SYLLABUS OF MASTER OF MECHANICAL ENGINEERING

First semester

Category:- Departmental / Specialization Basket

PAPER-I

PG / ME / T/ 111A-Theory of Elasticity
Stress and strain tensors, equations of equilibrium and compatibility in rectangular and curvilinear coordinates, Cauchy's formula, stress transformation, principal stresses, Lame's stress ellipsoid, Cauchy stress quadratic, octahedral stress, stress-strain relations, basic equations of elasticity, Boundary value problem, Uniqueness of solutions, Torsion of non-circular sections, St. Venant's theory of torsion, Scalar and Vector potentials, Strain potentials.
Plane state of stress and strain, Airy's stress function for problems, Representation of biharmonic function using complex variables, kolosoff-Mushkelishvili method.
Thermal stress, Applications to problems of curved beam, thick cylinder and rotating disc, stress concentration.
Introduction to numerical methods in elasticity.

PG / ME / T / 111B-Continuum Mechanics:
Introductory concepts and mathematics- ideas of vector calculus, elements of tensor algebra, calculus of variations, orthogonal curvilinear co-ordinates.
Theory of deformation- concepts of normal and shear strain, physical significance of terms of €-matrix, principal strains, rotation of volume element, its relation to displacement gradient, affine deformation, homogeneous deformation, kinematics of deformable media, compatibility relations, discussions on curvilinear co-ordinates and in general co-ordinate systems.
Theory of stresses- definition, tensoral character, principal stresses, mean, deviatoric, octahedral stresses, differential equations of motion in orthogonal curvilinear co-ordinates.
Three dimensional equations- Elastic/non-elastic response of a body, intrinsic energy density function, generalized Hook's law, equations of thermoelasticity, differential equation of heat conduction, stress-strain temperature relations, spherico-symmetric stress distribution, energy principles- its applications to a deformable media (Navier-stokes equations), non-linear constitutive relations.
Plane Elasticity- Plane strain, stress, compatibility in terms of stress, Airy stress function, general solutions of plane elasticity problems, plane elasticity with couple stresses, plane theory with complex variable analysis, plane elasticity in polar co-ordinates.
Typical case of studies - prismatic bar with end load, torsion problem, bending problem, analysis of tapered beam.
General Solutions of Elasticity - equilibrium formulation, Helmholtz transformation, Galerkin vector.

PG / ME / T/ 111C -Advanced fluid mechanics–I
Description of Fluid motion : Eulerian and Lagrangian description; Reynolds' Transport Theorem; Rates of linear and angular strain; Rotation, Decomposition of

Velocity gradient matrix into symmetric and antisymmetric part; normal and shear stresses; Navier–Stokes' equation.
Idea Fluid Flow : Veolocity potential and stream function; circulation and vorticity; Kelvin–Helmholtz theorems; Unsteady Bernoulli's equation; Solution of Laplace's equation by separation of variables – lid driven flow in a square cavity, flow past a stationary and accelerating cylinder and sphere in an infinite expanse of fluid; introduction of complex potential for some basic flows.
Incompressible Viscous Flow : Exact solutions – Coutte Flow, rotating cylinders, Stoke's first and second problem, porous wall; 'Low Reynolds' No solution – uniform flow past a sphere; Boundary Layer Flow – Blasius equation, Falkner–Skan equation.Introduction to Turbulent Flow : Physical description of instabilities and turbulence; Statistical nature of turbulence; Reynold's averaging of Navier–Stokes' equation;Turbulent boundary layer over a flat plate.

PG / ME-AuE / T/ 111D-Combustion Engine

Analysis of Engine Cycles
Analysis of fuel-air cycle and actual cycles.
Power Plant for Automotive Vehicles
Details of engine construction: Reciprocating and Rotary Combustion engines, Stratified charge engine, Sterling Engine.
Engine Components
Material, construction and design aspects of engine components - piston assembly, connecting rod, crankshaft, cylinder head, cylinder block, flywheel, valve ports, valves, valve actuating mechanism, cams, camshaft drives, vibration damper.
Fuel Supply in SI Engines
Carburetion and mixture requirements, Transfer pump, Carburetors - types, constructional and design aspects, Mixture distribution and inlet manifold, Multipoint fuel injection system.
Fuel Supply in CI Engines
Injection system components, Jerk and Distributor pumps, Maximum and minimum speed governors, Mechanical and Pneumatic governors, Injectors and spray characteristics.
Combustion Chamber
Ignition and combustion in SI engine, Flame travel, Review of detonation and Diesel knock–effect of various factors, Combustion chambers for SI engines, Combustion in CI engine, Ignition delay and diesel knock, Excess air supply and air motion. Combustion chamber for CI engines - Construction and Performance aspects. M-combustion chamber.
Scavenging and Supercharging : Scavenging processes and efficiencies in 2 stroke engines, Supercharging-power required and effect on engine performance, different type of turbochargers.
Cooling System
Necessity, Air Cooling system, Water Cooling Systems construction of radiator, water- pump thermostat & cooling fan, Antifreeze solutions, Engine heat release and cooling system design.
Engine Friction and Lubrication
Friction estimates and Lubrication requirements.

Developments in Engines
Lean combustion engines, Adiabatic engines, Dual fuel engines, Multifuel engines, free piston engines.

PG / ME / T/ 111E -Nuclear Power Engineering
Nuclear reactions: Radioactive decay and half life; Neutron reaction, elastic and inelastic scattering, cross section of neutron reactions, thermal and fast neutrons; mechanism of nuclear fission, fission rate and reactor power, fission yield, prompt and delayed neutron.
Diffusion and slowing down of neutrons: Neutron diffusion theory, the diffusion equation, diffusion length, diffusion of one-speed neutrons from a point source, infinite plane source and a medium of finite thickness; Infinite and effective multiplication factors, geometric and material buckling; Elastic scattering, logarithmic energy decrement, slowing down in infinite media; Reflected ractors, four factor formula.
Energy removal: Thermal hydraulic analysis of reactor-temperature distribution along path of generalised coolant channel; Sinusoidal axial source distribution.
Type of power reactors: PWR-core and reactor vessels, control and safety systems, steam
generating systems; BWR-core and reactor vessels, coolant recirculation system; PHWR-core features, primary heat removal systems, control and safety features; FBR-general features and coolant systems.

PG / ME / T/ 111 F -Stress and Deformation Analysis
Advanced strength of materials: beam bending and stability problems, Analysis of thick cylinder and rotating disk etc., Application of energy methods.
Equation of stress equilibrium: Cauchy's equation, Stress Quadratic, Principle stresses; Strain Compatibility: strain displacement relations, principle strains; Stress and strain invariants.
Generalized Hooke's law, Lame's equation of equilibrium. Introduction to theory of Plasticity. Experimental stress analysis: basic concept of measuring systems, Causes and types of experimental errors, models and scale factors.
Strain gauges: mechanical, optical, electrical etc., Rosette analysis, dynamic applications, strain gauge circuits, recording and indicating devices, digital interfacing, data acquisition and processing.
Introduction to theory of photoelasticity.

PG / ME / T/ 111G-Advanced Design of Weldment
Brief review of modern developments in welding technology, analysis of welded joints – types, classes, their field of application, symbols and standards etc.
Design of welded joints for machine elements subjected to static and dynamic loads.
Fatigue of welded structures and machine elements, thermal analysis of welded joint
Residual stresses, their evaluation, prevention of distortion, Optimization of process variables and design parameters of welded-on fabricated structures.
Application of welding for designs of wear resistance surfaces, design of welded-on structures, case studies for redesigning of cast-on integral into welded ones.
Recent advances on welded practice and their impact on machine design.

PG / ME / T/ 111 H -Machine Tool Design:
Stiffness and rigidity of the separate constructional elements and their combined behavior under load, standardization of spindle speed and feed rate, Layout and design of speed change gears.
Electrical, mechanical and hydraulic devices for operational movements; Automatic control of machine tools; Design of constructional elements: Machine Tool structures, Slide-ways, Spindles, Spindle bearings etc.; Numerical Control, Computer Numerical Control, Direct Numerical Control, Adaptive Control

PAPER-II

PG / ME / T/ 112A -Theory of Mechanical Vibration
Scope of the subject. SDOF systems-review of SDOF problem (Free and forced vibration, response to harmonic excitation, rotating unbalance and support excitation, vibration isolation and transmissibility, critical speed, equivalent viscous damping).
Response to periodic and arbitrary excitation - Duhamel's integral and impulse response function, Fourier transforms, frequency response function, Nyquist plot, phase plane technique, energy methods, MDOF systems-2dof system, Lagrange equation, matrix formulation of free and forced vibration, beat phenomenon, damped and undamped vibration absorbers, stiffness and flexibility influence coefficients, eigen value problem, normal modes and properties, matrix interaction techniques, modal analysis.
Continuous system - axial vibration of bar, torsional vibration of shafts, transverse vibration of string and bending vibration of beams, free and forced vibration and normal mode theory.
Approximate methods - Rayleigh-Ritz method, Galerkin's method.

