FOURTH SEMESTER

4ME1 – Applied Mathematics IV

L : 3 hr. T : 1 hr per week

Unit – 1] Matrices : Inverse of matrix byadjoint method, rank of a matrix, consistency of system of equations, inverse of matrix by partitioning method. Linear dependence, Linear and orthogonal transformations. Characteristics equations, eigen values and eigen vectors. Reduction to diagonal form, statement and verification of Cayley – Hamiltone Theorem (without proof), Sylvestor's theorem, solution of second order linear differential equation with constant coefficient by matrix method. Special matrices – Rotation matrix, Spearse matrix, Vandermonde matrix . [10]

Unit – 2] Numerical methods : Error analysis, solutions of algebraic and transcendental equations by False position method, Newton – Raphson method, Newton-Raphson method for multiple roots, solution of System of simultaneous liner equations, Gauss elimination method, Gauss Jordan method; Gauss Seidel method, Crouts method. [8]

Unit – 3] Eigen values and eigen vector by interation method, by Jacobi method, Givens method and Householder's method. Solution of ordinary differential equation by Taylors series method, Runge Kutta 4^{th} order method, Euler modified method. Milne's predictor corrector method.

[7]

Unit – 4] Random variables, distribution fuctions of continuous and discrete random variables, joint distributions, mathematical expectations, moment, moment generating function and characteristic function.

[7]

Unit – 5] Special probability distribution Geometric, Binomial, Poisson's. Normal, Exponential, uniform and weibul probability distributions. [8]

Random processes, Esemble average and temporal average, Auto correlation and cross – correlation stationary random process power spectrum stationary processes and ergodic random process.

Unit – 6] Calculus of variation : Functional, externals of functional, variation principle, Euler's equation, constrained extremes, Hamilton principle and Lagrange's equation in solid mechanics. [5]

Text Books :

1. Higher Engineering Mathematics : B.S. Grewal.
2. Theory and Problems of Probability and Statistics : M.R. Spiegal (Mc Graw Hill) Schaum Series.
3. Introductory methods of numerical analysis by S.S. Sastri.

Reference books :

1. Advanced Engineering Mathematics : Kreyszig
2. Mathematics for engineers : Chandrika Prasad
3. Advanced Mathematics for Engineers : Chandrika Prasad
4. Applied mathematics for Engineering and Physics : L.A. Pipes and Harvile.
5. Calculus of variation : Forrey

4ME2 – Machine Design I

Unit I [8 Hrs.]

Concept of simple stresses and strains : Introduction, stress, strain, types of stresses, stress – strain diagram for brittle and ductile material, elastic limit, Hooks law, modulus of elasticity. Modulus of rigidity, factor of safety, analysis of tapered rod, analysis of composite section, thermal stress and strain, thermal stresses with heat flow in cylinders and plates, Hertz's contact stresses Longitudinal strain and stress, lateral stresses and strains, Poisson's ration, volumetric stresses and strain with uni-axial, bi-axial and tri-axial loading, bulk modulus, relation between Young's modulus and modulus or rigidity, Poisson's ratio and bulk modulus.

Principal stresses and strains :- Definition of principal planes and principal stresses, analytical method of determining stresses on oblique section when member is subjected to direct stresses in one plan in mutually perpendicular two planes, when member is subjected to shear stress and direct stresses in two mutually perpendicular planes, Mohr's circle for representation of stresses. Derivation of maximum and minimum principal stresses and maximum shear stresses when the member is subjected to different types of stresses simultaneously (i.e. combined stress)

Unit II [8 Hrs.]

Shear force and bending moment : Types of beam (cantilever beam, simply supported beam, overhung beam etc.). Types of loads (Concentrated and UDL), shear force and bending moment diagrams for different types of beams subjected to different types of loads, sign conventions for bending moment and shear force, shear force and bending moment diagrams for beams subjected to couple, Relation between load, shear force and bending moment.

Stresses in beams : Pure bending, theory of simple bending with assumptions and expressions for bending stress, derivation of bending equation, bending stresses in symmetrical sections, section modulus for various shapes of beam sections.

