SEMESTER – I

18MD01 APPLIED NUMERICAL METHODS


NUMERICAL SOLUTION TO ODE: Boundary value problem - Shooting method, finite difference method, derivative boundary conditions, Finite Element Method - Rayleigh-Ritz method, Collocation and Galerkin methods (8-7)

NUMERICAL SOLUTION TO PDE: Finite difference method: Liebmann's method for Laplace and Poisson equations, alternating direct implicit method, irregular and non-rectangular grids, explicit method and Crank-Nicolson method for parabolic equations, explicit method for hyperbolic equations. (8-7)

MODELLING AND SIMULATION: Simulating deterministic behaviour, area under a curve, generating random numbers, simulating probabilistic behaviour, inventory model: gasoline and consumer demand. (8-7)

Total L:32 + T:28 = 60

REFERENCES:

18MD02 DETERMINISTIC AND PROBABILISTIC DESIGN

STATIC AND DYNAMIC FORCE ANALYSIS: Review of basics of work, energy, torque, power, load analysis, external and internal forces, equilibrium equations, free-body diagrams; Force analysis in single rigid bodies and multi-body assemblies, inertia force analysis; Force flow concept, locating critical sections, practical considerations. (10)

DESIGN AGAINST STATIC LOAD: Design against simple and combined stresses: theories of elastic failure, modified Mohr theory, design against static loading of machine elements in typical assemblies; Design of bolted joints – elastic analysis of bolted joints, Light construction based on strength and stiffness: material saving by form design, possible weight and cost reduction. (11)

CYCLIC AND IMPACT LOADING: Design against cyclic loading: effect of stress concentration, low cycle and high cycle fatigue, endurance limit modification factors, cumulative damage; Influence of non-zero mean stress: Gerber line, Goodman line, Soderberg line, yield line, modified Goodman diagram, design of machine elements and bolted joints under cyclic load. Design against impact loading. (12)

STATISTICAL CONSIDERATIONS IN DESIGN: Statistics and design, frequency distribution and its characteristics, probability distribution, analysis of variance, regression analysis, overview of response surface methodology, probabilistic approach to design. (12)

Total L: 45

REFERENCES:

18MD03 MACHINERY VIBRATION AND DIAGNOSTICS

FUNDAMENTALS OF VIBRATION: Introduction, sources and effects of vibration, types of vibration, harmonic analysis, transient time function, random time function, frequency spectrum; Single Degrees of Freedom System: free vibration, free damped vibration, forced vibration: nature of excitation, critical speeds, quality of balance, vibration isolation. (12)

TWO AND MULTIPLE DEGREES OF FREEDOM SYSTEMS: Normal mode vibration, co-ordinate coupling, Lagrange's equation, free harmonic vibration, tuned un-damped vibration absorbers;MDOF: influence coefficients, orthogonality, matrix iteration, Holzer method, branched system, geared system, Rayleigh's principle, Dunkerley's principle. (12)

TRANSIENT AND RANDOM VIBRATION: Impulse and arbitrary excitation, base excitation, Laplace transform formulation, response spectrum; Random vibration: frequency response function, spectral density, probability distribution, correlation, Fourier
transform.

VIBRATION AND NOISE - MEASUREMENT AND CONTROL: Vibration analysis overview, measuring instruments: selection of sensors, acceleration mountings, vibration excitors; Experimental methods in vibration analysis: free and forced tests, FFT analyzer, methods of vibration control, excitation reduction at source, balancing of rigid, flexible and variable mass rotors; Dynamic properties and selection of structural materials: viscoelastic polymers; Noise sources and control: noise in centrifugal fans and blowers, gears, chain drives and bearings, reduction measures, machine enclosures, silencers and mufflers.

REFERENCES:

18MD04 MECHANISMS AND ROBOT KINEMATICS

3 2 0 4

KINETIC ANALYSIS AND DYNAMICS OF MECHANISMS: Kinematic analysis: Analysis of complex mechanisms, Goodman analysis, auxiliary point method; Dynamics of mechanisms: inertia force in linkages, kineto-static analysis by complex numbers, superposition and matrix methods, virtual work.