PG / ME / T/ 112B -Modal Analysis
Fundamental of Modal Analysis - Analysis of SDOF and MDOF systems, Representation and properties of FRF.
Signal processing for Modal analysis, Fourier Analysis, SISO and MIMO analysis of mechanical structures.
Modal testing, selection and use of response transducers, Approaches to measurements of force. Exciter structure interaction, Overview of testing methods.
Modal analysis identification methods - Time and frequency domain methods, other methods. Coupling techniques, Structural dynamic modification, Updating FE results using experimental data, Introduction to non-linear Modal analysis.

PG / ME / T/ 112C -Advanced hydropower engineering
Importance and place of hydropower in the total power scenario; compression with thermal and nuclear power; economic and environmental considerations.
Hydrology : Descriptive hydrology; Hydrograph; Mass Curve; Storage; Dams.
Water Ways : Pressure conduits; Penstocks; Water Hammer; Surge tanks.Selection of hydro–turbines and their accessories; Hydroturbine design, installation, operation and maintenance. Tidal power plant; Pumped Storage Plant; Multipurpose projects.

PG / ME / T/ 112D -Turbomachinery – I
Classification and Constructional features : Radial, Axial and Mixed–Flow pumps, Fans and Compressors and turbines; Single–stage and Multi–stage machines;

components – impeller, runner, inlet guide vanes, inducers, outlet guide vanes, vaneless and vaned diffuser, scroll casing, nozzles, diffuser, etc.
Two–dimensional flow analysis for a turbomachine: Conservation principle of mass, angular momentum and energy in inertial and non–inertial frame of reference; Application of these principles in radial flow machines and in cascade analysis of axial–flow turbomachines; Velocity diagram; Concept of total head, total pressure, rotor work, stagnation enthalpy and modified relative stagnation enthalpy; slip; Incidence and deviation of Flow; constant rule; Degree of reaction; Multistage compressor and turbine.
Losses and Efficiency : Boundary layer losses; Flow separation; clearance and leakage losses; Windage losses; Partial admission losses; Secondary flow losses; Volumetric, mechanical, hydraulic, manometric and overall efficiencies; Diffuser, Nozzle and Blade efficiency; Mollier diagram for expansion and compression processes in turbine, compressor, diffuser and nozzle; Total–to–total and Total–to–static efficiency; Polytropic efficiency; cavitation, stall, surge and choking.
Dimension Analysis and Machine Performance : Dimensional analysis for incompressible and compressible flow turbomachines; Work, head and power coefficients; Mach number. Reynold's Number, Specific Speed and Cavitation parameter; Overall characteristics curves for pump, fan, compressor and turbine; Similarity concept; Model study and scale effects.

PG / ME / T/ 112E -Computational Heat Transfer
Brief overview of the transport equations. Solution of linear and non-linear Ordinary Differential Equations (ODE) applicable in Thermal and Fluids Engineering.
Classification of Partial Differential Equations (PDE).. Introduction to Finite Difference, Finite Volume and Integral Methods. Solution of Steady and Transient Heat Conduction Problems, Solution of Laplace and Poission type PDEs. Introduction of Explicit and Implicit Schemes. Stability and Consistency of Numerical Methods. Fourier Stability Analysis of typical Solution Algorithms. Alternate Direction Implicit (ADI) method.
Solution of Simultaneous Algebraic Equations. Tri-Diagonal-Matrix Algorithm (Thomas Algorithm), Gauss-Siedel and Gauss-Jordon Methods. Strongly Implicit Procedures (SIP Solvers – Stone's Algorithm) for two and three dimensional problems.
Introduction to Vorticity Transport Equation in Two Dimensions, Solution of Fluid Flow Problems by Stream-function Vorticity Method. Examples of Derived Boundary Conditions for Stream Function and Vorticity. Derivation of Pressure Poission Equation and Their Solution.
Integration of Navier Stokes equation in primitive variables and Scalar Transport Equation. Various Schemes of Discretisation – First and Second Order Upwind Schemes, QUICK, Hybrid, Exact and Exponential Differencing Schemes.
Solution of Navier Stokes and Scalar Transport Equations. Introduction to Staggered Grid Layout. Solution by SIMPLE, SIMPLER and SIMPLEC Algorithms.

PG / ME / T/ 112F -Analytical Methods in Heat Transfer
Heat conduction equations in different coordinate systems.
Separation of variables. Application of Laplace transform and integral transform in heat conduction. Application of Green's function in heat conduction. Variational methods in heat conduction. Perturbation methods in heat conduction. Buried cable

problem. Analytical methods in non-linear heat conduction problems.

PG / ME / T/ 112G -Principles of Tribology

Introduction: History, Industrial Importance.

Engineering Surfaces: Properties and Measurement: Measurement Methods, Surface Profilometry, Statistical Description, and Fractal Description.

Surface Contact: Non-conforming Surface Contact Geometry, Stresses in Non-conforming Contacts, Contact of Rough Surfaces, Numerical Surface Contact Models.

Adhesion: Adhesion at Solid-Solid Contact, Basic Models, Factors influencing Adhesion, Adhesion produced by Surface Tension, Stiction, Adhesion at the Contact between Rough Surfaces.

Friction: Measurement Methods, Origin of Friction, Friction Theories, Mechanisms, Friction of Metals, Non-metallic Materials: Ceramics, Polymers, Solid Lubricants.

Wear: Types: Adhesive, Abrasive, Corrosive, Fatigue, Minor Forms: Fretting, Erosion, Percussion, Delamination Theory, Wear Debris Analysis, Wear Testing Methods, Wear of Metals, Ceramics, Polymers, Systems Approach for Wear Reduction.

Thermal Considerations in Sliding Contact: Measurement of Surface Temperature in Sliding: Thermocouples, Thin Film Sensors, Radiation Detectors, Metallographic Observation, Liquid Crystals etc., Theoretical Analyses: Archard's Approach, Multiple Heat Input Considerations.

Surface Engineering: Surface Treatments: Microstructural and Thermochemical Treatments, Surface Coatings: Hard Facing, Vapour Deposition Processes: PVD, CVD, PECVD etc., Selection of Surface Treatment / Surface Coatings.

Nanotribology: Measurement Tools: Surface Force Apparatus, Scanning Tunnelling Microscope, Atomic / Friction Force Microscope, Measurements, Fabrication Techniques for MEMS / NEMS, Atomic Scale Simulations.

Fractal Analysis in Tribology: Fractal Geometry, Fractal Characterization of Rough Surfaces, Evaluation of Fractal Dimension, Fractal Contact Model, Fractal Analysis of Adhesive Contact.

PG / ME / T/ 112 H -Stability of Elastic Systems

Concept of stability: stability theorems, Criteria for linear systems.

Classification of systems: conservative, pseudo-conservative, gyroscopic and circulatory systems;

Liapunov function; Multiple parameter stability theory and its application.

Direct variational methods of stability analysis: Numerical and approximate methods; Dynamic relaxation technique.

Simple problems: Euler Buckling load, Complicating effects, tapered columns, local buckling, instability of frames and open section columns, Stability analysis of plates and shells.

Post elastic buckling phenomena.

PG / ME / T/ 112 I -Theory of metal cutting

Introduction. Deformation of metal in the context of metal cutting.

Mechanism of chip formation, deformation zone, shear zone, shear angle, shear strain, strain rate, models of shear plane.

Tool angles: different systems, nomenclature, interrelationships, and concepts of master lines. Tool grinding: single and multi point tools. Mechanism of metal cutting

(machining): orthogonal cutting, oblique cutting, force analysis in orthogonal cutting, velocity analysis in orthogonal cutting; force analysis in oblique cutting, velocity analysis in oblique cutting, effective rake, chip flow direction and its measurement techniques. Characteristics and analysis of various machining processes.
Measurement of force components, design of dynamometer. Friction in metal cutting.
Thermal aspects of machining, cutting fluids. Failure of cutting tools, tool wear and tool life.Tool materials, coating techniques – fundamentals. Optimization of tool geometry. Surface finish and surface integrity. Economics of machining. Design aspects of cutting tools: fundamentals

PAPER-III

PG / ME / T/ 113A -Mechanics of Composite Materials
Reinforced composites and their engineering applications, Fibres and other reinforcements, Types of composites: Polymer matrix composites, metal matrix composites and ceramic matrix composites, Micro and macro mechanics theory, Characterizations tests, failure and fracture of composites, environmental effects, bending, buckling and vibration composite elements, product development and manufacturing.