Shear stresses in beams : Concept, derivation of share stress distribution formula, shear stress distribution diagram for common symmetrical sections, maximum and average shear stress.

Unit III [7 Hrs.]

Deflection of beams : Derivation of differential equation of elastic curve with the assumptions macein it. Deflection and slope of cantilever, simply supported, overhung beams subjected to concentrated load UDL, Relation between slope, deflection and radius curvature Macaulay's method, area moment method to determine deflection of beam.

Unit IV [8 Hrs.]

Torsion of circular shafts : Derivation of torsion equation with the assumptions made int. Torsion shear stress induced in the shaft, when it is subjected to torque. Strength and rigidity criteria. For design of shaft. Torque transmitted by solid and hollow circular shaft. Derivation of maximum, minimum principal stresses and maximum shear stress induced in shaft when it is subjected to bending moment, torque and axial load.

Column and Struts : Failure of long and short column, slenderness ration, assumptions made in Euler's column theory, end conditions for column. Expression for crippling load for various end conditions if column. Effective length of column, limitations of Euler's formula, Rankine formula, Johnson's parabolic formula.

Unit V [7 Hrs.]

Interlocution to fracture mechanics : Modes of fracture, stress intensity factors, crack propagation. Paris law, creep phenomenon, design for creep.

Strain energy and impact loading : Definition of strain energy stored in a body when it is subjected to gradually applied load, suddenly applied loads and impact loads. Strain energy stored in bending and torsion. Castingliano's theorem.

Unit VI [7 Hrs.]

Factor of safety, Statistical methods in determining factor of safety. Theories of failure, modes of failure, compound stresses, eccentric axial loading, variable stresses in machine parts, stress concentration and stress raisers, notch sensitivity, stress concentration factor, methods for reducing stress concentration. Goodmans criteria, Soderberg criteria, Gerber's criteria, fatigue design for finite and infinite life of the parts subjected to variable loads.

Tutorials

1. Two problems on principle stresses
2. Two problems on Mohr's circle
3. Two problems on Thermal stresses with heat flow

1. Three problems on S.F. & B.M. diagrams
2. Two problems on Stresses in beam bending
3. Two problems on shear stresses
1. Two Problems on Macaulay's methods
2. Two problems on area moment method

Two problems on shafts
Two problems on columns and struts
Two problems on compound loading
Two problems on fatigue and variable loads.

Books Recommended

Strength of Materials – Timoshenko
Strength of Materials by – F.L. Singer
Machine Design – Shigley
Machine Design – Black and Adams
Design of Machine elements by – B.D. Shiwalkar
Design Data for Machine elements – B.D. Shiwalkar

4ME3 – Engineering Thermodynamics

Unit I [7 Hrs.]

Introduction to Thermodynamics : Basic concept of Thermodynamics, Closed and Open Systems, Forms of energy, Properties of a system, State and Equilibrium, Processes and Cycles, Temperature and Zeroth Law of Thermodynamics. Introduction to First Law of Thermodynamics (Law of Conservation of Energy), Heat and Work, Mechanical forms of work, Non-Mechanical Forms of Work (electrical, Magnetic etc.)

The Ideal Gas equation of state, Difference between Gas and Vapor, Compressibility Factor, Internal energy and specific heats of gases, Universal Gas constants.

Unit II [8 Hrs.]

First Law Of Thermodynamics : Closed Systems (Control mass systems), Work done, Change in Internal energy, Heat transferred during various thermodynamic processes, P-V diagrams. Open Systems (Control volume systems), Thermodynamic analysis of control volumes, Conservation of energy principal, Flow work and enthalpy, The Steady flow process applied to (i) Nozzles and Diffusers (ii) Turbines and Compressors, (iii) Throttle Valves. Unsteady Flow process (simple systems like charging and discharging of tanks).

Unit III [8 Hrs.]

Second Law Of Thermodynamics : Introduction (Law of degradation of energy), Thermal energy reservoirs, Kelvin – Plank and Clausius statements, Heat engines, Refrigerator and Heat pump, Perpetual motion machines, Reversible and Irreversible processes, Carnot cycle, Thermodynamic temperature scale.