KINETIC SYNTHESIS: Graphical synthesis, motion, path and function generation: two, three and four prescribed positions, overlay method, analytical synthesis techniques; Complex number modeling in kinematic synthesis, the dyad or standard form, three prescribed positions for motion, path and function generation, circle point and center point circles, ground pivot specification, Freudentstein’s equation.

SPATIAL MECHANISMS: Introduction, transformations describing planar finite displacements, planar finite transformations, identity transformation, planar matrix operator for finite rotation, homogeneous co-ordinates and finite planar translation - concatenation of finite displacements - rotation about an axis not through the origin, rigid body transformations, spatial transformations, analysis of spatial mechanisms.

ROBOTICS: Topology arrangements of robotic arms, forward kinematics, treatment of inverse position analysis and inverse velocity and acceleration analysis, robot, actuator force analysis; Parallel kinematic machines: serial and parallel systems, configurations and characteristics, degrees of freedom, design principles, kinematic modeling.

REFERENCES:
4. Xiao-Ping Susan Su, Computer-aided Kinematics and Dynamic Analysis of Spatial Mechanisms, Davis, 1997

18MD05 MECHATRONICS SYSTEM DESIGN

3 2 0 4

REVIEW OF MECHATRONIC SYSTEMS: Elements of mechatronic systems, design process, actuators – magnetostrictive, fluidic and electrical (PMDSC, AC induction, Stepper, Servo), valves, selection of motors.

FLUIDIC SYSTEM DESIGN: Cascade, KV-Map and step counter methods, Integration of fringe condition modules, sizing of components in hydraulic and pneumatic systems, synchronizing circuits, regenerative circuits, Accumulators.

PLCs, SENSORS and CONTROLLERS: Servo valves and Proportional valves; Sensors: proximity, displacement, velocity, acceleration, force, torque, temperature and flow measurements; PLCs: construction and working, programming using ladder logic diagram; Microprocessor and Micro controller.

REAL TIME INTERFACING: Data acquisition systems, Virtual Instrumentation, interfacing of sensors/actuators with PC, condition monitoring, adaptive control and SCADA systems.

REFERENCES:

Total L: 45 + T: 30 = 75
18MD51 VIBRATION ENGINEERING LABORATORY

In this course, students will be provided with an orientation on the following topics for a duration of 12-16 hours. Each student is expected to perform a case study by formulating and completing an activity of interest derived from the orientation under the guidance of faculty. The details expected in the final report to be submitted at the end of the semester are: Problem definition, literature review, objectives, methodology, analysis and interpretation of results and conclusions.

TOPICS FOR ORIENTATION
1. Introduction to VI software and Data Acquisition (DAQ) systems.
2. Vibration response of a given structure using free and forced vibration test- FRF. Damping ratio with and without smart materials.
3. Vibration response of a balanced and unbalanced system.
4. Shock response of a system subjected to impact loading.
5. Sound level measurement using (a) Sound level meter and (b) Microphone and VI software.
6. Determination of mass ratio in tuned dynamic vibration absorber.

CASE STUDY
Experimental modal analysis of components / assemblies of mechanical systems.

Total P: 60

SEMESTER II

18MD06 APPLIED ELASTICITY AND PLASTICITY

ANALYSIS OF STRESS AND STRAIN: Introduction to general theory of elasticity, assumptions and applications of linear elasticity, stress tensor. Cauchy’s stress principle, principal stresses, octahedral stresses, equations of equilibrium, strain tensor, principal strains, kinematic equations and compatibility conditions, Generalized Hookes’s law, plane stress and plane strain conditions, elasticity theorems, strain energy in elastic body.


CONTINUUM PLASTICITY I: Introduction to the concept of plastic deformation, role of geometry and thermodynamics in plastic deformation, stress-strain curve of real materials, plastic flow, hardening rules, strain hardening and parameters, Bauschinger effects, yield criterion, rate dependent and rate independent plasticity.