PG / ME / T/ 113B -Atmospheric Fluid Dynamics
Introduction to atmosphere; structure of the atmosphere.
Elements of meteorology; lapse rate of temperature; temperature inversions; isotherms and isobars.
Atmospheric circulation; vertical convection; centrifugal effects; stability of the atmosphere.
Effect of earth's rotation on local atmosphere; wind deflection force due to earth's rotation; geostrophic, cyclonic & anti-cyclonic motion; effect of friction; gradient height and velocity; wind velocity spiral.
Atmospheric motions; wind scales; thermally direct secondary motions; monsoons; hurricanes; local winds; thunderstorms; tornadoes; cyclostrophic wind.
Atmospheric boundary layer; governing equations; Ekman spiral; logarithmic & power laws; atmospheric turbulence.
Wind speed data; wind directionality.
Effect of wind on smoke dispersion; determination of chimney height.

PG / ME / T/ 113C -Turbulence
Introduction: Laminar, Transitional and Turbulent Flows, Reynolds Number, Velocity and Length Scales. Flow Instabilities, Isotropic and Anisotropic Turbulence,
Turbulence Modeling.
Modeling of Turbulent Flow: Governing Equations – Mean Flow, Turbulent Flow and Concept of Eddy Viscosity, Zero-Equation Model.
Turbulence Structure and Concept of Energy Cascading, Turbulent Kinetic Energy, Turbulent Energy Dissipation Rate, Reynolds Averaging of Navier-Stokes Equation. Transport Equations for Mean and Fluctuating Velocities, Turbulent Kinetic Energy and Turbulent Energy Dissipation Rate. Two-Equation (k-e) Modeling for High and Low-Reynolds Number Flows, Damping Functions. Introduction to RSM and ASM. Modeling of Turbulent Flow Boundary Conditions for k-e Model – Inlet, Exit and Symmetry Conditions.Wall Boundary Conditions by Wall Function Treatment through Flat-Plate Boundary Layer Modeling.

PG / ME / T/ 113D -Steam Generators

Fuels and boiler efficiency calculations; Pulverized coal burners; Pulverized coal combustion; Pulverized coal-fired furnaces; Introduction to circulation and boiler hydraulics; Introduction to boiling and two phase flow; Steam drums and headers; Convective heat transfer in boilers; Superheaters and reheaters; Low temperature heating surfaces – Air heaters and economizers; Ash; Combustion generated pollution from boilers; Noise aspects of power boilers and associated devices

PG / ME / T/ 113E -Analysis of Thermal Systems

Introduction to thermal systems; Classification of thermal systems; Mathematical model of linear and nonlinear thermal systems; Numerical methods for steady state and dynamic simulation of thermal systems; State space models for nonlinear dynamic systems; Fixed point analysis in state space; Analysis tools for dynamic characterization of thermal systems; Introduction to bifurcation and chaos in nonlinear systems; Identification of chaos in nonlinear dynamic thermal systems

PG / ME / T/ 113F -Advanced Design of Mechanism

Review of Kinematic synthesis: Graphical and analytical methods, two and three precision point synthesis.

Function, Path and motion generaion by 4-bar linkage: four and five precision point synthesis, synthesis of geared linkages, path and motion generation by Watt and Stephenson's six- bar chain, precision point synthesis vis – a vis optimization methods.

Synthesis of spatial linkages, displacement analysis, matrix method of analysis, Synthesis of 4 – revolute spherical mechanisms, synthesis of 2- revolute 2 spheric-pair mechanisms. An introduction to robotics, robot definition and anatomy, transformation matrices.

PG / ME / T/ 113G -Contact Mechanics

Generalized equations for stress and strain in 2 dimension and 3 dimension and boundary conditions and distributed tractions. Elastic Contact: Hertz contact, contact between elastic solids, Impact. Adhesive Contact: JKR, DMT, Maugis Models. Elastic-Plastic Contact: Elastic Recovery, Compliance. Plasticity and shakedown. Fracture: Linear Elastic Fracture, Brittle Fracture, Hertzian Fracture. Friction and slip in sliding and rolling contact, Relation to stability. Indentation Mechanics.

PG / ME / T/ 113H -Industrial operations research

Introduction to operations research; Role of operations research in industrial problem solving and decision making; Linear programming – Simplex algorithm, duality, sensitivity or post-optimal analysis etc.; Queuing theory; Network analysis in project scheduling and control (PERT/CPM/GERT); Simulation models; Markov chains; Integer programming: Dynamic programming; Decision theory under risk and uncertainty situations; Replacement models; Theory of games; Classical optimization methods – Jacobian method, Lagrangean method, The Kuhn-Tucker conditions, etc.; Non-linear programming algorithms – Direct search method, gradient method, geometric programming, etc.

Category:- Inter-Disciplinary Basket

PAPER-IV

PG / ME / T/ 114A -Mechanical Behavior of Materials

Basic concepts of stress-strain, uni-axial, biaxial and triaxial stress-strain, Plane stress and plane strain.

Stress-strain diagram for metals, ceramics and polymers, structure-property correlation, basics of deformation patterns : dislocation kinetics, surface defects.

Fracture of metals, ceramics and polymers, mechanisms of crack generation and propagation, interaction between cracks and defects.

Fracture of composites, Hydrogen embrittlement, stress corrosion cracking.

Fatigue and creep of materials, structure-property relationship, basic models.

PG / ME / T/ 114B -Electro-Hydraulic Systems and Controls

Introduction: Electro-Hydraulic Systems and their basic components, Open Loop and Closed Loop Controls, Applications, Schematic of a Typical Hydraulic Circuit and Control System.

Control Modeling for Mechanical and Electrical Elements – Nonlinear and Linear systems, Linearization, First Order and Second Order Systems, Spring-mass-damper System, Lumped Modeling for Fluid lines and Valve Ports, Control Valve Modeling, Modeling of Torque Motors and Permanent-Magnet Motors, Two-Tank System with Control Valve, Loaded Actuator Control by a Control Valve.

Linearized Dynamic Analysis – Transfer Functions, Block Diagrams and Laplace Transform, Poles, Zeros, Characteristic Equations, System Stability and Routh-Hurwitz Criterion.

Feedback Control –Comparison of Open-loop, On-Off and Feedback Controls, Proportional, Integral and Derivative Controllers, Motor Positioning and Speed Control, Water Level Control in Hydraulic Tank, Electro-Hydraulic Servo-actuation Control.

Frequency Response Analysis – Nyquist Stability criterion, Nyquist plot and Bode plot for Frequency Response Analysis, Gain margin and Phase margin.

Introduction to Nonlinear Control – Nonlinear behaviour and common nonlinearities, Phase-Plane Method, Reaching Control and Sliding-Mode control for Variable-Structure Control, Method of Isoclines for Control Analysis of a Second-order System, Speed Control of a DC Motor, Describing Functions – stability analysis, Liapunov Method, Popov and Circle Criteria for stability.

PG / ME / T/ 114C -Laser material processing

i) Basic LASER principles: a) light waves, E.M. spectrum, wave and particle nature of light - polarized and un-polarized light, electron photon energy levels b) theory of LASER: population inversion, spontaneous emission and stimulated emission, amplification, gain, lazing conditions, pumping schemes, resonant cavity c) properties of LASER light: coherence, mono-chromaticity, brightness and directivity d) output characteristics: output modes, beam diameter and divergence, CW beam, pulsed beam and ultra short pulses e) modified LASER output: wavelength selection and tuning, non-linear wavelength, changes, Raman shifting, Q switches, mode

locking, cavity dumping, amplification f) types of LASERs: He Laser, argon-ion LASER, Nd-Yag LASER, EXCIMER LASER, semiconductor LASERs g) fundamentals of optics: * geometrical optics- reflection, refraction, lens and focal length; * physical optics: diffraction, polarization, interference; * optical components: high power optics, adaptive optics, LASERs, mirrors, lengths, defects, windows prism, ultraviolet optics, infrared optics, filters and coatings, reflective optics

ii) Interaction of high power laser beam with materials: Material and LASER parameters- uniform constant irradiants model, energy balance approximation, heating, melting, material removal, heating with vaporization, keyhole drilling

iii) LASER machining system: beam delivery system, mirrors, seam, splitter, focusing lens, laser head, fiber optic coupling and laser workstation

iv) High power LASER application: surface hardening, welding, cutting, drilling, marking, alloying and cladding

v) LASER based measurement system

vi) Application of the high power LASER in different materials: metals, ceramics, plastics, composites, wood etc.

vii) LASER safety – the essentials of LASER safety, hazards of LASER, LASER hazard assessment

PG / ME / T/ 114D -Project management

Module 1 – Business strategy, Change management, Stakeholder management, Organizing for projects, Scoping the project, Advanced project disciplines, Resource management, Project monitoring and control, Risks assessment in projects, Success factors & Case studies

Module2 – Contracting implications, Strategy to specification, defining the requirements, partitioning the work, the tender process, Defining the contract, Contract agreement, managing the contract.