Entropy : The Clausius inequality, Entropy, Principle of increase of entropy, Change in entropy for Closed and Steady flow open systems.

Second law analysis of engineering systems : Availability, Reversible work and Irreversibility.

Unit IV [7 Hrs.]

PROPERTIES OF STEAM : Critical state, Sensible heat, Latent heat, Super heat, Wet steam, Dryness fraction, Internal energy of steam, External work done during evaporation, T-S diagram, Mollier chart. Work and Heat transfer during various thermodynamics processes with steam as working fluid. Determination of dryness fraction using various calorimeters.

Unit V [7 Hrs.]

Air Standard Cycles : Otto cycle, Diesel Cycle, Stirling and Ericsson cycle, Brayton cycle. Vapour Cycles : Simple and Modified Rankine cycle with reheat and regeneration.

Unit VI [8 Hrs.]

Compressible Flow : Stagnation properties, speed of sound wave, Mach number, One dimensional isentropic flow, Stagnation properties, Isentropic flow through convergent – divergent nozzles, Normal shock.

Books Recommended

Thermodynamics – An Engineering approach – Yunus A. Cengel, Michael A. Boles
Thermodynamics – C.P. Arora – Tata Mc-Graw Hill publication.
Fundamentals of Classical Thermodynamics – Gorden J.Van Wylen, Richard E. Sonntag,
Engineering Thermodynamics – P. K. Nag.
Basic Engineering Thermodynamics – Reiner Joel.

Tutorials

Problems on

Steady flow systems.
Charging and discharging of vessels
Measurement of dryness fraction.
Clausius Inequality
Chocking of nozzles
Study of various Air Standard cycles.

4ME4 – Theory of Machines II

Unit I [8 Hrs.]

Concepts in machine element dynamics. Dynamic Stresses in machine elements. Various approaches for dynamic analysis – D' Alembert principle, Hamilton principle and Lagrange equation. Application of these approaches for simple two or three degree of freedom systems. Rigid body motion in space. Euler's equation of motion, simple precession and gyroscopic couple Gyroscopic effect on airplane, ship, vehicles and grinding mills.

Unit II [7 Hrs.]

Dynamic force analysis of planar linkages such as four bar chain and reciprocating mechanism by graphical method, virtual work method and analytical (complex number) method Cam dynamic and jump – off phenomenon.

Unit III [7 Hrs.]

Balancing in reciprocating mechanism. Turning moment Vs crank angle diagram for single – cylinder and multiple – cylinder engines, punching machines etc. Flywheel selection.

Unit IV [8 Hrs.]

Static and Dynamic balancing in rotating machines. Balancing machines and field balancing by vector diagram. Speed governors, centrifugal and inertia type, Watt, Portal, Proell, Hartnell governors, operating characteristic of governors.

Unit V [8 Hrs.]

Derivation of equation of motion for vibratory system. Free vibration of single degree – of freedom system with and without damping. Logarithmic decrement and damping estimation. Forced vibration of single – degree – of – freedom and vibration isolation, whirling of shaft and critical speed of stores.

Unit VI [7 Hrs.]

Equation of motion for two degree of freedom system. Natural frequencies and mode shapes vibration absorber. Torsional oscillation of two – disc and three disc rotors.

LIST OF EXPERIMENTS

Determination of jump – of speed of typical cam – follower system
Dynamic balancing of rotating masses
Balancing of reciprocating mechanism
Critical speed of shafts

Gyroscope
Free vibration of single DOF and two DOF spring mass system
Natural frequency determination of cantilever beam
Damping determination through free vibration logarithmic decay of a simple damped system
Natural frequency determination of two and three rotor system
Torsional vibration of bifilar or trifilar pendulum
Transmissibility of single degree of freedom system
Dynamic vibration absorber
Dynamic force analysis of four bar mechanisms
Dynamic force analysis of slider crank mechanism
Flywheel selection and parameter design for a typical multicylinder engines
Performance characteristics of governors.

