE-III

(FORGING AND MOULDING)

Forging: Introduction to forging tools, furnaces and forging machines; to practice basic forging operations- drawing out, upsetting, necking etc.; introduction to forge welding.

Introduction to moulding practice – preparation of moulding sand and use of moulder’s tools; making of moulds by using selected pattern’s; introduction to melting and pouring practice; experiments sand testing like permeability, moisture content, shutter index, mould strength, grain fineness number etc.; demonstration of injection moulding machine.

ME/EE/S/213

Electrical Technology Lab – II

To supplement ME/EE/T/122 and be provided by Electrical Engg Dept.

Second Year, Second Semester

ME/MATH/T/221

Mathematics - IV

Probability and Statistics (Marks : 50)

Definition of probability; Conditional probability and independence; Bayes' theorem; Statistical data: mean, median, mode, standard deviation; Random variables; Discrete and Continuous distribution; Poisson, Normal and Binomial distribution; Correlation and Regression; Expectation and Variance; Chebysheff's inequality.

Advanced Linear Algebra (Marks: 50)

Vector space, subspace, Basis and Dimension; Linear transformation; Representation of linear transformation by matrices; Linear functional; Dual space; Transpose of a linear transformation; Diagonalization, Symmetric and orthogonal matrices, Invariant subspaces; Cyclic subspaces; Annihilators; Cyclic decomposition; Rational form; Jordan canonical form; Inner product spaces; Gram-Schmidt orghogonalization; Adjoints of linear operators; Unitary and Normal operators.

ME/T/222

FLUID MACHINERY- I

Introduction: Definition, Classification and Application.

(1 hr)

Turbomachines: Classification and Constructional Features: Incompressible and compressible flow machines, Pump, Turbines and Compressor. Radial, axial and mixed flow type machines; Impulse and reaction turbines; Impeller, volute casing, diffuser, runner and inlet guide vane. Principles of Energy Transfer, Euler one-dimensional pump and turbine equations, Euler head, Bernoulli equation, Rotor work and efficiency for incompressible flow turbomachines, Velocity diagrams for radial and axial flow machines, Blade twist. Different heads and efficiencies for pumps, fans and turbines. (25 hrs.)

Special Devices: Analysis of flow through propellers and windmills, Slipstream and actuator disc theory; Jet propulsion devices, Analysis of thrust and other performance parameters; Jet pump. (5 hrs.)

Positive Displacement Pumps: Reciprocating and rotary Pumps, Working principle and indicator diagram for reciprocating pump, Air vessel. (9 hrs.)

ME/T/223

Engineering Mechanics-IV

Dynamics: Revision of system of particles and Force, energy and momentum equations in 2d rigid body dynamics, Kinematics of rotation about a point and three-dimensional motion, Mass moment of inertia including rotation of axes, Euler's equation, Gyroscopic motion and balancing of rotating masses, Work-energy principle in 3d, Impact/collision of rigid bodies in plane motion.

Deformable Mechanics: Three-dimensional stress state, Theories of failure, Unsymmetrical bending, Thin walled beams and shear centre, Curved beam, Thick cylinder, Rotating disk.

ME/T/224

KINEMATIC ANALYSIS AND SYNTHESIS

1. Introduction to kinematics; concept of machine, mechanism and structure, kinematic pairs; analysis and synthesis; 4-bar linkage, Grashoff's law, inversions of linkages; equivalent linkages. (5 periods).

2. Analysis of planar kinematic devices: Velocity analysis of linkages (graphical methods: resolution and composition, instantaneous axis and relative velocity) Acceleration analysis of linkages (graphical and analytical methods), Kennedy's theorem, analytical treatment by using complex algebra. (9 periods).

3. Linkage: drag link mechanism, automobile steering mechanism, slider-crank mechanism, swinging block mechanism, oscillating arm quick return mechanism, isosceles linkage, elliptic trammel, toggle mechanism, straight line mechanism, pantograph, universal joint, etc. Geneva wheel mechanism, intermittent motion from continuous motion. (3 periods).
4. Gears: Fundamental laws of gearing, types of gears - involute and cycloidal; spur, helical, bevel and worm gears; gear nomenclature, interference and undercutting - minimum number of teeth, backlash, velocity of sliding, analytical method of gear tooth design. Gear trains: simple, epicyclical and epicyclical bevel trains, train value; applications: automobile transmission and others. (13 periods).
- Cam drive: plate and cylindrical, inline and offset – displacement, velocity and acceleration diagram, different cam displacement functions and cam profiles, analytical approach to design of different types of cams. (6 periods)
6. Syntheses: movability of linkages – Grubler’s criterion, type and number syntheses, minimum number of binary linkages in a constrained mechanism, maximum number of hinges on a link, graphical and analytical methods of syntheses, (Freudenstein equation, Chebysev spacing, approximate syntheses, multi-bar linkages. (10 periods)
7. Introduction to Robotics, Robot arm kinematics: matrix representation, forward kinematics, homogeneous transformation matrices, Denavit-Hartenberg algorithm in forward kinematics, (10 periods)

Ref: Ghosh and Mallik; Uicker, Pennock and Shigley; Sandor and Erdman; Mabie-Reinholtz; Mittal and Nagrath, Hartenberg & Denavit.

ME/T/225

MACHINE DESIGN-I

Introduction to design,	[2]
Design philosophy, Optimised design.	[2]
Review of common engineering materials and their properties, Different types of materials – Metallic Ferrous, Non Ferrous, Non- metallic, Composites, ceramic, Plastics, Polymers, etc.	[5]
Improvement of properties through heat treatment and alloying	[2]
Modes of failure, Review of stress calculation in various situations - axial, bending, torsion loads and combined effect, stress concentration, Factor of safety, Theories of failure and choice of failure theory of design,	[4]
Manufacturing aspects of design – Manufacturing processes (casting, forming, machining, welding etc.) Fit and tolerance, surface roughness	[5]
Design of shaft – FOS, ASME Code /IS Code Design , strength and rigidity (Axial . bending torsion & combined loading), Effect of keyway and splined, Stepped shaft	[8]
Endurance diagram and Design criteria, Design for fatigue life, Cumulative fatigue damage, Strain life equation.	[8]
Design criteria for fracture and creep.	[4]
Design for Stability - Buckling analysis	[2]
	Total: 42 pds.

ME/T/226

MANUFACTURING PROCESSES

Introduction to manufacturing Processes; Casting-The basic idea, patterns, moulding materials properties and mould making; various casting processes; cores, gating and risering; foundry furnaces; special casting method; casting defects, inspection and repair.

Forming-hot and cold working; rolling; forging and forging dies; drawing, deep drawing; extrusion; bending; coining, hubbing, embossing, thread rolling, tube piercing etc; HERF processes; press working etc; Defects in metal working.

Welding and joining processes-classification; gas welding; flame cutting; arc welding-electric arc welding-theory of heat generation, power source selection, arc structure, arc characteristics; metal transfer in arc welding; different arc welding processes-SMAW, Carbon Arc Welding, Atomic Hydrogen Welding, MIG, TIG, CO2-MIG, FCAW; other welding processes like ESW, EBW, PAW, USW, Explosion Welding etc.; welding consumables; characteristics of weldment; welding defects and inspection soldering and brazing and braze welding.

Introduction to rapid prototyping; Generative manufacturing processes like stereolithography, selective laser sintering and others.

Processing of composites, ceramics etc.

ME/S/221 **Machine Drawing II** (Computer Terminal mode)

Tool head of a shaping machine	(2x3 hours)
Engine parts: Eccentric, Piston, Cross head and Connecting rod	(5x3 hours)
Valves: Steam stop valve, Anyone of safety, relief and non-return valves	(5x3 hours)
Solid modeling of Plummer block	(2x3 hours)

ME/S/222 **FLUID MECHANICS LABORATORY**

Study of different methods of measurement of pressure, velocity and discharge including calibration of selected measuring instruments. Study of flow visualisation technique: study of characteristics of laminar and turbulent flow. Verification of Stokes law. Study of cavitation phenomenon. Determination of loss through pipes and fittings. Study of characteristics of hydraulic jump. Study of subsonic wind tunnel technique – study of growth of boundary layer.

ME/S/223 **Heat Power Laboratory-I**

(THERMODYNAMICS AND HEAT TRANSFER LABORATORY)

1. Determination of dryness fraction of steam
2. Determination of critical pressure ratio for an orifice
3. Measurement of temperature by different methods
4. Determination of thermal conductivity by Guarded Hot Plate method
5. Determination thermal conductivity of insulating powder
6. Determination of thermal conductivity of metal rod
7. Heat transfer from a pin fin
8. Natural convection from vertical cylinder
9. Determination of Emissivity of metal disc

ME/S/224 **Applied Mechanics Lab I**

Simple experiments of Mechanics and Strength of Materials – Moment of inertia of flywheel, spring testing, tension, torsion, bending tests, Hardness tests, impact tests etc

Third Year, First Semester

ME/T/311

FLUID MACHINERY- I I

- Fluid Coupling and Torque converter- Working Principle. (1 hrs)
- Analysis of axial flow machines: Introduction to isolated aerofoil and cascade theory-CL and CD for blade design, blade nomenclature, degree of reaction, stalling. (4 hrs)
- Performance characteristics: Pumps and Fans-Radial, Mixed flow and Axial flow. (4 hrs.)
- Turbines-Francis, Kaplan and Pelton wheel-operating characteristics and Muschel curves, Governing of Turbines. (6 hrs.)
- Dimensional analysis for fluid machinery: Dimensionless quantities and their use in design, selection and testing. (3 hrs.)
- Cavitation : NPSH, Thoma's cavitation parameter and suction specific speed. (2 hrs.)
- Elements of pump and turbine systems: General description and functions-foot valves, NRV, Penstock, Draft tube, regulating valves etc., Bend guide vanes and flow straightener. (6 hrs.)
- Interaction of pumps and Turbines and systems: Series and Parallel operation of Pumps, Performance and selection of Pumps for different systems characteristics, Surging in Pipelines and method of control. (10 hrs.)
- Introduction to Sump design - Surface and sub-surface vortices, basic geometry and dimensions. (4 hrs.)