PG / ME / T/ 114E -Optimization Techniques for Engineering Design

Introduction:- Historical development, Engg. Application, Statement and Problem definition, Classification and techniques of optimization, Classical optimization techniques.

Linear programming: simplex algorithm, duality in LP, Decomposition principle, Transportation problem. Linear programming and fractional programming.

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.

Stochastic Programming: Introduction to stochastic programming.

Evolutionary algorithms: Quadratic Programming, Genetic Algorithm, Particle swarm optimization (PSO), Differential Evolution.

Application of evolutionary algorithms and comparative study

PG / ME / T/ 114F -Advanced Thermodynamics

Review of the zeroth, first and second laws of thermodynamics; Concept of entropy generation; Exergy concept; Physical and Chemical Exergy; Availability analysis for processes, cycles and devices; The third law of thermodynamics. Review of the property relationships of simple compressible substances; Thermodynamic properties of homogeneous mixture and multiphase, multi-component systems; Chemical availability.

Stability; Phase transition; Critical phenomena; Nernst postulate; General systems; Properties of materials; Classical irreversible thermodynamics.

PAPER-V

PG / ME / T/ 115A -Reliability engineering

Probabilistic and statistical concepts of reliability, Reliability of repairable and non-repairable element, Principles of reliability in machine design, Failure analysis, Component and system reliability, Human reliability engineering, Maintainability, Case studies, Reliability testing, Network modeling for reliability evaluation

PG / ME / T/ 115B -Basics of Finite Element Method

Basic concepts, approximate solution, Weighted residual methods, Galerkin method, Piecewise defined trail functions, shape functions, vibrational methods - Rayleigh-Ritz method.

One dimensional problems in finite element procedure - modeling, element formulation with different approaches, assembly, properties of element matrix and system equations and treatment of boundary conditions, solution of equations. Standard discrete system- like truss, beam etc.

Two dimensional problems of continuum, simple elements-application to plane and axisymmetric problems of elasticity, Scalar field problems - torsion, steady state heat transfer, potential flow, seepage, electric and magnetic fields, fluid flow in ducts(FEA of heat transfer, field problem and fluid flow).

Isoparametric elements, higher order shape functions, mapping and numerical integration.

PG / ME / T/ 115C -Experimental Methods in Mechanical Systems

Introduction – Theoretical, Computational and Experimental Research Methodologies. Objectives of Experiments: Monitoring, Control and Research. System and Variable Identifications for Mechanical Systems, Planning of Instrumentation, Design of Experiments.

Basic Concepts in Measurements – Generalized Description of Measurement System. Operational Description of a General Measurement System and Elimination Methods of Interfering Inputs to the Desired Inputs. Null and Deflection Methods of Measurements, Analog and Digital Measurements, Static and Dynamic Measurements. Accuracy, Precision, Sources of Errors in Measurements, and Uncertainty Analysis. Performance Characteristics, Order of Instruments and Calibration.

Sensors and Transducers; Data Sampling, Signal Conditioning and Acquisition. Examples of Transducer for Mechanical Measurements, Working Demonstration.

PG / ME / T/ 115D -Renewable Energy

Comparison between renewable and conversional energy sources; Basic principles of renewable energy; Fundamentals of solar, wind, hydel and biomass utilization; Solar thermal and solar Photo Voltaic; Wind resources and wind mills; Micro hydel plants; Biomass and biogas utilization processes; Tidal and wave power; Ocean thermal energy conversion; Fuel cell.

PG / ME / T/ 115E -Cryogenic Engineering

Basic principles of low temperature generation; Behaviour of materials at cryogenic temperatures; Gas liquefaction systems; Gas separation and gas purification; Cryogenic refrigeration; Cryogenic storage and transfer systems; Vacuum technology; Measurement of low temperature; Applications of cryogenics.

PG / ME / T/ 115F -Statistical Thermodynamics

Statistical mechanics in the entropy representation; The micro-canonical formulations; Canonical formalism; Generalised canonical formulations; Quantum fluids; Fluctuation; Variational properties; Perturbation expansions and mean field theory; Symmetry and the conceptual foundations of thermostatics.

PG / ME / T/ 115G -Computer Aided Design

Introduction to CAD.
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, design consideration of database, Structure of database organization, Accessing database from design programs.Introduction to design optimization.
Finite element modelling and analysis, Use of typical softwares
Typical problems through CAD.

PAPER-VI

PG / ME / T/ 116A -Integrated management system

Introduction to Integrated Management Systems, ISO 9000, ISO 14001, OHSAS 18001, CMMI, ISO 22000, TQM, Strategies of developing integrated management system, Implementation strategy and efficacy, Assessment of system effectiveness, Involvement of people, Organization benefits, International scenario, System certification process, Follow up method

PG / ME / T/ 116B -Waste management

Types of wastes, Sources, Factory waste, Municipal waste: waste category, Treatment of waste, Applicable legislation, Waste to wealth, Energy recovery from waste, Plastics waste, paper waste, Recycling, Methodology of waste reduction, Case studies

PG / ME / T/ 116C -Fracture Mechanics

Introduction

Historical perspective, Fracture mechanics approach to design, Overview and **Classification.**

Linear Elastic Fracture Mechanics

Griffith Energy balance, R- curve instability, Stress field around rack, Stress Intensity Factor K, Crack tip plasticity, K- controlled fracture, Relationship between K & G.

Elastic-plastic Fracture Mechanics

Elastic - Plastic fracture parameters, CTOD, J-Contour Integral, Different methods of measurement of J-CTOD relationship, J-R curve, J - controlled fracture. EPRI method, Failure assessment diagram, Fatigue crack propagation

Dynamic fracture: Dynamic crack propagation and crack growth arrest, Dynamic fracture toughness (K_{ID}), Determination of K_{ID}.

Fracture Mechanisms in metal

Ductile fracture, Cleavage fracture, Ductile to brittle fracture, Intergranular Fracture.

PG / ME / T/ 116D -Theory of Pressure Vessels

Introduction

Cylinders under internal pressure : Review of Thin Cylinder, Thick Cylinder. Autofrettage of thick cylinder, Influence and potential of autofrettage. Thermal stresses, Two wall, multilayer and stiffened cylinder, Partially plastic deformed cylinder.

Cylinders under external pressure : Thick Cylinder, Thin Cylinder of infinite length, Stiffened cylinder, stiffened ring.

Spherical vessels : Spheres under internal pressure, Thick sphere, Thermal stresses, Partially plastic deformed sphere. Spheres under external pressure. Stresses on intersecting sphere.

Heads : Hemispherical heads, Dished heads, conical heads, Flat heads etc.

Discontinuity stresses in pressure vessels - stresses in bimetallic joint, Deformation and stresses in flanges.

Buckling of vessels under External pressure : Buckling of Circular rings and cylinder under external pressure, Collapse of thick-walled cylinder or tubes under external pressure. Buckling of spheres, Buckling under combined external pressure and axial loading.

PG / ME / T/ 116E -Dynamic Modeling for Mechatronic Systems

Introduction – Mechanistic and Non-mechanistic Modeling, Input-Output Modeling, State-Space Modeling and Fuzzy Modeling; Dynamic Modeling for Mechatronic and Control Applications, Direct and Inverse Modeling.

Input-Output Modeling – Positioning a Small Load by Hydraulic Actuation; Electrical Actuation of a Servo-valve; Combustion for Heating of Small Block; Open-loop and Closed-loop Modeling.

State-Space Modeling – Linear and Non-linear Modeling; Linearization of Non-linear Model; Heating or Cooling of a Large Block; Governing of a Hydraulic Turbine;

Electro-hydraulic Servo-system with Friction and Pipeline Transience; Modeling Flow and Pressure Ripples in a Positive-Displacement Pump.
Fuzzy Modeling for Control Application – Basics of Fuzzy Set, Operation and Control; Example of Hydraulic Servo-Actuation Control Formulation.
Introduction to Mechatronic Systems and Control.