Recommended Books

Theory of Machines and Mechanism – Shigley
theory of Machines and Mechanism – Ghosh and Mallik
Theory of Mechanism – S.s. Rattan
Mechanism and Machine Theory – Rao and Dukipatti
Theory of Vibrations – W.T. Thomson

REFERENCE BOOKS :

Theory of Machine – Thomas Bevan
Theory of Machines – Sandor and Erdman
Mechanical Vibrations – Grover

4ME5 – Fluid Power II

Unit I [8 Hrs.]

Impact of Jet and Jet propulsion : Impact momentum principle, Dynamic action of jet on fixed and moving flat plates and curved vanes, Series of plates and vanes, Water wheels, Velocity triangles and their analysis. Introduction to jet propulsion of ships.
Principles and Classification of Hydraulic Machines ; Principles of fluid machineries, Classification of hydraulic machines, Theory of turbo machines and their classification, Elements of hydro – electric power plant.
Impulse Turbines : Principle, constructional features, Installation of pelton turbine, Velocity diagram and analysis, working proportions, Design parameters, Performance characteristics, Governing and selection criteria.

Unit II [8 Hrs.]

Reaction of Pressure turbine : Principles of operation, Degree of reaction, Comparison over pelton turbine, Development of reaction turbines, Classification, Draft tubes, Cavitations in Turbines. Francis turbine, Propeller turbine, Kaplan turbine : Types, Constructional features, Installations, Velocity diagram and analysis , Working proportions, Designs parameters, Performance characteristics, Governing, Selection of hydraulic turbines, Bulb turbines.

Unit III [7 Hrs.]

Hydrodynamic pumps : Classification and Applications.
Centrifugal Pumps : Principles of operation, Classification, Components of centrifugal Pump installation, Priming methods, Fundamental equation, Various heads, Velocity triangles and their analysis, Slip factor, Effect of outlet blade angle, Vane shapes, Losses and efficiencies of pumps, Multi staging of pumps, design considerations, Working proportions, N.P.S.H. , Cavitations in pumps, Installation and operation. Performance characteristics, Pump and system matching, Introduction to axis and mixed flow Pumps, Self priming pumps.

Unit IV [7 Hrs.]

Positive displacement Pumps : Basic principle, Classification.
Reciprocating Piston / Plunger Pumps : Types, Main components, Slip, Work done, Indicator diagram, Cavitations, Air vessels, Hand pumps.
Rotary Displacement Pumps : Introduction to gear pumps, sliding vane pumps, Screw pumps.

Unit V [7 Hrs]

Similitude : Types of similarities, Dimensionless number and their significance, Unit and specific quantities.

Model Testing : application to hydraulic turbines and hydrodynamic pumps.
Miscellaneous And Water Lifting Devices ; Air lift pumps, Hydraulic ram, Vertical turbine or Bore hole pumps, Submersible pumps, Jet pumps, Regenerative pumps.

Unit VI [8 Hrs.]

Essential Elements of Hydraulic System ; Flow actuators, Directional control valves, Pressure control valves, flow control valves, Basic hydraulic circuits, Meter in and Meter out circuit. Use of single and double acting actuators, Hydraulic accumulator and intensifier.
Pneumatic Systems : Principle of pneumatics, Introduction to air compressors, Comparison with hydraulic power transmission, Air preparatory, Unit basic valves and industrial pneumatic circuits etc.

Books Recommended

Fluid Mechanics with Engineering Applications – Daugherty and Fanzine.
Hydraulic Machines – Theory and Design – V.P. Vasandani
Fluid Mechanics – A.K. Jain
Fluid mechanics and Fluid Power Engineering – D.S. Kumar
Fluid Mechanics and Machines – R.K. Bansal
Theory of Machines - .AT. Sayers
Industrial Hydraulics – J.J. Pippenger
Pneumatics – Gadre
Hydraulic Machines – Jagdish Lal.
Hydraulics and Pneumatics – H.L. Stewart

Tutorials

Selection of Turbines
Design of Centrifugal Pumps
Design of Francis Turbine
Design of Reciprocating Pumps
Governing of Turbines
Study of Hydro – Kinetic Systems.