ME/T/312

Dynamics of Machines

- Force analysis of slider crank mechanism, Flywheel.
- Revision of Balancing of rotating masses, Balancing of Reciprocating masses. Applications to balancing of inline, V and radial engines.
- Introduction to Kinetics of Mechanisms
- Review of SDOF theory - free undamped, free damped, forced vibration, detailed engineering applications inclusive of Transmissibility, rotor vibration, principles of vibration measurement etc.
- Transient and Non harmonic vibration of SDOF systems.
- Introduction to random vibration of SDOF systems.
- Preliminary treatment of MDOF systems – natural frequency and mode shape, harmonic excitation and applications inclusive of vibration absorption.
- Approx methods - Dunkerlay & Rayleigh

ME/T/313

INTERNAL COMBUSTION ENGINES

1. Introduction: Principle of working, Basic Engine Types, Components of I.C. Engine etc. (2 hours)
2. Cycles: Analysis of air standard cycles (Otto, Diesel, Dual), fuel-air cycles and actual cycle. Availability aspects of cycles. (6 hours)
3. Fuels: Review of the family of hydrocarbon fuels, Classification of I.c. engine fuels, Desirable characteristics of SI & CI engine fuels, Rating of SI & CI engine fuels, Alternative fuels for SI and CI engine (liquid, gaseous, hydrogen, LPG, CNG, Biogas etc.), Air requirement, Analysis of combustion products, HHV and LHV of fuels. (6 hours)
4. Fuel Introduction in SI engine: Carburetion: Air-fuel ratio requirement, Working principle, Analysis of a simple carburetor, Defects of a simple carburetor and its remedy. Gasoline injection: mechanical & electronic fuel injection systems and their control. (4 hours)
5. Fuel Introduction in CI engine: Classification of diesel fuel injection systems, Working principle, Engine requirements, Injection pumps and nozzles. (5 hours)
6. Ignition: Battery, magneto and electronic ignition systems, Ignition timing and spark advance. (2 hours)
7. Combustion: Theories of normal and abnormal combustion in SI & CI engine, parameters influencing combustion, prevention of abnormal combustion in SI & CI engine. Types of combustion chamber & principle of combustion chamber design in SI & CI engine. (5 hours)
8. Supercharging and Scavenging: Engine requirements, supercharging limits, turbocharging. Scavenging of

- two stroke SI & CI engine, scavenging parameters, ideal & actual scavenging processes, scavenging pumps. (4 hours)
9. Lubrication: Principle of lubrication, properties of lubricating oil, lubrication systems. (2 hours)
10. Cooling: Principle of cooling, air & water cooling systems. (2 hours)
11. Performance and Testing: Performance parameters and their measurement, different types of dynamometers, heat balance, performance characteristics, governing methods. (3 hours)
12. Pollutant Emission: Formation and control of pollutants. (1 hour)

ME/T/314

MACHINE DESIGN-II

- Design of pin-joints – Cotter / Knuckle & Universal joint [4]
- Screw joints / bolted joints, Transmission screws, Riveted joints, Welded joints [10]
- Clutches: Use of clutch, Classification of clutches based on actuating method, operating principle, coupling method, Description of friction clutch, automatic type disc clutch, hydraulically operated multiple disc clutch, mechanically operated clutch release mechanism, Actuating force and frictional torque equation based on uniform pressure and uniform wear, friction material, Simple calculation of heat release rate, Cone clutch, centrifugal clutch, self locking cone clutch, problems [10]
- Brakes: Band Brake, short shoe brake, self energizing and de-energizing brake, long shoe drum brake – pressure distribution, force and torque analysis etc. [8]
- Couplings: Rigid, Flexible, Resilient, Fluid, Magnetic etc. [6]
- Belt drive: Design of belt (Flat Belt and V- Belt) and pulley, Multiple belt drive [6]
- Helical springs, types of end for extension and compression spring, spring material, set removal. Design for static and dynamic loading, Failure diagram, Factor of safety, problems. Critical frequency of helical spring, surge and governing equation. Leaf spring: Multi leaf spring, graduated leaf spring, load- deflection equation, nipping, preloading, problems. [12]
- Total: 56

ME/T/315

MACHINING TECHNOLOGY AND METROLOGY

- Machining- Machining principles, motions required and chief elements in machining; basic idea of machine tool; classification/ types of machine tools.
- Basic machine tools- Lathe, shaping machine, planing machine, slotting machine, drilling machine, milling machine, broaching machine, and grinding machine- their important constructional features and mechanisms; basic and auxiliary motions, types, specifications and applications/ operations, including taper turning, thread cutting, gear cutting, helical milling etc.; estimation of machining time; job holding devices, indexing and elementary idea about jigs and fixtures; honing, lapping and super-finishing processes.
- Preparation of process sheet.
- Cutting tools - Materials of cutting tools, elementary idea of tool geometry, tool wear etc.
- Introduction to the principles and applications of non-conventional machining processes; emerging areas in machining technology.
- Surface quality- Waviness, roughness, surface integrity; influence of surface unevenness on performance of machined components.
- Metrology- Machining accuracy, various types of error, the concepts of maximum attainable accuracy and economically feasible accuracy, the factors affecting accuracy; principles of measuring and gauging; accuracy, precision and sensitivity of measuring instruments; line and end standards of measurement; limits, fits and tolerances; plug and snap gauges; limit gauges- Taylor's principle; comparators; measurement of lengths, angles and tapers; optical flat- principle of use and applications; measurement of elements of threads and gears; co-ordinate measuring machine- an introduction; assessment of surface roughness- the various parameters and measurement principles; introduction to laser metrology.

ME/S/311

WORKSHOP PRACTICE-IV A

(MACHINE SHOP PRACTICE)

Introduction to machine tools - lathes, drilling machines, shaping machines, planning machines, slotting machines, milling machines, grinding machines; machine shop work involving different operations by using the above mentioned machines through making of jobs.

Experiments on: Study of the speed structure of a lathe, study of apron mechanism and calibration of feeds in a lathe.

Study and grinding of various cutting tools.

ME/S/312

METROLOGY AND METALLOGRAPHY LABORATORY - A

Metrology Lab.: Introduction to Metrology Laboratory; Ideas of different standards of Measurement; Study and use of slip gauges; Calibration of different measuring instruments and gauges; Measurement of length, diameter, taper and angle by means of different measuring instruments and gauges; Measurement of eccentricity, concentricity and estimation of errors.

Use of comparator, Optical flat, Profilometer, Tool makers' microscope and surface roughness measuring instrument; Measurement of different elements of Thread and Gear; Concept of quality control and inspection; Concept of process capab

Metallography Laboratory

Study of metallurgical microscope and other accessories; Heat treatment of different samples; Preparation of specimens for study of microstructure; Mounting of specimen for metallographic study; Preparation and study of microstructures of cast iron; Study of microstructure mild steel (annealed); Study of microstructure of mild steel (hardened); Study of microstructure of welded specimen; Study of microstructure of powder metallurgy specimen; Study of electroless coated substrate.

ME/S/313

Applied Mechanics Lab II

Buckling test, Applications of Electric wire resistance strain gauge, Experiments on Dynamics and Vibration

Third Year, Second Semester

ME/T/321 Mechanical Measurement and Instrumentation

Introduction. Functional elements of an instrument. Active Passive transducers. Analog/digital mode of operation. Null/deflection methods of measurement. Generalized I/O configuration of measurement systems.

3 periods

Methods of correction of interfering and modifying inputs.

3 periods

Static characteristics: Static calibration. Basic statistics. Uncertainty analysis. Least square calibration curve. Static sensitivity. Linearity, Threshold, noise floor, Resolution, Hysteresis Dead space, Span, Scale readability.

10 periods

Loading effects.

2 periods

Dynamic characteristics: Generalized mathematical model, Operational and sinusoidal transfer functions. Zero order instrument. First order instrument: Step, Ramp, Frequency and impulse response of first order instruments. Second order instruments: Step. Terminated-ramp, Ramp, frequency and impulse response of second order instruments. Dead time elements. 10 periods

Logarithmic plotting of frequency response curves. Response of general form of instruments to periodic and transient inputs. 5 periods

Wheatstone bridge application with examples. Measuring instruments for measurement of Displacement, Velocity, Acceleration, Force, Pressure, Flow, Temperature. 10 periods

Signal conditioning and Data acquisition systems

2 periods

References:

1. "Measurement Systems Application and Design", Ernest O. Doebelin, TMH
2. "Experimental Methods for Engineers", J.P. Holman, TMH

ME/T/322 Steam Power Plant

1. Vapour Power Cycles: Effect of operating variables on Regenerative cycles, Binary vapour cycle. Co generative cycles. Availability analysis of cycles

2. Boilers:

(i) Introduction:

Classification. Fire-tube and water-tube boilers. Mountings and Accessories.

(ii) Coal and combustion: Coal analysis. Combustion calculations both mass and energ~ balance. heating values.

(iii) Types of coal feeding and firing methods.

(iv) Introduction to power station boiler.

(v) Circulation theory and processes.