CONTINUUM PLASTICITY II: Equivalent stresses, Prandtl-Reuss and Levy-Mises equations, theory of stability under plastic flow, effect of strain rate on strain hardening, effect of power law on strain hardening, plane problems: Introduction to slip line field theory and applications.

Total L: 45

REFERENCES:

18MD07 FINITE ELEMENT ANALYSIS IN MECHANICAL DESIGN


EIGENVALUE ANALYSIS: Formulation and solution of undamped and damped free vibration problems - lumped and consistent mass matrices, solution of longitudinal, transverse and torsional vibration problems using 1D elements; Formulation and solution of
buckling problems using 1D element.

HEAT TRANSFER ANALYSIS: Review of differential equations of heat transfer, one dimensional and two-dimensional finite element formulation using variational and Galerkin's methods, solution of steady state heat transfer problems, analysis of tapered fin.

REFERENCES:

18MD08 DESIGN AND FAILURE ANALYSIS

3 0 0 3

MATERIALS AND DESIGN: Factors affecting the behavior of materials in components, effect of component geometry and shape factors, designing with high strength and low toughness materials, designing for hostile environments, the design process, materials selection in design, processes and their influence on design, systematic process selection; Material selection for sustainability: material life cycle assessment and energy, selecting materials for eco design.


DYNAMIC AND TIME-DEPENDENT FRACTURE: Dynamic fracture, rapid loading of a stationary crack, rapid crack propagation, dynamic contour integral, creep crack growth-C integral, viscoelastic fracture mechanics, viscoelastic J integral, Determination of fracture toughness values: experimental determination of plane strain fracture toughness, K- R curve testing, J measurement, CTOD testing, effect of temperature, strain rate on fracture toughness.

WEAR FAILURES AND FAILURE ANALYSIS TOOLS: Wear failures: Types of wear, different methods of wear measurement, analysis of wear failures, wear at elevated temperatures, wear on different materials, role of friction on wear, stick slip friction, creep, stress rupture, elevated temperature fatigue, environmental induced failure;Failure analysis tools:Reliability concept and hazard function, life prediction, life extension, application of Poisson, exponential and Weibull distributions for reliability, bath tub curve, parallel and series systems, MTBF, MTTR, FMEA-design FMEA, process FMEA, analysis causes of failure, modes, ranks of failure modes; Fault tree analysis; Industrial case studies on FMEA.

REFERENCES:

18MD09 DESIGN FOR MANUFACTURE AND ASSEMBLY

3 2 0 4

DFMA TOOLS: Rules and methodologies used to design components for manual, automatic and flexible assembly, traditional design and manufacture vs concurrent engineering, DFA index, poka-yoke, lean principles, six sigma concepts, DFMA as the tool for concurrent engineering, three DFMA criteria for retaining components for redesign of a product; Computer-aided design for assembly; Process capability, process capability metrics, Cp, Cpk, cost aspects.

TOLERANCE ANALYSIS: Geometric tolerancing for manufacture as per Indian standards and ASME Y 14.5 standard, surface finish, review of relationship between attainable tolerance grades and different machining processes; Cumulative effect of tolerances, dimensional chain analysis -equivalent tolerances method, equivalent standard tolerance grade method, equivalent influence method; Limits and fits, interchangeable part manufacture; Selective assembly – Mod4: group tolerances of mating parts equal; Mod4B: total and group tolerances of shaft equal; Control of axial play - introducing secondary machining operations, laminated shims, selective assembly, examples. Datum features - functional and manufacturing, redimensioning to suit manufacturing.

DATUM SYSTEMS AND TRUE POSITION THEORY: Degrees of freedom, grouped datum systems - different types, two and three mutually perpendicular group datum planes; Grouped datum system with spigot and recess, pin and hole; Grouped datum system with spigot - recess pair and tongue – slot pair - computation of translational and rotational accuracy, geometric analysis and applications; True position theory - comparison between coordinate and conventional method of feature location; Tolerancing and true position tolerancing, virtual size concept, floating and fixed fasteners, projected tolerance zone, zero true position tolerance, compound assembly. Functional inspection techniques using CMM and paper layout gauging.