Practical

(Minimum ten to be performed : six experiments and four study)

To determine the Metacentiricy Height of given Floating Vessel.
To verify Bernoulli's theorem
To find the value of coefficient of a given venturi meter fitted in a pipe.
To find the value of coefficient of discharge for a given of orifice meter.
To find out critical velocity of flow by Reynold's experiment.
Performance characteristics of Pelton Wheel.
Performance characteristics of Francis Turbine
Performance characteristics of Kaplan Turbine
Performance characteristics of Reciprocating Pump.

Performance characteristics of Variable speed pumps
Performance characteristics of Axial flow pump
Study experiment on Fluidic devices
Performance of Hydraulic Ram
Practical on Pneumatic hydraulic circuit.

4ME6 – Manufacturing Process II

Unit I [8 Hrs.]

Casting Process : Introduction, Pattern making: Types, materials used, pattern making allowances, colour codes Core making :- Types, core material and its properties.
Moulding : Types of sand moulds, moulding sand composition, moulding sand properties, moulding machines.

Unit II [9 Hrs.]

Gating design – elements of gating systems, pouring time, riser design (Analytical treatment)
Melting furnaces – Types, Electric furnace, Induction female, Cupola – construction and operation, Cleaning, inspection and casting defects.
Foundry mechanism : Special casting processes such as investment Casting, Centrifugal Casting, Shall Moulding, CO Moulding, Slush Casting, Die Casting.

Unit III [7 Hrs.]

Mechanics of forming processes (including analytical treatment), Determination of rolling pressure and roll separation force, driving force and torque, power loss in bearing. Determination of forging forces and stresses, equipment (Hammer / Press) capacity required.
Rolling, Forging, Extrusion and Wire Drawing.

Unit IV [6 Hrs.]

Powder Metallurgy : Powder manufacture and Conditioning, Production of Sintered Structural components. Self lubricating bearing. Cemented Carbides, Ceramics, Sintered Carbide cutting tools.
Composite Materials : Classification, Different types of composite materials and its applications.

Unit V [8 Hrs.]

Joining processes : Introduction to Welding, Soldering, Brazing Processes. Types of Welding. Arc Welding and Gas Welding Processes, Defects and Inspection of Welding Joints, Electrodes, Weldability of Metals, Welding equipments of Fixtures.

Unit VI [7 Hrs.]

Processing of Plastics, Thermoplastic, Thermosetting plastics, general properties and applications of Thermosetting and Thermo Plastics.
General Plastic Processes : Extrusion, Injection Moulding, compression Moulding, Transfer Moulding Blow Moulding, Calendaring, Wire Drawing, Embossing.

List of Practical

Study of Cupola Furnace
Study of Moulding Techniques.
Study of Casting Processes.
Practice on wood pattern making
Machining Work At least two Mechanical assemblies using three or more parts involving machining on lathe, drill, shapes and milling machines.
** [It is expected that while planning practicals for manufacturing process – I : the job should be designed, such then the job machined in MP – I could also be used for assembly (either few or all of them in MP-II with little machining (if required)]
A Visit ; A visit to a foundry shop for more understanding of the casting practices.

Recommended Books :

1. Manufacturing Technology (foundry Forming and Welding) P.N. Rao
2. Manufacturing Science – Ghosh and Malik
3. Workshop Technology (Volume – I) – By Hajra Choudhary
4. Manufacturing Engineering and Technology – s. Kalpakjian and SR Schmid

Reference Books

1. Workshop Technology Vol I – III- By WAJ Chapman
2. Manufacturing Processes – M Begman
3. Processes and Materials of Manufacture – R Lindberg
4. Workshop Technology (Volume I & II) – By Bawa
5. Workshop Technology Vol. I & II – by B.S. Raghuvanshi

4MEL7 – Mini – Project

A group of students (not more than 9 students in a group) should fabricate a working model of any mechanical or electro – mechanical system. Computer / mathematical model or simulation is not acceptable Students should submit (at least) one page abstract and a photograph of the model.