(vi) Auxiliary heating surfaces: Super heater. re heater. economizer. air pre-heater.

(vii) Draft: Definition. classifications and calculations.

(viii) Losses in boilers. Equivalent evaporation. Boiler Efficiency.

(ix) Basics of water treatment.

(x) Basics of ash handling.

3, Steam turbine:

(i) Parts & classifications

(ii) Nozzles: types, flow through nozzles. nozzle efficiency.

(iii) Impulse turbine: Flow through impulse blading. velocity diagram. work done. Blade efficiency.

(iv) Multi-staging of turbines: pressure compounding and velocity compounding

(v) Impulse-Reaction turbine: Flow through impulse-reaction blading. velocity diagram. degree

of reaction. Parsons Turbine.

(vi) Principles of turbine governing.

(vii) Different losses in turbine. blade erosion.

4. Condenser: Classification. Elements of condensing plant. Power plant condensers Air leakage-effect and removal.

5. Power plant economics: Load curve. load factor. utilization factor etc. Fixed and variable operating cost Principle of load sharing.

ME/T/323

Industrial Management

Introduction: Concepts of Management and Industrial Management; Development of management thoughts and ideas – Contribution of Taylor and others; System concepts in management [3 Hrs]

Organization: Organization structure, various types, organization principles – unity of command, responsibility, authority, span of control, structural balance, communication, division of labour, etc. [3 Hrs]

Types of Production – Plant location and plant layout (various types) [2 Hrs]

Materials Management – Inventory – types, different cost, EOQ and EPQ models, Basic ideas of MRP and MRP II, purchasing functions, vendor rating etc., ABC analysis, Basic ideas of supply chain management [3 Hrs]

Forecasting – Factors affecting demand, Types of forecasts and forecasting techniques, Time series analysis and various qualitative and quantitative forecasting techniques, forecasting errors [3 Hrs]

Scheduling – Gantt chart, network scheduling – PERT, CPM, crashing [3 Hrs]

Linear Programming – Fundamentals, formulations, various variables, graphical solutions etc., Sequencing – simple cases, introduction to transportation models [3 Hrs]

Quality Control and Inspection – Concept of quality, quality control and inspection, Acceptance sampling – OC curve, control charts, Introduction to ISO 9000 standards, Total quality management, quality circle, brainstorming, fishbone diagram, Pareto analysis [4 Hrs]

Work Study – Work measurement, time study, motion study, method study, job evaluation, merit rating [2 Hrs]

Queuing Theory – Basic concept and a simple model [2 Hrs]

Maintenance Management – Types of maintenance, replacement models, bath tub curve, terotechnology and some fundamentals of safety management [2 Hrs]

Break Even Analysis – Some basic ideas and applications [2 Hrs]

Reliability Analysis and Risk Management – Basic concepts, hazard rate, reliability functions, MTTF [2 Hrs]

Basic ideas of Agile Manufacturing, Lean manufacturing, Flexible manufacturing and group technology, Ergonomics

ME/T/324

MACHINE DESIGN-III

1.Design of gear drive:Spur Gear –Introduction, Modes of Gear tooth failure, Beam Strength of gear tooth and Lewis Equation, Lewis Form Factor, Service Factor [3]

Dynamic load, Bucklingham Equation, Spott’s Equation, Error on gear tooth and Grade of Gear Manufacturing. [4]

Wear Strength, Derivation of load Stress Factor, Bucklingham Equation for Wear, problems [4]

Helical Gear- Type of helical gears, virtual no. of teeth, Minimum Face width, Force analysis, Beam Strength, Dynamic load, Wear Strength, problems [3]

Bevel Gear: Force analysis, Formative no. of teeth, Beam Strength, Dynamic load, Wear Strength, problems. [3]

Worm gears : Uses, drawback, self locking arrangement, centre distance calculation, force analysis, friction in worm gear, efficiency, selection of material , problems [3]

2.Design of rotors: Shafts and axles with bearing mountings, High-speed rotor- constant thickness and variable thickness [4]

Design in post-elastic region, limit speed analysis, interference fits in rotors [4]

3.Chain drive:Types, roller chain- constructions, polygonal effect, power rating, failure [4]

Sprocket wheel, chain lubrication, maintenance	[3]
Design of chain drive, selection from catalogue, silent chain	[3]
4. Rolling contact bearings Types, static load capacity- Stribeck equation, dynamic load capacity, equivalent load, load-life relation, bearing life selection, load factors	[6]
Bearing selection from Manufacturer's catalogues	[2]
Selection of taper roller bearing	[1]
Design for cyclic load and speed	[2]
Bearing reliability, lubrication, mountings	[3]

Total: 56

ME/T/325

ELECTROHYDRAULIC CONTROL SYSTEMS

Introduction: (6 hrs)
 Applications and Comparison with Electrical and Electropneumatic Systems. Basic Components and their Symbolic Representations – pump, valve, actuator, line, connector, filter, heat exchanger, accumulator and intensifier. Open Loop and Closed Loop Control Systems – block diagrams and schematics with symbols. Overall functioning and Choices of System Fluids.

Components: (3+4+2 hrs)
 Positive Displacement Pumps and Actuators – Classification, Schematic and Symbolic Representations with Working Descriptions.
 Valves – Flow, Pressure and Direction Control Valves, Schematic and Symbolic Representation with Working Descriptions.
 Solenoids and Permanent-Magnet Motors, Proportional Valves and Servovalves –Schematic and Symbolic Representations with Working Descriptions.

Hydraulic Circuits: (5 hrs)
 Linear, Regenerative, High-Low Circuits. Sequence Circuit, Accumulator Circuit, Intensifier Circuit, Speed Controlling by Metering in, Metering out and Bleeder Arrangements.

Elemental Modeling and Characteristics: (4 hrs)
 Electrical Resistance, Magnetic Reluctance of Air Gap, Flow resistance in orifices and hydraulic lines. Electrical Inductance and Capacitance, Capacitance of Compressible Fluid Volume. Frictional Nonlinearities, Magnetic Hysteresis, Valve flow Characteristics – flow gain, pressure gain, leakage, threshold.

Dynamic Modeling of Systems: (5 hrs)
 Proportional Solenoid and Linear Force Motor, Spool Valve, Hydraulic Actuator, Electrohydraulic Servoactuation System.

Linear Control Analysis: (5+3+3 hrs)
 Transfer Functions, Block Diagrams and Laplace Transform, Block Diagram Reduction. Poles, Zeros, Characteristic Equations and Characteristic Polynomial. On-off and Feedback Controls, Proportional, Integral and Derivative Controllers. System Stability and Routh-Hurwitz Criterion.
 Time-Domain Response – Proportional Solenoid and Hydraulic Actuation, Speed of Response, Steady-State Error and Overshoot.
 Frequency Response – Phase-Gain plot, Gain margin and Phase margin.

ME/T/326

Elective 1

ME/T/326A **PRINCIPLES OF ENGINEERING TRIBOLOGY**

Engineering Surfaces; Properties and Measurement, Surface Contact
Adhesion, models, indices, adhesive surface contact
Friction, origin, theories, components, measurement, friction behavior of materials.
Wear, origin, types – adhesive, abrasive, corrosive, fatigue, erosion etc., measurement, theories, delamination theory, wear debris analysis, ferrography, wear behavior of materials.
Thermal Considerations in Sliding Contact, measurement of flash temperature, modeling.
Surface Engineering – treatments and coatings.
Liquid Lubricants: Properties and Measurement, Fluid Film Lubrication, Hydrodynamic and hydrostatic lubrication, Thrust and Journal Bearing, Squeeze Film Bearings, Gas-Lubrication, Elastohydrodynamic Lubrication
Rolling Element Bearings
Boundary Lubrication – metal working, Bio-tribology.
Nanotribology – concept, measurement tools.

Ref: Sahoo; Bhushan; Hutchings

ME/T/326B **OPTIMIZATION TECHNIQUES FOR ENGINEERING DESIGN**

Introduction:- Historical development, Engg. Application, Statement and Problem definition, Classification and techniques of optimization, Classical optimization techniques.
Non-linear programming:- Introduction, Formation of N.L.P
Optimization methods for single variable: region elimination methods, bracketing methods, Interpolation methods.
Optimization methods for multiple variable: Direct search methods, random search, simplex method, Gradient based method- Steepest descent method, Conjugate gradient method, Quasi-Newton method etc.
Constrained optimization: Introduction, Direct method, Complex method. Indirect method: Penalty function method etc.
Evolutionary algorithms: Quadratic Programming, Genetic Algorithm, Particle swarm optimization (PSO), Differential Evolution. Simulated annealing.
Application of evolutionary algorithms and comparative study.
Optimum design of Mechanisms, structural components and mechanical systems.

Ref: Rao; Arora

ME/T/326C **MECHANICAL MEASUREMENT AND INDUSTRIAL STATISTICS**

Mechanical Measurement: Measurement of displacement, velocity, acceleration, force, strain, temperature, pressure, flow, shock, vibration and sound.
Industrial Statistics: Statistical distributions and their applications to engineering and management problems; testing of hypothesis; z, t, χ^2 (chi-square) and F – test; least – square methods; failure statistics and reliability engineering; stochastic problems in engineering and management.
Analysis of basic experiment and their designs; factorial experiments; randomized block design; latin square design; orthogonal latin square; optimization using taguchi methods and design of experiment.
Markovian and non-Markovian processes; Poisson processes and diffusion processes.