(7+7)

(7+7)

Total L: 30+T:30=60
REDESIGN, TOLERANCE CHARTING AND DFE: Redesign of castings based on parting line considerations, minimising core requirements, redesigning cast members using weldments, design guidelines for welding. Redesign of components to facilitate machining. Tolerance charting. Operation sequence for typical shaft type of components, preparation of process drawings for different operations, tolerance worksheets and centrality analysis, examples: Design for the Environment - environmental objectives, global issues, regional and local issues-basic DFE methods-design guidelines-examples of application.

Total L: 45 + T: 30 = 75

REFERENCES:

18MD52 COMPUTER AIDED ENGINEERING LABORATORY

TOPICS FOR ORIENTATION
1. Linear static analysis and non-linear analysis using FEM
2. Dynamic analysis using FEM
3. Transient thermal analysis using FEM
4. Fluid flow analysis using FEM
5. Fatigue analysis of mechanical components using FEM
6. FEA for sustainable design

CASE STUDY
Finite Element analysis of sub-systems/complex components of typical mechanical systems followed by design sensitivity analysis

Total P: 60

REFERENCES:
1. Laboratory Manual prepared by Department of Mechanical Engineering.

18MD53 SENSOR INTERFACE AND ROBOTICS LABORATORY

TOPICS FOR ORIENTATION
1. Calibration of sensors using Virtual Instrumentation software
2. Sensor interface using Virtual Instrumentation software
3. Control of actuators using Virtual Instrumentation software
4. Programming of a typical pick and place robot
5. System control using PI and PID controllers

CASE STUDY
Interface and integration of sensors/actuators for development of mechatronic systems

Total P: 60

REFERENCES:
1. Laboratory Manual prepared by Department of Mechanical Engineering, PSG college of Technology.

18MD61 INDUSTRY VISIT AND TECHNICAL SEMINAR

Total P: 60
This course, likened to a mini-intern, requires each student to identify a manufacturing or service industry and pursue the solution of an industrial problem consistent with the credits allotted for the course. Students are expected to study the problem, survey pertinent literature, gather relevant data and carry our engineering and scientific analysis followed by a detailed presentation both oral and written. The report submitted for final assessment should be in line with that required for Project Work.

Total P: 60

SEMESTER III

18MD71 PROJECT WORK I

0 0 6 3

- Identification of a real-life problem in thrust areas
- Developing a mathematical model for solving the above problem
- Finalization of system requirements and specification
- Proposing different solutions for the problem based on literature survey
- Future trends in providing alternate solutions
- Consolidated report preparation of the above

Total P: 90

SEMESTER IV

18MD72 PROJECT WORK II

0 0 28 14

The project work involves the following:

Preparing a project - brief proposal including

- Problem Identification
- A statement of system / process specifications proposed to be developed (Block Diagram / Concept tree)
- List of possible solutions including alternatives and constraints
- Cost benefit analysis
- Time Line of activities

A report highlighting the design finalization [Based on functional requirements & standards (if any)]

A presentation including the following:

- Implementation Phase (Hardware / Software / both)
- Testing & Validation of the developed system
- Learning in the Project

Consolidated report preparation

Total P: 420

PROFESSIONAL ELECTIVE THEORY COURSES

18MD21 MODELING OF DYNAMIC SYSTEMS

3 0 0 3

MATHEMATICAL MODELS OF PHYSICAL SYSTEMS: Introduction to control systems: differential equations of physical systems, dynamics of robotic mechanisms, transfer functions, block diagram algebra, signal flow graphs; Feedback characteristics of control systems: feedback and non-feedback systems, reduction of parameter variations, control over system dynamics, control of the effects of disturbance signals, linearizing effect, regenerative feedback,