PG / ME / T/ 116F - Flight dynamics
Rigid body Kinematics : The rigid body, finite rotation, direction cosines, orthogonal transformation, matrix notation; properties of rotation matrix, compositions of rotations; Euler angles; Rodrique's formula; Moving Frame of reference, Effect of earth's rotation on flying bodies.
Rigid body kinetics : Inertial parameters in rotated axes; Angular momentum and principal axes; canonical reference; general motion of rigid bodies; impulsive motion; the spinning top; gyroscope theory; free gyros, rate gyros, rate integrated gyros. Hamilton–Jacobi Principles : Canonical transformations, free Canonical transformations; Hamilton–Jacobi equations; Principle of perturbation, elements of quaternions.
Elements of flight : Aircraft Control Surfaces, nomenclature, use and operations. Fundamentals of Aerodynamics Principles : Aerodynamic forces and moments on a flight vehicle ; Aerodynamic coefficients; Airfoil and Wing characteristics, centre of pressure, aerodynamic centre; Boundary Layer Control on Wing; Finite Span effect of a Wing.
Flight stability : Types of stability and equilibrium; criterion of static and dynamic stability of a flight vehicle; Longitudinal stability, static margin, neutral point, phugoid motion; Lateral Stability; Stability.

PG / ME / T/ 116G -Industrial Pollution & Control
Introduction; classification of pollution; effects of pollution on human beings, plants and animals.
Air pollution: physical effects; atmospheric dispersion and diffusion; method of sampling and analysis; modeling technique; practical control of air pollution and abatement.
Water pollution: water quality parameters; dispersion and diffusion of pollutants in water; control and abatement of water pollution.
Noise pollution: physics of sound generation and transmission; physical characters of noise; physiological effects of noise; measuring instruments and technique; assessment of noise; noise control principle, practice and laws.

PG / ME / T/ 116H -Heat and Mass Transfer
Conduction: Fourier law of heat conduction; Governing equation and boundary conditions for different coordinate systems; One dimensional steady state conduction with and without heat sources; Fins of constant and variable cross sectional area; Transient heat conduction; Multidimensional steady state heat conduction problems with and without heat sources; Heat conduction in anisotropic media. Convection: Reynolds transport theorem and transport equations; One dimensional problems–Couette flow, Poisuille flow, Stefan flow etc.; Forced convection in thermally developed and developing flows; Derivation of boundary layer equations by order of magnitude analysis; Solution of boundary layer equations by similarity variable and integral methods; Introduction to natural convection; Natural convection in boundary layers; Integral method, scaling analysis. Radiation: Basic definitions,

surface properties, view factors; Radiation exchange in black and grey enclosure; Radiosity matrix; Interaction of surface radiation with other mode of heat transfer. Mass Transfer: Basic definitions; Fick's law of diffusion; Species conservation equation; Solution of one dimensional mass transfer problem.

PG / ME / T/ 116 I -Non-linear Vibration

Introduction to the different phenomena in Non Linear Vibration, Mathematical (quantitative) method of solution like Straight forward expansion, L.P Method, M.M.S, Method of Harmonic balance, Ritz averaging etc. Use of numerical tools for analysis of non-linear vibration direct integral.

Qualitative analysis - concept of phase plane, Method of Isoclines, Lienards method, Delta method etc.

Application of the method of conservative SDOF system. Examples of simple systems like bilinear systems, Non-linear spring, Pendulum, Undamped Duffing's oscillator, Study of non conservative SDOF system, Various damping mechanisms, Vander Pol's oscillator, Use of various solution methods, Non stationary vibration, Relaxation Oscillation.

Forced vibration of SDOF system, cubic non-linearity, primary, super harmonic, sub harmonic and combination resonance, self sustained oscillation, parametrically excited system, example of pendulum with moving support, stability of steady state solution, Floquet theory.

Introduction to non linear vibration of multi-DOF and continuous system.

PG / ME / T/ 116 J -Advanced Dynamics

Introductory concepts - generalised coordinates,Constraints and classification, Principles of virtual work, D'Alemberts's principle, Lagrange equation- Derivative and integrals of motion, Special application of Lagrange equation- Impulsive motion, Gyroscopic systems, velocity dependent potentials.

Hamilton's equation and principle, Hamilton-Jacoby theory, Canonical Transformation, Introduction to relativity.

PG / ME / T/ 116 K -Multi-body Dynamics

Multi-body systems, reference frames, particle mechanics, rigid body mechanics, deformable bodies, constrained motions.

Rotation matrix, Properties, angular velocity, acceleration equations, Rodriguez Parameters, Euler angles, transformation matrix.

Generalized coordinates, kinematic constraints, virtual work, Lagrangian Dynamics, Variational Calculus, Equation of motion of rigid body systems, Newton-Euler equations.

Kinematics, Strain field, rigid body motion, stress field, equations of equilibrium, constitutive equations, virtual work of elastic forces.

Kinematic description, Inertia of deformable bodies, application to a multi-body system, dynamic equations with multipliers, coordinate partitioning.

Nodal coordinate formulation, stiffness matrix formulation, consistent mass formulation, velocity transformation matrix, lumped mass formulation

Category:- Sessional Courses

Sessional I

PG / ME / S / 111- Laboratory

Sessional II

PG / ME / S / 112- Seminar

Second Semester

Category:- Departmental / Specialization Basket

PAPER –VII

PG / ME / T/ 127A -Rotor Dynamics
Introduction to dynamics of rotating and reciprocating machines. Torsional vibration in rotating machines. Flexural vibration of rotors – Response analysis and critical speed of rotors and factors affecting it. Bearing elasticity. Influence of elastic and inertial anisotropy. Stability of rotors.
Vibrations of discs and blades of turbo machines.
Torsional vibration of reciprocating machines. Power smoothing of reciprocating engines.
Balancing of rotating and reciprocating machines. Balancing machines.
Introduction to condition monitoring of rotating and reciprocating machines.

PG / ME / T/ 127B -Random Vibration
Introduction to probability theory and random processes, probability distribution, average, mean, auto and cross correlation, covariant, stationary and ergodicity, temporal averages. Frequency decomposition and stationary random processes, spectral densities, wide band and narrow band processes, linear time invariant system, excitation-response relations for stationary random process. Response of SDOF, MODE and Continuous systems to random excitation, failure due to random vibrations.

PG / ME / T/ 127C -Gas Dynamics
Thermodynamic Consideration; Speed of Sound; Steady State Energy Equation; Isentropic Flow Equation. Wave motion in compressible medium; Normal Shock Wave analysis; Rankine–Hugoniot relations Moving Normal Shock Wave; Oblique shock wave analysis; Supersonic Flow over a Cone; Expansion wave analysis Prandtl–Meyer Flows; Shock Expansion Procedure. Development of Governing Equations for Generalised One–dimensional Flows; Simple area change (isentropic); Simple frictional flow (Fanno Flow); Simple Heat addition or rejection (Rayleigh flow); Applications; Normal Shock and Rayleigh and Fannolines; Simple mass addition or removal. Differential forms of Conservation Equations for multidimensional inviscid flows; Alternate forms of these differential equations; The entropy equation; Crocco's theorem; Equations of motion in terms of velocity potential. The small disturbance equation – Linearised Pressure Coefficient; Subsonic and Supersonic Wavy Wall; Prandt–Glauert Rule. The method of characteristics; Development of equations of characteristics for planar flow; Numerical Computation methods; supersonic nozzle design. Measurement of Pressure, Temperature, Velocity and Density in Compressible flow; Optical methods of flow visualisation.

PG / ME / T/ 127D -Turbomachinery – II

Propulsion : Turbojet and Ramjet Components – Diffuser and air intake, Compressor, Combustion chamber, gas turbine and nozzle; Equation of motion of a rocket; Specific impulse; Matching of Compressor and Turbine. Three Dimensional Flow Analysis Through Turbomachines : Radial Equilibrium Theory; Free, Forced and Combined Vortex design of blades; Actuator Disc Approach; Blade row interaction effects; Design of stationary and moving blades. Design and Performance Analysis of Turbomachines : Radial flow pumps, fans, compressors and turbines; Axial flow pumps, fans, compressors and turbines; Wind turbines, Steam turbine and Gas turbines.

PG / ME / T/ 127E -Convection Heat Transfer

Transport equations with discontinuous property variation. Conservation laws for interface phenomena.

Forced convection in turbulent flows: Introduction to turbulent flows. Turbulent heat transfer, and Turbulent Prandtl number.