Problems of carburetor based engines ----- (1 Period)

Injection systems in SI engines, Basic Classifications like throttle body injection, Port fuel injection and direct injection systems, Their advantages and disadvantages ----- (2 Periods)

Fuel injector system, shape of the input pulse and necessity for control of the pulse width. Calculation of basic injection time and necessity of subsequent correction factors, Numerical problems -----(3 Periods)

Introduction to engine control unit (ECU); Generation of the control signal for operation of fuel injection system in SI engines -----(2 Periods)

Problems associated with conventional spark ignition circuit. Introduction to Transistorized ignition system, Study of the different methods of generation of input signals, its subsequent processing and the detail role of EeU ----(8 to 10 periods)

Generation of pollutants and Pollution control systems; Measurement of pollutants; oxygen lambda sensor and feed back control in PFI engines.-(12 Periods)

Intake and exhaust systems; Helmholtz resonator, inertial charging and wave charging in engines, brief introduction to lean engines and variable valve lift technology, numerical problems -----(8 periods)

Introduction to turbulence; its generation and decay; Special flow problems in combustion chambers of modern SI engines. (4 Periods)

Overview of Navier-Stokes and Scalar Transport Equations 2

Introduction to Finite Difference, Taylor Series, Expansion, Evaluation of First and Second Order Derivates, Truncation Error 4

Numerical Solution of One Dimensional Problems, Solution of Fin Equation, One Dimensional Transient Heat Conduction Equation 2

Finite Volume and Integral Method of Discretisation, Solution by Tri-Diagonal-Matrix Algorithm. 2

Consistency and Stability of Numerical Methods, Fourier Stability Analysis 2

Solution of Two-Dimensional Steady and Transient Heat Conduction Equations, Alternating Direction Implicitly (ADI) method, Solution of Poisson Equation, Solution of Linear System of Equations 6

Formulation for Steady One-Dimensional Convection-Diffusion Problems, Central Upwind, Exact Hybrid and Power Law Schemes, Deferred correction method. 4

Discretisation of convection-diffusion equations in two and three dimensions, solution of Navier Stokes and scalar transport equations in primitive variables 6

SIMPLE, SIMPLER and SIMPLEC algorithm on staggered grid, Different boundary conditions, wall, symmetry, exit periodic boundary conditions, convective and radiative boundary, conditions 8

Introduction to non-staggered (collocated) grid, Introduction to generalized curvilinear coordinates 2

Introduction to phase change problems, Numerical treatment of surface radiation 2

Total – 40

Significance of primary and secondary energy sources, renewable and non-renewable energy. Energy conversion chain. 03

Energy and economic development - interrelations. Definition of parameters and review of present scenario. Significance of energy conservation in present perspective. 04

Overview of world energy resources and use. National perspective. Comparison and relevant conclusions. Future trends. 03

Energy and environment. Sources of pollution from energy sector and effects. Climate change and its effects and possible mitigation steps. 05

Definition and scopes of energy conservation. 02

Good house keeping' practices in industry. Performance monitoring and improvement of energy efficiency of a few energy systems. 06

'Energy cascading' - thermodynamics and advantages. Combined cycle, cogeneration. Possible schemes for

better efficiency, retrofitting of existing systems. Definition of performance parameters and evaluation 06
 Waste heat recovery- definition, advantage and limitations. Review of significant WHR equipment and their performance. Waste heat recovery economics 06
 Heat pump systems and their significance 02
 Alternative sources of energy. Concept of sustainable energy use. 03

ME/T/326G

COMBUSTION ENGINEERING

INTRODUCTION: Definition, need, application, classification etc. of combustion systems.

REVIEW: Thermodynamics (1 st & 2nd law for pure, non-reacting (mixture) and reacting systems; stoichiometry, thermo-chemistry, Clausius-Clapeyron equation etc.); Conservation Equations (continuity, momentum, total & thermal energy); Fluid Mechanics; Heat Transfer. 2 hours

MASS TRANSFER: Pick's law of diffusion; derivation of species conservation equation, solution for Stefan problem & droplet evaporation; mass transfer as an analogy to heat transfer. 3 hours

CHEMICAL KINETICS: Classification (homogeneous/heterogeneous; explosive/non-explosive reactions); Collision theory; reaction rate and it's functional dependence; Arrhenius equation; order of reaction. steric factor. collision frequency, activation energy etc.; Single-step chemical reaction: first / second! third order & uni-molecular/ bi-molecular/ ter-molecular reactions. Multi-step chemical reaction: consecutive/ competitive/ opposing/ chain/ chain-branching etc. reactions. Explosion limits; relation between reaction rate and equilibrium constant; computation of kinetic data. 5 hours

MODELING OF COMBUSTION SYSTEM: Connection among Fluid Mechanics, Heat Transfer, Mass Transfer. Chemical Kinetics & Conservation Equations through Thermodynamics. 1 hour

LAMINAR PREMIXED FLAME: Definition, principal characteristics; Simplified Analysis: assumptions, conservation (mass, species & energy) equations with boundary conditions and their solutions to find out temperature & mass-fraction distribution; determination of flame velocity & thickness; quenching; flammability & ignition. 6 hours

LAMINAR DIFFUSION FLAME:

(I). non-reacting & reacting laminar jet; Burke Schumann Flame: assumptions, simplification and solution of mass, species, momentum & energy equation with the boundary conditions; determination of temperature & mass-fraction distribution as well as flame height; 7 hours

(II) Droplet evaporation & combustion: assumptions, simplification and solution of mass, species & energy equation with the boundary conditions; determination of temperature & mass-fraction distribution, mass evaporation rate, flame stand-off ratio, flame temperature, expression for transfer numbers, evaporation/burning rate constant. droplet life-time etc. 8 hours

SOLID COMBUSTION: Introduction to different features of solid combustion; One-film model: Two-film model:

Assumptions, simplification and solution of species & energy equation with the boundary conditions for the two models; determination of temperature & mass-fraction distribution, carbon burning rate, flame stand-off ratio. flame temperature, expression for transfer numbers etc. for the two models. 7 hours

INTRODUCTION TO ADVANCED PROBLEMS: Ignition; spray combustion; finite rate chemistry; fuel vapour accumulation; laminar/turbulent flow situations etc. 1 hour

Total=41 hours

Books:

1. An Introduction to Combustion: concepts and applications by Stephen R. Turns; McGRAW-HILL
2. Principles of Combustion by Kenneth K. Kuo, JOHN WILEY & SONS

ME/T/326H

Introduction to Finite Element method for mechanical engineers

Direct stiffness and its use to derive stiffness matrix of spring assemblage and plane truss, space truss, plane beam and three-dimensional beam element, introduction to variational calculus, stationary principles, Rayleigh Ritz method, virtual work method, interpolation function, derivation of stiffness matrix of truss and beam using interpolation function, derivation of nodal equivalent loads on beams using Castigliano's theorem and interpolation functions, third point specification for three-dimensional beam elements, introduction to thermal stress, examples using MATLAB/FORTRAN programs and commercial finite element package

Plane stress problem, CST, axisymmetric problem with axisymmetric and non-axisymmetric loading
Isoparametric formulation in one and two dimensions, quadrilateral Isoparametric elements, numerical integration, triangular Isoparametric elements
Kirchoff plate bending element and flat shell or folded plate elements

ME/T/326I

HYDRO, WIND AND WAVE POWER

Hydropower – hydropower potential in India and in the world. Water power estimate from stream flow data, hydrographs, mass curve; water ways - canal and penstock; general arrangement of hydropower station; water hammer surge tanks; water turbines – determination of important dimension - selection, performance, governing; cavitation model.

Tidal power plant – estimation of power, types of turbine – operational characteristics; pump-storage-plant – economic consideration, single machine acting as pump and turbine.

Atmospheric circulation: wind speed variation and flow patterns; estimation of wind energy, energy conversion methods – windmill, air turbines.

Energy balance of the environment and ocean; tidal waves and ocean currents, tidal cycles; harnessing tidal and ocean energy; low head water turbines.

ME/T/326J

ELEMENTS OF ATMOSPHERIC FLUID DYNAMICS

General structure of the atmosphere; elements of meteorology - lapse rate of temperature, temperature inversions, isotherms & isobars.

Atmospheric circulation, vertical convection, centrifugal effects, stability of the atmosphere.

Effect of earth's rotation, effect of friction.

Atmospheric motions; wind scales.

Atmospheric boundary layer, governing equations; Ekman spiral; logarithmic and power laws; atmospheric turbulence.

Effect of wind on smoke dispersion; determination of chimney height.

Basic similarity requirements; dimensional analysis; basic scaling considerations; wind tunnel simulations of atmospheric flows; wind tunnel testing.

ME/T/326K

EXPERIMENTAL METHODS IN FLUID DYNAMICS

Measurement of total and static pressure; 3 hole probes, 5 hole probes, projection manometer.

Measurement of velocity: hot wire anemometers, their types, construction and uses; laser Doppler anemometer, measurement of velocity components by 3 holes and 4 holes probes, their construction and calibration.

Measurement of discharge through pipes and open channels.

Measurement of turbulence: constant temperature hot wire anemometer, LDA, use of CRO, signal analysing instruments etc.; use of PIV.

Measurement of flow angles of turbomachines etc; measurement of pitch angle; measurement of torque by dynamometer, transducers, strain gauge.

Measurement of rotational speed: tooth wheel gear method, electronic speed meter.

Optical methods.

Detection of flow separation and measurement.

Uncertainty analysis.

ME/T/326L

ELEMENTS OF COMPUTATIONAL FLUID DYNAMICS

Introduction -Theoretical, Computational and Experimental Techniques and their comparison. Scope of CFD. Different CFD Approaches. Modeling, Discretization and Basic Solution Module. Convergence, Stability and Consistency.