COMPONENTS OF CONTROL SYSTEMS AND FREQUENCY RESPONSE ANALYSIS: Linear approximation of non-linear systems: stepoper motors, hydraulic systems, pneumatic systems; Frequency response analysis and stability in frequency domain: correlation between time and frequency response- polar plots- bode plots, abarass and minimum-phase systems; Experimental determination of transfer functions: log-magnitude versus phase plots, Nyquist stability criterion, assessment of relative stability, closed loop frequency response, sensitivity analysis,

TIME RESPONSE ANALYSIS AND STABILITY IN TIME DOMAIN: Standard test signals: time response of first-order systems, time response of second-order systems, steady-state errors and error constants, effect of adding a zero to a system; Design specifications of second-order systems; Design considerations for higher-order system: performance indices, robust control solutions, approximation of higher-order systems by lower order systems; State variable analysis: concept of stability, necessary conditions, Routh stability criterion, relative stability analysis,

DESIGN AND STATE VARIABLE ANALYSIS: Preliminary considerations, realization of basic compensators: cascade compensation in time domain and frequency domain, feedback compensation, robust control system design; State variable analysis and design; concepts of state, state variables and state model, state models for linear-continuous-time systems, state variables and linear discrete-time systems, solutions of state equations; concepts of controllability and observability, pole placement by state feedback,

Total L: 45

REFERENCES:

18MD22 MECHANICS OF COMPOSITES AND SMART MATERIALS

3 0 0 3

COMPOSITES AND SMART MATERIALS: Modern materials in design, types, metals, polymers, ceramics, composites, classification of composites, advantages, applications and limitations, Matrix and reinforcement-their roles, principal types of fiber and matrix materials; Smart materials: rheological, piezoelectric, shape-memory and magnetostriuctive materials; Material characteristics of smart materials; Application of smart materials for design of intelligent structures,

(11)

MANUFACTURE OF COMPOSITE COMPONENTS: Lay-up and curing, open and closed mould processes, bag moulding, filament winding, puttrusion, pultrusion, thermforming, injection moulding, blow moulding; An overview of metal matrix composite processing and ceramic matrix composite processing.

(10)

MICRO AND MACRO MECHANICAL BEHAVIOUR OF A LAMINA: Volume and mass fractions, evaluation of elastic moduli, strength of unidirectional laminas, Hooke's law for different types of materials, engineering constants for orthotropic materials, Stress, strain relations for plane stress in an orthotropic material and in a lamina of arbitrary orientation, strength of an orthotropic lamina, basic strength theories.

(12)

MACRO MECHANICAL BEHAVIOUR OF A LAMINATE: Classical lamination theory, lamina stress; Strain behaviour; Resultant forces and moments in a laminate, types of laminates, strength and stiffness of laminates, inter laminar stresses in laminates; Analysis of composite structures. Fatigue, fracture mechanics-basics principles, fracture initiation, crack growth and crack growth modes, toughening mechanisms, environmental effects, composite joints-bonded, bolted and bonded/bolted joints.

(12)

REFERENCES:

18MD23 INDUSTRIAL TRIBOLOGY

3 0 0 3


(12)


(11)

HYDROSTATIC BEARINGS: Arrangement, advantages and limitations, Hydrostatic step bearing analyses-energy losses, optimum design, temperature rise; Hydrostatic conical thrust bearing, pad coefficients; Hydrostatic journal bearings - design procedures; Hydrostatic squeeze film bearings-analysis; Aerostatic bearings: principle, requirement, merit, demerit and application, thrust bearings and journal bearings - design procedure; Seals: Different types - mechanical seals, lip seals, packed glands, soft piston seals, mechanical piston rod packing, labyrinth seals and throttling bushes, of finger rings and drain grooves - selection of mechanical seals.