Natural convection: Introduction to natural convection. Boussinesq approximation and scaling analysis. Similarity solution of natural convection equations for boundary layers,

Thermal stability: Concept of hydrodynamic and thermal stability. Rayleigh-Benard convection.

PG / ME-AuE / T/ 127F-Advanced Refrigeration and Air Conditioning Methods

Analysis of vapour compression refrigeration system (theoretical and actual); Effect of various factors on the performance of vapour compression refrigeration system; Multiple evaporator systems; Compound vapour compression systems; Low temperature and multi-temperature systems.

Analysis of vapour absorption refrigeration system (theoretical and actual); LiBr-H2O system; Electrolux systems; Binary mixtures; Analysis of absorption systems using analysis and rectification columns.

Refrigeration equipments: Compressors (reciprocating and centrifugal); Expansion devices; Condensers; Evaporators; Controls used in refrigeration systems. Properties of refrigerants; Their development and applications; Principles of various other refrigeration systems; Psychrometry (definitions and processes); Application of psychrometric processes of summer and winter air conditioning (applied psychrometry); Heat load estimation; Human comfort; Comfort chart; Sol-Air temperature air-conditioning system; Different types of air conditioning plants and air conditioning equipments.

PG / ME / T/ 127G -Energy Conservation & Management

Significance and scope of energy conservation & management.

Basic principles. Total energy concept. Waste heat recovery; high medium and low temperature applications.

Economics and feasibility of energy conservation applications.

Industrial energy conservation.

Design principles.

Case studies.

Energy audit.

Energy management in practice.

PG / ME / T/ 127H -Lubrication Engineering

Liquid Lubricants: Properties and Measurement: Oil Lubricants: Natural Organics, Synthetic Organics, Greases, Viscosity: Effect of Temperature, Pressure and Shear Rates on Viscosity, Viscosity Measurement, Other Properties.
Basic Equations for Fluid Film Lubrication: Navier-Stokes Equation, Continuity Equation,
Reynolds Equation: Derivation and Significance of Different Terms, Dimensionless Numbers, Flow Rate and Shear Stress.
Hydrodynamic Thrust Bearings: Pressure Development Mechanism, Plane Slider Bearing with Exponential Film Profile, Fixed Inclination Slider Bearing, Tilting Pad Slider Bearing, Parallel Step Slider Bearing, Finite Width Thrust Bearings, Design Procedure.
Hydrodynamic Journal Bearing: Infinitely Long Journal Bearing, Infinitely Short Journal Bearing, Finite Length Journal Bearings: Numerical Solution, Effective Temperature of Lubricant, Design Procedure, Hydrodynamic Instability, Oil Supply Grooves.
Hydrodynamic Squeeze Film Bearings: Infinitely Long Parallel Surface Bearing, Infinitely Long. Journal Bearing, Special Cases: Parallel Circular Plate Near A Plane, Infinitely Long Cylinder Near A Plane, Sphere Near A Plane.
Hydrostatic Bearings: Circular Step Thrust Bearing, Annular Thrust Pad Bearing, Rectangular Thrust Bearing, Hydrostatic Journal Bearing.
Gas-Lubricated Bearings: Governing Equations, Slip Flow, Surface Roughness Effects, Infinitely Long Plane Slider Bearing, Infinitely Long Journal Bearing, Finite Journal Bearings, Other Gas Bearing Types, Squeeze Film Lubrication, Instabilities in Gas-Lubricated Bearings.
Elastohydrodynamic Lubrication: Line Contact, Point Contact, Thermal Correction, Surface Roughness Correction, Lubricant Rheology, Different Regimes in EHL Contacts.
Rolling Element Bearings: Geometry, Ball Bearings, Roller Bearings, Kinematics, Load Capacity, Fatigue Life and Lubrication. Boundary Lubrication: Mechanism, Metalworking Lubrication, Solid Film Lubrication, Solid Lubrication Models, Solid Lubricants.

PG / ME / T/ 127 I -Design of Industrial Drives

Classification of drives, rotating and reciprocating drives, friction drive, positive drive, toothed drive, gears and gearing. Advance geometry of gears and kinematics. Gear accuracy and standards, Gear corrections, Integrated approach to gear design. Materials and heat treatment, Helical, bevel, hypoid gear and worm gearing. Gear dynamics, Noncircular gears, Novikov gears, planetary gearing and its application, Method of manufacture, Gear boxes, classification and types, Industrial gear box, Machine tool speed and feed gear box. Complete design of a gear box. Heat generation and lubrication, Chain and sprocket. Fluid motors, fluid coupling, hydraulic drives/selection of motors for industrial drives.

PG / ME / T/ 127 J -Advanced Manufacturing Systems

Introduction to automation and manufacturing operations: Introduction to manufacturing systems; Group technology and cellular manufacturing, Flexible manufacturing systems; Manual and automated assembly systems; Product design and CAD-CAM in the manufacturing system; Computer-aided process planning (CAPP);

Concurrent engineering and design for manufacturing; Aggregate production planning and master production schedule; MRP, MRP II and ERP; Just-in-time production systems; Kanban system; Lean production and agile manufacturing; Quality assurance and statistical process control in manufacturing systems

PAPER –VIII

PG / ME / T/ 128A -Principles and Applications of Linear Control Theory

Introduction, mathematical models of physical system, feed back characteristics of physical systems, control system and components, time response, analysis, design specification and performance indices, concepts of stability and algebric criteria, Root locus technique, frequency response analysis, stability in frequency domain, introduction to control system design based on frequency domain techniques, introduction to state variable analysis and digital control.

PG / ME / T/ 128B -Dynamic of Electro-Mechanical Systems

Dynamics of mechanical systems using Lagrange's equation and Hamilton's principle, Conservation laws, Dynamic of continuous systems.

Dynamics of electrical networks, constitutive equation of circuit elements, Kirchhoff's law, Hamilton's principle for electrical networks, Lagrange's equation.

Electromechanical systems, constitutive relations for transducers, Hamilton's principle, Lagranges equation, examples of electromechanical systems.

Dynamics of Piezoelectric system, Piezoelectric transducer, single and multiple transducer systems, General Piezoelectric structure, Piezoelectric laminates.

Active and passive damping with piezoelectric transducers, Active Magnetic bearings, components, characteristics, Magnetic suspension of rotor and control of magnetic bearings.

PG / ME / T/ 128C -Acoustics and Machinery Noise Control

Basic acoustic principles.

Plane and spherical wave propagation. Derivation and solution of wave equation for plane and spherical waves. Terminologies in acoustics like energy density, intensity, loudness, pitch etc.

Sources of sound- monopole, dipole and quadrapole theories. Sound transmission and absorption, Nasc law transmission through walls and ducts sound absorbing materials. Structure borne sound radiation and structural response acoustic fatigue.

Machine noise- noise generation by bearing, gears, motors etc.

Noise control - noise instrumentation, noise retting and standards, human tolerance level and loudness contours, engine noise and muffler design, noise control through barriers and enclosures and absorbents linings, environmental noise control.

PG / ME / T/ 128D -Advanced Fluid Mechanics – II

Two–dimensonal Potential Flow : Conformal Transformation technique; Flow round a sharp edge; Joukowski Transformation; Flow around an ellipse; Kutta condition and flow over thin air foil; Schwarz–Christoffel transformation.

Singular Perturbation Technique in fluid mechanics : Flow post a sphere; Boundary layer over a flat plate. Linear stability theory; physical description of fluid instabilities; Klein–Helmholtz and Rayleigh–Taylor instabilities; Orr–Sommerfeld equation; Rayleigh's equation; stability; Stability curves; Squire's theorem for an inviscid flow.

Advanced Turbulence Modelling :Turbelent Scales, Zero equation model; One equation model; One equation model; Two equation model.

PG / ME / T/ 128E -Radiation Heat Transfer

Radiative property predictions from electromagnetic theory; Radiative properties of real surface; Equation of radiative transfer in participating media; Radiative properties of molecular gases; Exact solution for one dimensional grey media; Approximate solution methods; Pn and Sn approximate methods; Zonal method; Monte Carlo method for thermal radiation; Experimental techniques on radiation heat transfer.

PG / ME / T/ 128F -Two Phase Flow, Boiling and Condensation

Boiling: Pool boiling, nucleate boiling mechanism; Bubble dynamics, film boiling; Leidengrost phenomenon; Transition between nucleate and film boiling; Hydrodynamic instability models.

Condensation: Nucleation, liquid-vapour interface phenomena; Drop-wise and film condensation on surfaces; Bulk condensation; Similarities between boiling and condensation.