Modeling in CFD - Navier-Stokes Equation for Laminar Flow in Cartesian Coordinate System. Potential, Boundary-Layer and Fully Viscous Modeling. Streamfunction-Vorticity Formulation. Boundary Conditions in Different Formulations and Case Studies like Potential and Viscous Modeling of Flow in a Cavity, Boundary-

Layer Modeling of Flow over a Flat Plate and Viscous Modeling of Flow in Entrance-Region for Flow between Parallel Plates.

Finite-Difference Discretization of CFD Model - Discretization of First and Second Derivatives by Forward, Backward and Central Differencing. Truncation and Order of Error, and Accuracy. Case Studies like Potential and Viscous Modeling of Flow in a Cavity, Boundary-Layer Modeling of Flow over a Flat Plate and Viscous Modeling of Steady Flow in Entrance-Region for Flow between Parallel Plates in Streamfunction-Vorticity Formulation along with Role of Upwinding. Unsteady Flow Modeling and Stability.

Special Topics in CFD - Solution of Simultaneous Linear Algebraic Equations by TDMA and ADI Techniques. Viscous Flow Modeling in Primitive-Variable Formulation: SIMPLE Algorithm.

ME/S/321 **WORKSHOP PRACTICE-IV - B**

Syllabus common with ME/S/311

ME/S/322 **METROLOGY AND METALLOGRAPHY LABORATORY - B**

Syllabus common with ME/S/312

ME/S/323 **MACHINE DESIGN SESSIONAL**

(Mode: Computer Terminal)

Computer Aided Design: Solutions of design problems and code generation using CAD mode programming languages. Application of solid modeling.

Application of FEM in typical design problems.

Use of typical optimization technique in design.

ME/S/324 **FLUID MACHINERY LABORATORY**

Study of the performance characteristics of centrifugal pump, blower, water turbines, jet pump.

Study of cavitation – characteristics of centrifugal pump.

Study of oil-hydraulic system including the characteristics of fluid power components such as pressure control valve, flow control valve, study of the characteristics of fluid control circuit using pneumatics servo system.

Study of the characteristics of submerged jet.

Study of supersonic wind tunnel technique. Determination of pressure distribution around an aerofoil.

Application of analogy technique in fluid mechanics.

Fourth Year, First Semester

ME/T/411

MACHINE DESIGN-IV

Pressure vessels: Thin and thick cylinders – Principal stresses, design of thickness based on failure criteria and end conditions. [5] , Autofrettage- pre-stressing by plastic deformation, wire winding, compound cylinder [2] End covers – design of different heads/cover (ellipsoidal, hemi spherical, tori-spherical and conical) and their specific application and function [2], Openings in pressure vessels– area compensation method [1], Spherical vessels, Cylindrical and spherical shells [2] , Support structure for horizontal and vertical pressure vessels [1], Fired and unfired vessels, class of vessels, weld categories and inspection [3], Industrial codes [3]

Sliding contact bearings: Lubricant properties, types of lubrications, Petroff equation, Stribeck curve [3] Tower experiment, Hydrodynamic theory, Pressure development, Reynold's equation [4], Long and short bearing theory, finite bearing solution, Raimondi-Boyd Charts [2], Design of hydrodynamic journal bearings [3] Design of hydrodynamic thrust bearings [2], Hydrostatic bearings – circular stepped thrust bearing, annular pad bearing, journal bearing [2], Introduction to squeeze bearing, gas bearing, elasto-hydrodynamic lubrication [2]

Introduction to design optimization [8]

Introduction to systems design- material handling systems/pneumatic and hydraulic systems/ Robotic systems etc. [11]

Total: 56

ME/T/412

REFRIGERATION AND AIR CONDITIONING

1. Introduction: Concepts of Refrigeration and Air-conditioning. Unit of refrigeration.
2. Simple Vapour Compression Refrigeration System(Simple VCRS): Vapour compression cycle on p-h and T - s diagrams. Cycles with subcooling and superheating, their effects; Effect of changes in evaporator pressure and condenser pressure on the performance of a simple VCRS; dry compression and wet compression of refrigerant; actual Vapour Compression Cycle.
3. Air Refrigeration System (ARS): open-air and dense-air system, limitations of Bell- Coleman refrigerator. COP determination, actual air-refrigeration cycle.
4. Vapour Absorption Refrigeration System (VARs): Advantages of V ARS over VCRS. Working principle of simple VARs, practical VARs. Limitations of V ARS, maximum COP of a V ARS, Lithiumbromide-water System; Aqua-ammonia systems.
5. Equipments And Control: Major Refrigeration Equipments - Compressors: Types; reciprocating, rotary & centrifugal, volumetric efficiency, Condensers: types used in refrigeration systems; Evaporators: expansion devices: capillary tubes and thermostatic expansion valves.
6. Other Refrigeration Systems: Basic idea of Thermoelectric refrigeration system; Steam-jet (vapour-jet) refrigeration system.
7. Basic definitions and principles related to Psychrometry; Psychrometric Charts & their uses; Heating, cooling, heating & humidification & cooling & dehumidification processes. Adiabatic saturation. By-pass factor. Sensible Heat Factors. Heat Load estimation: Simple cases.
- Types of Air-conditioning systems: window air conditioners & split air conditioners. Single duct, double duct & V A V systems.
10. Air-conditioning equipments: chillers, airhandling units, cooling towers, cooling coils.

Texts & References:

Refrigeration and Air Conditioning - Stocker & Jones, Mcgraw Hill

Refrigeration and Air Conditioning - C.P. Arora

Refrigeration and Air Conditioning - P L Ballaney

Refrigeration and Air Conditioning – R.C. Arora, TMH

ME/T/413

METAL CUTTING AND MACHINE TOOLS

Theory of metal cutting: tool geometry, specification, conversion and selection; basic mechanisms and geometry of chip formation of orthogonal cutting, continuous and discontinuous chips, built up edge; mechanics of metal cutting, theory, measurement of shear angle; tool dynamometer; thermal aspects of metal cutting; weld theory of friction and action of metal cutting fluids, tool wear and tool life; economics of machining.

Machine tool: features of construction: layout of speed for various machine tool drives; introduction to hydraulic and electric drives; design of gear boxes for speed and feed changes; rigidity and vibration analysis.

Numerical control machine tools: basic concepts, field of applications, coordinate system and machine motions, types of NC systems, MCU and other components, NC part programming- manual and computer assisted; engineering analysis; CNC, DNC.

Basic concepts of open loop, closed loop and adaptive control systems.

ME/T/414

ELECTIVE II

ME/T/414A

COMPUTER AIDED DESIGN

Introduction to CAD and design optimization.

Basics of Computer Graphics;

Modelling of Curves and Surfaces: Representation, Cubic Spline, Bezier curves etc., Parametric Design of Surfaces: Cubic, B-spline surfaces, Bezier bicubic surfaces etc., Surface modeling in commercial drafting softwares.

Solid Modelling: Schemes of representing solid objects, procedure for creation of solid models using solid modelling packages.

Basics of computer drafting through high-level languages.

Design Database: concept of database, objective, data structure, Accessing database from design programs.

Finite element modelling and analysis, Use of typical softwares.

Typical problems through CAD.

Ref: Rogers; Hearn and Baker; Zeid

ME/T/414B

DESIGN OF PRESSURE VESSELS AND PIPING SYSTEMS

Introduction to Pressure Vessels: Fired & Un-fired vessels.

Vessel Mechanics & Design considerations: Thick/Thin shells -cylindrical, spherical & different types of end-covers.

Failure theories, Thermal design. Design of vessel supports.

Design of a typical pressure vessel using industrial software.

Introduction to Piping Engineering – their design.

Method of stress analysis of piping system – Thermal & other static modes of loading.

Design of a typical piping problem using industrial software.

Ref: Harvey; Rao; Annaratone; Spence and Tooth; Begajewicz et al.

ME/T/414C

DESIGN METHODOLOGY FOR FRACTURE, FATIGUE AND CREEP

Review of Failure theories

Concept and significance of fracture mechanics theory (LEFM & EPFM).

Fracture parameters applicable in design

Fracture toughness testing

Computational Fracture Mechanics

K_{Ic} based design, CTOD design curve, ductility instability analyses, EPRI method, R6 method, practical considerations, Failure assessment diagram, Probabilistic Fracture mechanics.

Fatigue : Failure Mechanism, Design Methods : Stress based (S-N Curve), Strain based (strain - life) , Crack growth (Paris ' law), Damage tolerant.

Creep : Failure mechanism, Creep curve, Design methods based on creep failure.

Ref: Liu; Yoon; Shibli et al; Penny and Marriot.

ME/T/414D

ADVANCED PRODUCTION PROCESSES

Basic principles of automation applied to drives and controls.

Introduction to Numerical Control, Adaptive Control, Mechatronics.

Unconventional machining processes – AJM, USM, ECM, CHM, EDM, EBM, LBM, PAM – Parameters, responses, mechanism and analysis, effect on material, applications, economics and selection of process; Hybrid processes.

Generative Manufacturing processes like stereolithography, SLS, and other processes.

Introduction to Micro and Nano manufacturing

ME/T/414E

QUANTITY PRODUCTION METHODS

System of production, Inter-changeability of machine parts, Tolerances, fits and standardization, Measuring instruments for mass production and design of gauges, Machine tools for mass production, application of interchangeability in cutting practice.

Jigs and fixtures, economic principles, principles of design, types of jigs and fixtures.

Factors affecting mass tool products, different types of die, design principles of dies and punches.