(12)


(10)

REFERENCES:

Total L: 45

18MD24 GEOMETRIC MODELING

OVERVIEW OF CAD SYSTEMS AND GRAPHICS TRANSFORMATION: Conventional and computer aided design processes, subsystems of CAD-CAM hardware and software, analytical and graphics packages, CAD workstations, networking of CAD systems, generative, cognitive and image processing graphics, static and dynamic data graphics, Transport of graphics data; graphic standards, generation of graphic primitives, display and viewing, transformations, customizing graphics software, (12)

MATHEMATICAL REPRESENTATION OF CURVES AND SURFACES: Introduction, wireframe models, parametric representation of curves-analytic - synthetic, curve manipulation; Surface models: types of surfaces, introduction to parametric representation of surfaces, design examples. (11)

MATHEMATICAL REPRESENTATION OF SOLIDS: Fundamentals of solid modeling, boundary representation, constructive solid geometry, solid manipulations, solid modeling based applications. (10)

VISUAL REALISM AND COMPUTER ANIMATION: Model cleanup, hidden line removal, shading, computer animation, animation systems, design applications, mass property calculations, geometrical property formulation, mass property formulation, design and engineering applications. (12)

REFERENCES:

Total L: 45

18MD25 STRATEGIES FOR PRODUCT DEVELOPMENT

PRODUCT DESIGN APPROACHES AND REVERSE ENGINEERING: Product design: characteristics of successful product development, challenges of product development, phases of design process, product development versus design, types of design and redesign, concept of CPC, COMPLM,Product design approaches: quality function deployment, axiomatic design, feature mode and effect analysis, concurrent engineering, Reverse engineering: scanning methods for reverse engineering, cloud points, NURBS surfaces, reengineering, tear down approach, bench marking, case studies. (12)

NEW PRODUCT DEVELOPMENT: Design creativity, innovations in design alternatives, S-curve, gathering customer needs, organizing and prioritizing customer needs, establishing product function, FAST method, establishing system functionality; Concept generation, Information gathering, brain ball, C-sketch/5-5 method, morphological analysis, Concept selection, technical feasibility, ranking, measurement theory, case studies; Role of rapid prototyping in product development. (12)

MATERIALS SELECTION FOR PRODUCT DEVELOPMENT: Performance characteristics of materials, the material selection process, economics of materials, methods of material selection, materials performance indices, material selection by expert systems, value analysis, cradle to cradle reuse practices, composites and advanced materials, case studies. (11)

INTELLECTUAL PROPERTY AND PRODUCT DEVELOPMENT ECONOMICS: Intellectual property, steps in patenting, preparation of patent application, case studies; Product development economics: elements of economic analysis, economic analysis process, case studies. (10)

REFERENCES:

Total L: 45

18MD26 DESIGN OF AUTOMOTIVE SYSTEMS

DESIGN OF PROPULSION SYSTEMS: Review of design considerations for components under static and dynamic loading; Design of IC engine components - cylinder, piston, connecting rod, crankshaft, flywheel, valves and valve springs; Design principles of electric vehicle. (10)

DESIGN OF TRANSMISSION ELEMENTS AND BRAKES: Clutches: power transmission requirements of clutches, design of single and multi-plate clutches, diaphragm clutch, cone clutch and centrifugal clutch; Design of gear box and drive lines; Concepts of
variable transmission systems; Design of power train for vibration; Brakes: brake power requirements, design of drum and disc brakes, principles of regenerative and anti-lock braking systems.

DESIGN OF STEERING AND SUSPENSION SYSTEMS: Design of steering systems, power assisted steering; Suspension systems: classification of suspension, design of springs – coil springs, leaf springs, air springs; Design of steering and suspension systems for vibration.

AUTOMOTIVE BODY DESIGN: Automotive body structural elements: design of automotive beam sections, torsion of thin-wall members, thin-wall beam section design in automobiles, buckling of thin-walled members, design for body bending and body torsion; strength and stiffness requirements; Principles of body panel design; Structural requirements for crashworthiness; Design of body structure for vibration.