Two-phase flow: Two-phase flow parameters and equations; Dimensionless groups for two-phase flow, flow patterns in two-phase flow, pressure drop and heat transfer in two-phase flow; Basic types of instabilities and introduction to phenomena like flow excursion and flow oscillation; Instrumentation for two-phase flow.

PG / ME / T/ 128G -Advanced Power Plants

Review of conventional power plants, limitations, trends of modern power generation, environmental issues, combined power plants, coal gasification, plants with coal gasification, high temperature fuel cells, fuel cell integrated systems, other plants, parametric analysis, performance estimation, retrofitting of old plants, case studies.

PG / ME / T/ 128H -Design of Structural Elements

Euler beam theory; Deflection due to shear: Shear center and asymmetric bending; Analysis of thick beams, curved beams, beam-columns etc.; Approximate Methods: minimum potential energy, Ritz / Galerkin, FDM / FEM etc.
Basic equations of thin plate: Slope, strain and moment-curvature relations; Equilibrium relations of rectangular and circular plates; Different types of loading: Concentrated, uniform, patch etc.; Boundary conditions; Navier and Levy solution, method of superposition. Shear deformation theories: first order, higher order; Analysis of thick plates, orthotropic plates etc. Shells: theory of thin elastic shells; Introduction to theory of surfaces; Bending and membrane theory; Cylindrical shells and shells of revolution. Elastic stability of structural elements; dynamic analysis of beams, plates and shells; free and forced vibration.

PG / ME / T/ 128 I -Design of Industrial Pressure Vessels

Introduction , Review of Theory, Design philosophy, Criteria in vessel design, Design of pressure vessel to code specification, Organization of the ASME Boiler and Pressure Vessel Code , Materials, Specifications and their Selection, Materials and Metallurgy, Vessel Supports, Skirts, Base Rings, Saddles, Lugs and Legs Rules of Design including Earthquake, Wind Loadings, External Loadings and Nozzle Forces, Design-Construction features, Fabrication , Innovation and Economics, Post

Weld Heat Treatment, Inspection and Non Destructive Testing, including Radiography, Hydrostatic Testing Design through pressure vessel package like PV Elite e. g. Tall vertical vessel, horizontal vessel, Heat Exchanger, with different codes.

PG / ME / T/ 128J -Design of Mechanical Handling Systems

Review of commonly used mechanical handling systems, Design of mechanical handling system, selection of appropriate equipment, pneumatic and hydro-pneumatic handling system.

Rope and ropeways, Mechanical handling system for powerhouse application, Loading and unloading of ships and barges.

System design for various materials- abrasive, electrostatic, sticky, hot, hazardous nuclear materials, Closures, containers and packaging design, case studies.

PG / ME / T/ 128K -Advanced Manufacturing Science

Metal forming: Introduction, tensor analysis of stress and strain, yield criteria of metals, stress evaluation using slip line analysis, hanky evaluation for plain strain, deformation & work hardening properties of materials, construction of sleeve lines for the solution of metal forming problems, determination of working load of metal forming processes, different methods of solutions of metal forming problems, analysis of different metal forming processes, e.g. rolling, drawing etc., fundamental/ principles of newer forming processes – super plastic forming etc.

Metal casting: Introduction, theory of solidification of casting, cooling of casting, heat transfer between metal and mould, methods of manipulating the heat transfer- use of chills and chilling action, high conductivity sand molding: metal fluidity, metal velocity, effects of friction, gases in metals, formation and prevention of gas, porosity, control of chemical composition and metallurgical characteristics, calculations; shrinkage phenomenon in metal casting, riser design, residual stresses, stress-strain relationships in castings during cooling, distortion of castings, inspection and quality control of castings, different casting techniques , special casting methods and newer processes – underlying principles and science.

Welding of metals: Introduction, development of heat energy during welding, metal transfer and forces affecting metal transfer, melting rate, electrode wire feeding rate, electrode stick out, residual stress development in weldment, preheating and post heating of weldments and stress relieving, defects of welding, inspection and quality control, different welding processes, principles of welding methods using non-conventional energy sources, automation in welding, future/emerging trends in welding – the fundamentals.

PAPER –IX

PG / ME / T/ 129A -Finite Element Analysis in Engineering

Formulation of displacement based finite element method-general derivation of finite element equilibrium equations. Shape functions, convergence, compatibility, patch test, minimization of potential energy-Virtual work application of finite element to elasticity problems-plane stress, strain, axisymmetric problems with non axisymmetric loading, plate bending elements-flat shell elements-3D brick elements, degenerated shell elements. Time dependent problem- discussion on eigen problems-eigen values and eigen vectors- Rayleigh's quotient, shifting, effect of zero mass, direct integration methods, mode superposition, discussion on damping, stability and accuracy. Introduction to non linear problems, error estimation and adaptivity.

PG / ME / T/ 129B -Computational Fluid Dynamics

Types of Partial Differential Equation: parabolic, elliptic and hyperbolic equations; boundary conditions – well posed and ill posed problems. Finite Volume formulation of basic conservation equations in fluid mechanics, discretisation of potential flow problems, solution of simultaneous algebraic equations. Stream function: vorticity formulation and its discretisation for viscous flow modelling; one and two dimensional viscous flow modelling in primitive variables – rectilinear and curvilinear geometry; SIMPLE class of algorithms.

PG / ME / T/ 129C -Conduction Heat Transfer

Inverse heat conduction problems.
Probability methods in heat conduction.
Heat conduction in porous media.
Phase change problems.
Ablation.
Moving heat source problems.
Non-Fourier conduction problems.

PG / ME / T/ 129D -Advanced Computational Heat Transfer

Brief Overview of Solution of Navier-Stokes and Scalar Transport Equations on Staggered Grid. Non-Staggered Grid Layout and Appreciation of Associated Problems. Evaluation of Cell-Face Velocities and Pressure. Solution of Navier-Stokes and Scalar Transport Equations on Non-Staggered Grid. Derivation of Appropriate Pressure Correction Equation on Non-Staggered Grid.
Introduction to Numerical Grid Generation. Algebraic, Elliptic and Hyperbolic Grid Generation Methods.

Derivation of Navier-Stokes and Scalar Transport Equations on Generalised Curvilinear Coordinates. Expressions of Base Vectors and Unit Vectors, Covariant and Contravariant velocities, Gradient and Divergence of variables.

Methods for Solving Phase Change and Two-Phase Flow Problems. Enthalpy-Porosity Formulation, Volume of Fluid (VOF) Methods.

Turbulent modeling: Overview of RANS, Large-eddy simulation, Direct numerical simulation.

PG / ME / T/ 129E -Heat Exchangers

Introduction to exchangers. Mechanisms of heat transfer. Basic theory of heat exchangers. Selection of heat exchangers. Sizing and rating of different types of heat exchangers. Fouling of heat exchangers. Pinch analysis. Introduction to Codes and Standards of heat exchanger (IS, TEMA).

PG / ME / T/ 129F -Combustion Engineering

INTRODUCTION: Definition, need, application, classification etc. of combustion systems.
REVIEW: Thermodynamics (1st & 2nd law for pure, non-reacting (mixture) and reacting systems; stoichiometry, thermo-chemistry,Clausius-Clapeyron equation etc.); Conservation Equations (Continuity, momentum, total & thermal energy and species); Fluid Mechanics; Heat Transfer & Mass Transfer.
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.
MODELING OF COMBUSTION SYSTEM: Connection among Fluid Mechanics, Heat Transfer, Mass Transfer, Chemical Kinetics & Conservation Equations through Thermodynamics.
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.
LAMINAR DIFFUSION FLAME:
(I). Laminar Jet: (i) non-reacting & burning (ii) 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.
(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.
SOLID COMBUSTION: Introduction to different features of solid combustion;
(i) One-film model:
(ii)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.
INTRODUCTION TO ADVANCED PROBLEMS: Ignition; spray combustion; finite rate chemistry; fuel vapour accumulation; laminar/turbulent flow situations etc.

PG / ME / T/ 129G -Design for fracture-fatigue and creep
Introduction
Review of elementary fracture mechanics theory (LEFM & EPFM).
Fracture parameters applicable in design
K_{Js}, J_{Jc}, CTOD, R-Curve.
Fracture toughness testing
General consideration, K_{Ic} testing, K-R curve, J testing, J-R curve, method for measuring J_{Ic}, CTOD testing.
Computational Fracture Mechanics
FE methods for computing fracture parameters
Application to structure
KIc based design, CTOD design curve, ductility instability analyses, EPRI method, R6 method, practical considerations, Failure assessment diagram, Probabilistic Fracture mechanics. LBB approach of design. Fail safety and damage tolerence.
Fatigue
Introduction

Fatigue failure mechanism, classification. Stress based method, S-N Curve – design concept.
Crack growth based models
Empirical models for crack growth, crack closure, fatigue threshold, variable amplitude loading, Life prediction.
Creep
Introduction
Creep behavior of material, creep curve, Modeling for creep behavior, factors influencing creep behavior, design concepts based on creep failure.