Plastic working of metal, forging, drop forging, bending, forming, embossing and drawing operations and die design principles, types of presses, accessories and attachments, selection of presses.

Die-casting and moulding methods, products manufactured by die casting and plastic moulding, production by powder metallurgy.

Relative cost of different production methods.

ME/T/414F

LASER MACHINING PROCESS

Basic Laser principles:

Light waves, EM spectrum, Wave and particle nature of light, polarized and unpolarised light, electron photons energy levels;

Theory of laser: Population inversion, Spectrum vs emission and stimulated emission, Amplification gain, lasing conditions, pumping schemes, resonant cavity;

Properties of laser light: Coherence monochromaticity, brightness, directivity;

Output characteristics: Output modes, Beam diameters and divergence, CW beams, Pulsed beam, Ultra short pulses;

Modified laser output: Wave length selectivity tuning, Non-linear wavelength changes, Raman shifting, Switches, Mode locking, Cavity dumping, Amplification.

Types of Lasers:

He-Ne laser, C O₂, Argon – ion lasers, Nd- YAG laser, Excimer laser, Semiconductor laser and others.

Fundamental of Optics:

Geometrical Optics: Reflection, Refraction Lens, Focal length.

Physical Optics: Diffraction, Polarisation, and Interference.

Optical Components: High Power Optics, Laser Mirrors, Lens, Defects, Filters and coating, Reflective optics.

Interaction of high power laser beams with materials:

Material and laser parameters, Uniform condition, irradiance Model, Energy balance approximation, heating with melting, material removal, heating with vaporization, Keyhole welding;

Laser machining system:

Beam delivery system, Mirrors, Beam splitters, Focussing lens, Laser Head, Fibre optic coupling, Laser workstation.

High power laser applications:

Surface hardening, welding, cutting, drilling, marking and alloy cladding.

ME/T/414G

ADVANCED POWER GENERATION

Demand and supply of electric power. Definition of different parameters and their significance. 03

Review of conventional power plants and their operation. Reheat and regeneration - significance and optimum solutions. 05

Limitations of conventional plants and future development trends. Identification of goals and constraints. 02

Combined power plant. Development, different schemes, thermodynamic analysis. Problem with high sulfur fuel. Supplementary firing - options and limitations. Performance evaluation. Retrofitting of existing plants. 08

Cogeneration - definition, advantages and limitations. Different schemes. Performance evaluation. 02

Environmental impact of power plants. Possible options. Different fluidized bed systems. 04

Gasification of coal. Advantages and constraints. Different options and development directions. Integrated gasification combined cycle (IGCC) power plants. Pre and post combustion carbon capture - advantages and limitations. Different schemes - thermodynamics 06

Supercritical power plants. Thermodynamics, advantages and limitations. 02

Fuel cells. Large scale fuel cell integrated hybrid power and cogeneration plants. Schemes, advantages and limitations. 04

Membrane separation of gases and future trends of hybrid systems including renewable. 04

ME/T/414H

Design of Thermal Systems

Introduction to Thermal System Design (2)

Basic Considerations in Design (2)

Mathematical Modeling of Thermal Systems (6)

Numerical Modeling and Simulation (5)

System Simulation and System Identification (5)

Formulation for Optimal Design; Lagrange Multipliers; Search Methods (4)

Geometric, Dynamic and Linear Programming (3)

Dynamic Modeling of Thermal Systems (8)

Introduction to use of soft computing in Thermal System Design (5)

ME/T/414I

Finite elements for dynamics and non-linearity

Dynamic problems in elasticity

Derivation of mass matrix using virtual work method and Hamilton's principle, truss, beam and Isoparametric elements, Governing differential equation, a discussion on computation of eigenvalues and eigenvectors, Harmonic and non harmonic response, transient response using central difference, Newmark techniques and mode superposition. Introduction to the solution of random vibration problems, Component mode synthesis, Solution of simple problems using commercial finite element package

Non linearity – an introduction

Material nonlinearity -Introduction to plasticity, Formulation for small strain, Computational procedure

Discussion of geometric nonlinearity

Nonlinear Dynamic problems

Stress stiffening and buckling

Bar, beam and plate elements, a general formulation, Buckling load, Stress stiffening and its uses.

Advances topics in structural mechanics

Co-ordinate transformation applied to stress, strain, material property, stiffness matrix, inclined support, joining dissimilar elements, rigid elements.

Sub-structuring, structural symmetry and cyclic symmetry

Handling of constraints, Lagrange multiplier, penalty function, constraint counting, Incompressible media.

Modeling consideration and software use

ME/T/414J **INTRODUCTION TO WATER RESOURCE ENGINEERING**

Water resources – global perspective; fields of Water Resources Engineering.

Water requirement – for hydropower project, irrigation, navigation, industrial and municipal supplies. -6 hours

Hydrology – the hydrologic cycle, precipitation-stream flow, evaporation and transpiration, hydrograph, unit hydrograph, hydrograph of basic flow, mass curve, ground water hydrology. - 12 hours

Source of water - surface water source, storage, determination of storage capacity, setting of reservoir; ground water occurrence, ground water hydraulics, wells, yields of wells. -12 hours

Flood control – estimation of flood discharge, various methods of flood control – reservoir, floodwalls, channel improvement, drainage and reclamation.-5 hours

Planning for water resources development –project formulation, multipurpose projects, engineering economy in water resources planning, cost allocation and an introduction to water laws. -5 hours

ME/T/414K **AERODYNAMICS**

Introduction: definition, vistas of aerodynamics, historical development.

Kinematics of gas flow: equation of motion, circulation, Stoke's theory, stream function and velocity potential.

Vortex motion: vortex tube, vortex sheet, Bio-Savart law, Kelvin's theorem, vortex theorems of Helmboltz.

Combination of basic flow patterns: lift on a rotating cylinder, Magnus effect, Joukowski's transformation.

Lift on an aerofoil: aerodynamic forces on a lifting surface; nomenclature and shape of aerofoils; lift and drag coefficients of aerofoils; circulation theory of lift; effect of wave on lift.

Thin aerofoil theory and its application; finite span effects; induced drag.

Drag on an aerofoil: effect of viscosity, skin friction and form drag; flow separation and stalling; boundary layer control and its effect.

Effects of compressibility: Prandtl Glauert rule; shock waves on wings and bodies; effect of sweep on two-dimensional wings.

Application of the knowledge of aerodynamics in the design of turbomachine blades, streamlining vehicle structures, reducing wind-load on buildings and structures etc

ME/T/414L **FLUID TRANSPORTATION**

Introduction to pneumatic and hydraulic transportation; advantages and disadvantages.

Fluid mechanics of multiphase flow; liquid-solid flow; pressure drop in conduits and fittings in multiphase flow; critical velocity.

Special types of pumps and blowers for fluid transportation; analysis of pump-pipeline and blower-pipe interactions; resistance to wear; analysis of pipe wear for multiphase flow; selection of pump for handling liquid-solids, liquid-liquid (petroleum products); air handling systems etc.

ME/S/411 **WORKSHOP PRACTICE-V A**
(ADVANCED MACHINE SHOP PRACTICE AND MACHINE TOOLS LABORATORY)

Manufacturing / making the components of a complete equipment / device/ machine tool, like reciprocating pump / drilling machine/ Centrifugal pump/ some other – fitting, machining, assembly work and testing.

Experiments in metal cutting: study of chip formation mechanism and influence of various parameters on shear angle; determination of force, temperature, tool life etc.

Alignment test of machine tools, other experiments on machine tool /machining (study of machine tool rigidity & vibration etc.).

Study and operation of gear generating machines, auto-screw machine, broaching machine, cylindrical grinding machine, CNC lathe; Introduction to machining center etc.; study of non-conventional machining.

ME/S/412 **HEAT POWER LABORATORY-II**

(THERMAL DEVICES LABORATORY)

1. Parallel flow/counter flow heat exchanger
2. Cross flow heat exchanger
3. Refrigeration laboratory unit
4. Air conditioning laboratory unit
5. Steam turbine
6. Study of boiler
7. Valve timing diagram of I.C. engine
8. Performance test of I.C. engine

ME/S/413 **Colloquium**

Each student will be required to submit to the class teacher at least four different articles containing about 2000 words on four engineering topics assigned by the class teachers, and will be required to give concise talks on those topics in the class according to the direction of the class teacher, and will have to participate in the discussion on such talks of the other students also. The result of those assignments will be considered as that of practical work. There will be no written examination for this course.

ME/S/414 **Project I**

Each student has to work on two research topics or advanced design and analysis projects – one in Project I (first semester) and other in Project II (second semester). The two projects must be in two different specialization topics (Heat Power/Fluid Mechanics/Machine Design/ Applied Mechanics/ Production) from a list of topics offered by the department. Students have to submit a project report to the respective supervisors and give a presentation of the work done in front of a specialization specific evaluation board. For each project, distribution of marks will be: 50 marks to be evaluated by the supervisor and 50 marks to be evaluated by the specialization specific evaluation board.

Fourth Year, Second Semester

ME/HUM/T//421

Humanities

Part A: English (50 marks)

2 classes per week * 14 weeks = 28 classes. Internal Assessment 2 weeks.

Teaching: 24 classes.

1. Basic writing skills: Based on sections 1 and 2 of English for All = 8 classes (4 weeks).

2. Communication skills.

- Report writing = (4 classes) 2 weeks
- Precis writing = (4 classes) 2 weeks
- CVs and resumes = (4 classes) 2 weeks
- Reading Scientific papers: Scholarly conventions= (4 classes) 2 weeks

3. Two prose extracts from English for All (may be changed from time to time: proposal for this year, JBS Haldane , “ Scientific research for Amateurs” and Rabindranath Tagore “ The Religion of the forest”) = (4classes) 2 weeks.