PG / ME / T/ 129H -Mechanical Systems and Vibration Control
Dynamic analysis of machine parts: MDOF system, Continuous system, Modal analysis etc.
Design of rotors: Torsional vibration of rotating m/cs, Critical speed, Turbine and helicopter blade dynamics, Balancing, Reduction of bearing reactions.
Vibration Control: Factors affecting vibration model, dynamic properties and selection of structural materials, Vibration absorbers, Vibration isolation, Vibration control using smart actuator and smart material.
Nonlinear Vibration: Analytical techniques, Jump phenomenon, Stability.
Case studies: Vehicle response owing to road undulation, shock absorber.

PG / ME / T/ 129 I -Advanced Manufacturing Processes
Generative manufacturing processes – the back ground, basic idea and various processes, application feasibility, process selection, the trends
Processing of advanced materials like ceramics, plastics, polymers, fiber reinforced materials and composites, HSTR alloys etc.
Intelligent manufacturing
Advanced metrology and quality control.

PG / ME / T/ 129J -ADVANCED METHODS OF MACHINING:
Introduction, theory and applications of**:**

a) Mechanical processes: abrasive jet machining, water jet machining, abrasive flow machining,

Hydrodynamic machining, ultrasonic machining, thermally assisted machining,

Advanced methods in grinding

b) Chemical processes: chemical machining, electro-polishing, thermo chemical machining, and electronics fabrication

c) Electrical processes: electrochemical machining, electrochemical grinding, shaped-tube electrolyte machining, electro- stream, electrochemical arc machining, electrochemical discharge machining

d) Thermal processes: electrical discharge machining, wire electrical discharge machining, electron beam machining, ion beam machining, plasma arc machining.
Process selection and future trends

Category:- Inter-Disciplinary Basket

PAPER –X

PG / ME / T/ 1210A -Introduction to Concurrent Engineering

Design principles, need statement, idea generation processes like brain storming, cybernetics etc.: concept of concurrent engineering, design morphology, optimization and reliability in engineering design:: economics in design: ergonomics and quality engineering applications: design management.

Selection of Manufacturing processes, new trends in manufacturing – some fundamentals; methods of surface modification, outline of CIM.

PG / ME / T/ 1210B -Total Quality Management

Concepts, Introduction to Quality & Total Quality Management: TQM, Company wide quality improvement, Tools of TQM- PST, Different QC Tools, House of Quality – Quality Function Deployment, Six Sigma Methodology, Business Excellence Models, TQM Implementation Strategies, Performance measurement, Case Studies, TQM implementation, 5S, JIT

PG / ME / T/ 1210C -Solar Energy Engineering

Fundamental principles of solar radiation; Handling of solar radiation data; Thermal analysis of flat plate collectors; Performance test of flat plate collectors; Concentrating collectors; System sizing by F-chart; Utilizability method; Economics of solar energy; Application of solar thermal energy to cooling, drying and distillation; Storage of solar energy; Solar ponds.

PG / ME / T/ 1210 D-Safety Engineering

Introduction to safety; Responsibility for safety; Removing the hazards from job; Safeguarding of machines; Material handling; Plant house keeping; Industrial lighting; Ventilation and heat control; Fire hazards and control; Electrical hazards; Noise and vibration; Hand tools and portable power tools.
Safety of pressure vessels; Plant and equipment safety appraisals and control techniques; Monitoring and data documentation; Control devices and appliances; Industrial hygiene and occupational health.
Safety in chemical industry; U.N. and other standard classification for chemicals; Basic precautions against chemical hazards; Use of material safety data sheet; Receiving, storing and handling of chemicals; Compatibility and consideration; Transportation of chemicals.

PG / ME / T/ 1210E -Micro-scale Heat Transfer

Basic concepts of microscale flows; Governing equations and models for different classes of microflows; Thermal effects in microscale flows; Electrokinetically driven and thermomagnetic microflow and heat transfer; Overview of different solution techniques for microscale flows and transport; Non-Fourier heat conduction

PG / ME / T/ 1210F -Robotics and Automation

Review of robotics: robot definition, robot anatomy, robot classification & specifications, general concept of automation and its impact on industry and society at large.
Robot kinematics: direct kinematics model, Denavit-Heartenberg algorithm; inverse kinematics model, solvability, solution techniques.
Robot dynamics: Newton-Euler formulations, inverse dynamics.

Trajectory planning: steps in trajectory planning, polynomial trajectory, straight line path, circular path.
Control of end-effectors: manipulator control, torque control, force control.
Robot programming languages: methods of robot programming, motion commands, manipulator and sensor commands, GUI based operation.
Introduction to machine vision system: image processing and analysis.
Robot based automatic loading, unloading and manufacturing: machine loading and unloading using robotic arm, application of robot in spot welding, arc welding, spray painting and other manufacturing operations.

PG / ME / T/ 1210G -Manufacturing Aspects of Design

Systems approach in design, design decisions based on various criteria. Form design, design rules for castings, design of cast parts, forged parts, design of welded components, design of extruded product, spinning product, powder metallurgical parts, design for machined parts, fastening of parts by cold plastic deformation. Concept of reliability in design and its implementation.

PG / ME / T/ 1210H -Control of Mechatronic Systems

Overview of Input-Output and State-Space Modeling of Mechatronic Systems.

State-space Analysis and Control – Controllability, Observability and Stabilizability; State-feedback Control Design by Pole Placement; Observer Design by Pole Placement; Temperature Control in a Furnace, Speed Governing of a Hydraulic Turbine.

Optimal Control – Regulator and Tracking Problems, Performance Index and Its Optimization, Sweeping Technique, Position Control of Electro-Hydraulic Actuation System.

Digital Control – Features and architecture of digital control, Sampling, aliasing and signal reconstruction, Z Transforms and Transfer Functions, Correspondence between continuous and discrete control models, Digital and Pulse-train filters.

Neural Network and Control – Introduction, Neurons and Transfer Function, Structures of Neural Network, Classification by a TLU Transfer Function and Back-propagation, Static and Dynamic Training.

PG / ME / T/ 1210 I -Wind Effects on Structures

Introduction; state of the art in wind engineering & industrial aerodynamics.
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.
Aero elastic phenomena: vortex shedding and lock-in phenomena; models of vortex-induced response; across-wind galloping; wake galloping; flutter; torsional divergence.
Basic similarity requirements: dimensional analysis; basic scaling considerations; wind tunnel simulations of atmospheric flows; wind tunnel simulation of aerodynamic and aero-elastic behavior of bluff bodies; wind tunnel blockage effects.

Application to design of tall buildings; along wind, across wind and torsional response.
Application to design of slender towers and stacks with circular cross section; Rumman's procedure; Vickery and co-workers' procedure; alleviation of vortex-induced oscillations.
Study of Indian and other standards for wind-resistant designs.

PG / ME / T/ 1210J -Theory of Plasticity
Introduction to theory of plastics, relevant stress strain analysis, equations of plastic states, elastic plastic equilibrium simple problems, elastic plastic bending and torsion, beams and frames, problem with spherical and cylindrical symmetry. Plastic instability, mechanism of metal forming. Theory of slip line field, Steady and non-steady problem in plain stress and strain. Dynamic problems. Viscoplasticity, creep. Introduction with numerical application.

PG / ME / T/ 1210 K -Theory of Plates and Shells
Classical bending theory of plates, rectangular and circular plates with various edge conditions and loading, plates of various shapes, strain energy method, approximate method in the theory of plates, introduction to differential geometry, various theory of thin elastic shells and fundamental equations.
Static analysis of shells – membrane analysis of shells of revolution, bending analysis of shells of revolution, approximate solutions.
Dynamic analysis of shells – free and forced vibration of shells, Buckling of shells.
Use of numerical methods on shells under static and dynamic loading.

Category:- Sessional Courses

Sessional I

PG / ME / S / 121-Term Paper Leading to Thesis

Sessional II

PG / ME / S / 122-Seminar

THIRD and FOURTH SEMESTER

Category:- Sessional Courses

Sessional I

PG / ME / TH / 21-Thesis Work

Sessional II

PG / ME / VV/ 22-Viva-voce