4. One short story from English for All (may be changed from time to time: proposal for this year, James Thurber, “The Secret Life of Walter Mitty”) = (4classes) 2 weeks.

Group presentations in class to be encouraged.

Part B: Society, Culture and Technology (50 marks)

2 classes per week

1. Understanding technology historically

- Emergence and growth of technology in response to collective needs
- Commodity production and expansion of trade; economic imperatives for technological advancement.

2. Technology and work

- Technology and industrial production: fordism and post-fordism
- Division of labour and social identities : race, ethnicity, gender

3. Technology, cultural globalization and global consumerism

- Computer, Media and Culture
- Information and Communication Technology. Role of communication technology: five components of communication, pyramid of communication.
- Global television and American cultural imperialism.

4. Internet and Community

- Understanding of Community in the information age
- The virtual individual and the virtual social
- Power and cyberspace

5. The Ecology Approach

- The natural world and the built environment; nature, man and science; eco-systems and eco-feminism
- Technology and sustainable development

6. The Gender question

- Sex and gender; science and technology; the malestream
- Women and technology. Domestic technology; persistence of gender roles

Introduction: engineering economy and its importance, want activity – satisfaction of wants. Resource planning and distribution in economic systems – Laissez.

Factors of production: the concept of optimum, laws of return; demand - elasticity of demand – demand-estimation market research; supply and industrial costs.

Money-value of money; quantity theory; inflation and deflation.

Banking: role of commercial banks; credit and its importance in industrial functioning – source of finance; Reserve bank of India and its functions.

Business management and organisation: proprietorship, partnership and joint-stock company – their formation.

Finance and management: elements of taxation, insurance, business combinations, basic principles of management.

Industrial record-keeping: double entry system, journal, ledger, trial balance, cash book, preparation of final accounts – trading, profit and loss account, balance sheet, simple study of balance.

Industrial costs: classification – material cost control, labour cost control and overhead cost control; depreciation and replacement studies.

Financial control: ratio analysis and their interpretation for industrial control; budgetary control.

Value analysis and project evaluation: pay back, DCF, IRR.

Definition of material handling, classification of materials, bulk load, unit load, their characteristics

Classification of mechanical handling equipments, different types of elevators and lowerers for handling materials in bulk and unit loads, their working principles and estimation of handling capacity.

Belt conveyors and their construction, capacity and power requirements, other conveyors like apron, steel plate and slat conveyors, flight and screw conveyors, vibrating and oscillating trough conveyors – estimation of handling capacity and power requirement, Automatic feeding devices for elevators and conveyors.

Gravity chutes and gravity roller runways accessories of gravity roller conveyors viz. humper, stacker and gadget, live rollers, pneumatic and hydraulic methods of conveying, monorails, and blast furnace hoists.

Loading/unloading and operation of railway wagons, motor trucks and fork lift trucks. Wire ropes, pulley blocks, crab winch, grabs and lifting magnets, different types of cranes.

Definition and types of robots – basic concept, working principle and application of robotics, manipulators.

Automation, Automated Guided Vehicles (AGVs) and application, Automated production and transfer lines.

Introduction; state of the art in wind engineering.

Bluff body aerodynamics: boundary layer separation; wake and vortex formations; pressure, lift, drag and moment effect.

Structural dynamics: single degree of freedom linear system; multi-degree of freedom linear system; example of along-wind response.

Aeroelastic phenomena; vortex shedding and lock-in phenomena; models of vortex-induced response; across wind galloping; wake galloping; flutter; torsional divergence.

Wind tunnel simulation of aerodynamic and aero-elastic behaviour of bluff bodies.

Application to design of tall buildings, slender towers and stacks.

STATE SPACE ANALYSIS AND DESIGN [10 HRS]

Introduction, state space models of SISO and MIMO mechanical systems – passive car suspension systems using quarter car and half car models, robotic manipulators; transfer function matrices and stability, solution of state equation – by Laplace Transform; formal solution: state transition ; state variable feedback and pole placement.

NONLINEAR CONTROL SYSTEMS [10HRS]

Common nonlinear behaviour of mechanical systems, concepts of phase plane analysis, singular points, constructing phase portraits, phase plane analysis of nonlinear systems, existence of limit cycles, concepts of stability, feedback linearization and the canonical form, input – state linearization, input – output linearization of SISO and MIMO systems; Lyapunov direct method, positive definite functions and Lyapunov functions, Lyapunov Stability Analysis: Stability of equilibrium state, asymptotic stability, graphical representation, Lyapunov's theorems, stability analysis of linear systems, nonlinear systems.

SLIDING MODE CONTROL [8HRS]

Introduction, concept of variable structure control (VSC), ideal sliding motion and chattering, switching function, reachability condition, properties of sliding motion, design of first and second order sliding mode control (SMC) for an electrohydraulic actuation system.

INTELLIGENT CONTROL [12HRS]

Artificial neural networks and its basic mathematical model, feed-forward multilayer perceptron, learning and training, neural control – direct and indirect; crisp sets and fuzzy sets, basic fuzzy set operation and approximate reasoning, fuzzy knowledge and rule bases, fuzzification, inferencing and defuzzification – Mamdani's and TSK methods, fuzzy modelling and control, application of fuzzy and neural controllers for some active car suspension systems and electrohydraulic actuation systems.

Introduction to turbulent flow, Characteristics of turbulent flow, Laminar turbulent transition, Origin of Turbulence , Wall bounded Turbulence and free turbulence. **(4Hours)**

Classification of Turbulence, Isotropic and anisotropic Turbulence, Time Mean motion and Fluctuations, Length scales, velocity Scales, Time scales and Kolmogorov scales, Intensity of Turbulence and Degree of Turbulence. **(4 Hours)**

The Governing equations of Turbulent flow, The N-S equations in Rectangular and Cylindrical Co-ordinates, Time averaging of the N-S equations, Reynolds Stresses, Significance of Reynolds stress, The concept of Eddy Viscosity. **(8 Hours)**

Turbulent Boundary-Layer equations, concept of Order of magnitude and its application to Boundary layer equations on a flat plate, Boundary conditions, Laminar sub-layer, Universal Velocity profile on a flat plate, rectangular duct and circular pipes and friction factors. **(8 Hours)**

The concept of vorticity dynamics, Energy producing Large eddies and dissipative eddies, vortex stretching, Concept of energy cascading, Kolmogorov Energy spectrum. **(4 Hours)**

Developing and Fully Developed Turbulent Flow in a pipe for Moderate Reynolds Number, variation of friction factors and shear stresses. **(2 Hours)**

Shear stress models, Prandtl's Mixing length Hypothesis, The eddy viscosity model, The two equation $\kappa - \epsilon$ model, The wall function conception, Solution methodology of $\kappa - \epsilon$ model. **(10 Hours)**

Review of variational calculus, Rayleigh Ritz method

Classification of problems governed by linear second order partial differential equations, linear self adjoint operators, obtaining functional from differential equation for simple one-dimensional cases

Method of weighted residuals, one-dimensional problems of elasticity, heat conduction and fluid flow,

General field problems

Equilibrium problems -Quasi-harmonic equations, Finite element equations using variational principle and weighted residual techniques, examples from heat transfer, two dimensional fluid flow, two dimensional electric and magnetic fields, torsion etc

Eigenvalue problems – Helmholtz equation, Finite element equations using variational principle and weighted residual techniques, examples from one-dimensional elasticity problem and wave equation

Propagation problems – Time dependent field problems, finite element equation, solution of first order equations, transient response using mode superposition and time-integration

Use of commercial packages for solution of heat transfer, fluid flow and electric and magnetic field problems

ME/T/424E

Mechatronics

Integration of Electromechanical systems, mechanical structure, sensor, actuator, computer monitoring, control

Modeling of sensor, strain, force, position, velocity, acceleration etc measurement, review of earlier concepts

Modeling of actuator, magnetic actuator, piezoelectric actuator, dc motor, stepper motor etc

Computer interfacing of sensor and actuator, power amplifier and actuator devices

Modeling and simulation of mixed dynamic system

Data acquisition and virtual instrumentation using MATLAB, NI/DSPACE or other equivalent packages

Real time Monitoring and control using PC based and embedded microcontrollers.

Laboratory experiments

ME/T/424F

Dynamics and Control of Electromechanical Systems

Dynamics of mechanical systems using Lagrange's method, Lagrange's equation and Hamilton's principle

Dynamics of electrical networks, Kirchoff's laws, Lagrange's equation and Hamilton's principle

Dynamics of electromechanical systems, constitutive relation for transducers, Lagrange's equation, Hamilton's principle

Piezoelectric systems, piezoelectric material, transducers – single and multiple, constitutive relation for transducers, Hamilton's principle

Piezoelectric beam actuator, laminar sensor, active beam with collocated actuator-sensor, piezoelectric laminates.

Active and passive damping with piezoelectric transducer

Magnetic levitation of a single rigid body

Components and characteristics of magnetic bearings

Magnetic suspension of rigid and flexible rotors

ME/T/424G

Fracture Mechanics

Deformation vs Fracture, Theoretical cohesive strength, Fundamentals of brittle fracture : Energy approach,

Griffith's criterion, concept of strain energy release rate : fixed load and fixed grip, stress approach- Irwin's

concept : stress intensity factor, Relationship between energy and stress approach, crack tip plasticity : models,

concepts of Plane stress & plane strain fracture, Fracture modes, K_{1C}, R-Curve behavior Ductile fracture : J-

Integral, Fractography, Fracture mechanisms in metals (MVC), ceramics (Mirror-Mist-Hackle zone), polymers (Crazing), Fracture toughness evaluation techniques, Toughening mechanisms : Intrinsic and extrinsic

mechanisms, Fatigue Fracture : Paris law, life time prediction, Persistent slip band, Stress corrosion cracking

ME/T/424H

Steam Generators

Layout of a typical pulverized coal fired power boiler plant (2 Periods)

Natural circulation based boiler, analysis of closed loop hydrodynamic systems, driving head and useful head,

hydraulic characteristics of closed circulation loops, determination of operating point of simple circuit,

circulation stagnation and flow reversal, complex circuits and determination of their operating points, presence

of steam in the down-comer and its effect on circulation, remedial measures (12 periods)

High pressure boilers, Types of cooling circuits in furnace region, typical layout of modern high pressure boilers (6 periods)

Fluid dynamic aspects of straight flow and vortex flow burners, arrangement of burners in the furnace (8 periods)

Introduction to two phase flow; nucleate boiling, sub-cooled boiling, saturated boiling, flow patterns in a vertical tube under diabatic condition, critical heat flux and its implications (10 periods)

Mineral matter content in coal, formation of ash, fouling and slagging (4 periods)

ME/T/424I

Gas Turbine Theory

Ideal cycle analysis for gas turbine including the effects of perfect inter-cooling, ideal reheating and ideal heat exchanger. Comparison between ideal and actual cycles including effects of pressure drop in heat exchanger, isentropic efficiencies of compressor and turbine and changes in composition of working fluid ~(4 periods)

Review of small stage efficiency and stagnation quantities (2 periods)

Use of Gas turbines in air craft propulsion systems: Momentum thrust and pressure thrust; propulsion efficiency; analysis of subsonic and supersonic intakes, analysis of subsonic and supersonic exhaust nozzles, Analysis of turbo-jet, turbo-fan and turbo prop engines; introduction to Ram jet engines (10 periods)

Centrifugal compressor, energy for compression, slip factor, power input factor, inlet pre-whirl, Mach number at the inlet of diffuser, Non-dimensional quantities and compressor characteristics; surge line and rotating stall. (8 periods)

Axial flow compressor, energy for compression, work done factor, Degree of reaction, three dimensional flow, review of radial equilibrium theory and free vortex design, losses in compressor, blade nomenclature, axial flow compressor characteristics (8 periods)

Gas turbine combustion chambers, types, pressure drop (4 periods)

Axial flow turbines, work done per stage, flow coefficient, blade loading coefficient and degree of reaction, nozzle loss coefficient, free vortex design and constant nozzle angle design, characteristics (6 periods)

Prediction of performance of gas turbine plant as a whole unit ... (2 periods)

ME/T/424K

SOLAR ENERGY

1. Sun Earth Geometry-3

2. Fundamentals of Solar Radiation-5

3. Flat Plate Collectors, materials & construction-2

4. Thermal analysis of FPC-8

5. Performance testing of FPC- 4

6. Concentrating collectors & Evacuated Tube Collectors-6

7. Economics of Solar Energy-6

8. Storage of Solar Energy _2

9. Status of solar energy in India & World-2

ME/T/424L

Operations Research

Introduction: Meaning; Models; Principles of modeling

Linear programming: Applications and model formulation; Linear dependence and independence; Convex combinations; Convex sets; Graphical method; Simplex method; Duality; Sensitivity analysis

Integer linear programming; Branch-and-bound algorithm; Gomory algorithm

Transportation problem: Mathematical model; Methods for finding initial solution; Vogel's approximation method (VAM); Test for optimality; Degeneracy; MODI method; Stepping-stone method

Assignment problem: Mathematical model; Hungarian method

Decision theory: Decision-making under risk and uncertainty situations; Naïve decision criteria; Prior and posterior probabilities and Bayesian analysis; Decision tree analysis; Utility functions and curves; Von Neumann utilities

Theory of games: Two-person zero-sum games; Saddle point; Value of the game; Pure and mixed strategies; Rules of dominance; Algebraic method; Graphical method; Linear programming method

Project planning: CPM/PERT/GERT; Critical path computations for CPM and PERT; Project time vs project cost

Queuing theory: Probability distributions in queuing systems; Solution of queuing models; M/M/1 systems

Markov chains: Applications and characteristics; Markov processes; State and transition probabilities; Ergodic matrices; Regular matrices; Steady-state conditions

Simulation: Monte Carlo simulation; Random number generation; Discrete and continuous simulation

Classical optimization methods: Constrained multivariable optimization; Standard forms; Lagrange multipliers method; Kuhn-Tucker conditions

References

Operations Research: Principles and practices - Ravindran, Phillips and Solberg - John Wiley & Sons (2006)

Introduction to Operations Research – Hillier and Lieberman - C. B. S Publishers and Distributors (2000)

Operation Research: Theory and Applications - Sharma, J. K. - Macmillan Publishers (5th Edition) (2013)

Operations Research – Bronson and Naadimuthu - Schaum's Outline Series: McGraw-Hill (2nd Edition) (1997)

ME/T/424M **THEORY OF METAL FORMING**

Introduction; Structure of metals; Stress and strain analysis; Fundamentals of plastic deformation; Basic theory of plasticity, yield criteria of metals; determination of working load in plastic deformation.

Introduction to metal forming; methods of solution of forming problems; Mechanics of metal forming processes, e.g. rolling, forging, drawing, extrusion, bending etc.

Friction and lubrication in metal forming processes; Defects in metal working.

ME/T/424N **PRODUCTION SYSTEMS AND CONTROLS**

Introduction:

Production and production system; Models of production systems, planning, analysis and control of production systems, production control information system; Integrated production control systems.

Forecasting:

Long and short term forecasting methods; time-series prediction; growth analysis by exponential smoothing; Forecast error analysis; the Box-Jenkins approach; Delphi Technique.

Aggregate planning and master scheduling:

Different approaches to aggregate planning; parametric approach to production planning; optimization approaches to aggregate planning; Desegregation to a master schedule.

Sequence and scheduling:

Sequencing tasks on processors; Job-shop scheduling; The line balancing problem; Line balance; project scheduling by network techniques; scheduling with resource constraints;

Manpower Planning and Behavioral Science; Control and Reliability of Production Systems: Quality assurance; Inspection and acceptance sampling; control charts; system reliability. Case study.

ME/T/424O **RELIABILITY IN ENGINEERING DESIGN**

Basic concept of reliability, Importance of reliability in design, Introduction to mathematical statistic and statistical distribution theorem.

Basic reliability principles, Single probability, Load-strength interaction, Bath Tub curve, Non-constant failure rate, Introduction to simple Weibull plot.

Introduction to reliability function, Structure functions, reliability of systems of independent components, bounds on the reliability function, the inclusion exclusion method, the intersection method.

Replacement, maintenance and inspection: examples and policies, life time and failure rates, expected system life time, fixed time replacement, preventive replacement, group replacement, control limit rules.

Introduction to quality control: examples and definitions, acceptance sampling, operating characteristic curve, sampling inspection plan, control charts, average run length, control chart construction, inspection problems, identification of risk factors, estimating survival functions.

Reliability in design: defining the user requirement, setting reliability metrics and definitions, risk assessment, objective based framework for product development.

Reliability in development, physics of failure, fault tree analysis, design reviews, critical items, production reliability, reliability qualification testing, failure mode effect analysis. Reliability assurance and maintainability, design from maintainability, logistic support analysis, life cycle costing, risk cost estimate, case studies.

Ref: Aggarwal; Birolini; O'Connor; Yang

ME/T/424P

ROBOTICS

1. Robot definition, classification, anatomy, degrees of freedom, characteristics, role in automation and social issues.
2. Robot arm kinematics: transformation matrices, Denavit-Hartenberg representation in forward kinematics, inverse kinematics solution of robots.
3. Differential motions and velocities: Jacobian, differential motions of a frame, differential motions of a robot and its manipulator, inverse Jacobian, dynamic equations for multi DOF manipulators.
4. Trajectory planning of robotic manipulator: Joint space vs. Cartesian space, Joint space trajectory planning (3^{rd} , 5^{th} and higher order polynomial trajectories), Cartesian space trajectories.
5. Actuators: actuating systems, hydraulic and pneumatic devices, electric motors (DC, AC, Brushless DC, Servo, Stepper).
6. Sensors and Vision Systems: position sensors, velocity sensors, acceleration sensors, force and pressure sensors, torque sensors, light & infrared sensors, touch and tactile sensors, proximity sensors etc. Vision systems, image, image processing, videocon and digital cameras, digital images.
7. Robot Control: the control problem, Fuzzy control, Fuzzification, Defuzzification, Fuzzy logic in robotics.

Ref: Mittal and Nagrath; Sandler; Groover; Gongalez, Lee and Fu.

ME/T/425

COMPREHENSIVE VIVA VOCE ON MECHANICAL ENGG.

Each student will have to appear at a viva voce examination in front of a board of examiners comprising of faculty members from all the specializations on all subjects completed during the course of his/her undergraduate study.

ME/S/421

WORKSHOP PRACTICE-V B

Syllabus common with ME/S/411

ME/S/422

Machine Elements Laboratory

Experiments on the following topic should be done:

Critical speed of a rotor, Natural frequency of vibration of a beam, Balancing of rotors, field balancing performance of hydrostatic & hydrodynamic journal bearing, NDT etc. Experiment on Robot kits, friction wear measurement, use of application software on condition monitoring.

ME/S/423

Project II

Syllabus common with ME/S/414