REFERENCES:

18MD27 DESIGN AND ANALYSIS OF THERMAL SYSTEMS

3 0 0 3

SYSTEMS AND MATHEMATICAL MODELLING: Design Principles, workable systems, optimal systems, matching of system components, economic analysis, depreciation, gradient present worth factor, Equation fitting, homography, empirical equation, regression analysis, different modes of mathematical models, selection, computer programs for models.

MODELLING THERMAL EQUIPMENTS: Modelling heat exchangers, evaporators, condensers, absorption and rectification columns, compressor, pumps, simulation studies, information flow diagram, solution procedures.

DYNAMIC BEHAVIOUR OF THERMAL SYSTEMS: Steady state simulation, Laplace transformation, feedback control loops, stability analysis, non-linearities.

SYSTEMS OPTIMIZATION: Objective function formulation, constraint equations, mathematical formulation, Calculus method, dynamic programming, geometric programming, linear programming methods, solution procedures.

REFERENCES:

18MD28 BIOMECHANICS OF TISSUES AND JOINTS

3 0 0 3

PRINCIPLES OF MECHANICS: Review of the principles of mechanics, vector mechanics, resultant forces of coplanar and non-coplanar and concurrent and non-concurrent forces, parallel force in space, equilibrium of coplanar forces, Newton’s laws of motion, work and energy, moment of inertia.

HARD AND SOFT TISSUE MECHANICS: Bone structure and composition, mechanical properties of bone, cortical and cancellous bones, viscoelastic properties, Maxwell and Voigt models- anisotropy, electrical properties of bone, fracture mechanisms; Soft tissue mechanics; pseudo elasticity, non-linear stress-strain relationship, viscosity, structure, function and mechanical properties of skin, ligaments and tendons.

BIOMECHANICS OF JOINTS: Skeletal joints, skeletal muscles, basic considerations, basic assumption and limitations, mechanics of the elbow, mechanics of shoulder, mechanics of spinal column, mechanics of hip, mechanics of knees, mechanics of ankle.

LOCOMOTION: Human locomotion, gait analysis and kinematics, ergonomics, foot pressure measurements – Pedobarograph; Force platform, mechanics of foot, total hip prosthesis: requirements, different types of components, stress analysis and instrumentation, knee prosthesis.

REFERENCES:

18MD29 MICRO ELECTRO MECHANICAL SYSTEMS

3 0 0 3
DESIGN OF PRESS TOOLS: Study of CNC shearing, press brake, mechanical and hydraulic power presses, accessories for power presses-coller and de-coller, straightening, feed units, fundamentals of blanking and piercing, tool clearances, estimation of tonnage, standard die sets, design of simple and compound tools, design of progressive tools with manual and auto feed, die materials, bending, drawing and forming tools.

DESIGN OF DIES: Plastic injection moulding dies: plastic materials, shrinkage, two plate mold design, standard mold plates, parting line, runner and gate design, mold cooling, ejection methods, tool materials, runner less molds, multi-color injection moulding, simulation of mold flow, Introduction to Thermo Setting dies, blow moulding dies, extrusion dies, forging dies, pressure die casting dies, powder metallurgy dies and rubber moulding dies.

REFERENCES:

18MD32 HUMAN FACTORS ENGINEERING

INTRODUCTION: Definition, human technological system, multidisciplinary engineering approach, human-machine system, manual, mechanical, automated system, human system reliability, conceptual design, advanced development, detailed design and development, human system modeling, Information Input/output and processing, text, graphics, symbols, codes, visual display of dynamic information, auditory, tactile, olfactory displays, speech communications; Human output and control physical work, manual material handling, motor skill, human control of systems, controls and data entry devices, hand tools and devices.

WORKPLACE DESIGN: Applied anthropometry, workspace design and sealing, arrangement of components within a physical space, interpersonal aspects of work place design, design of repetitive task, design of manual handling task, work capacity, stress, fatigue.

ENVIRONMENTAL CONDITIONS: Illumination, climate, temperature, noise, motion, sound, vibration; Human factors applications: Human error, accidents, human factors and the automobile, organizational and social aspects, steps according to ISO/DIS6386, OSHA's approach, virtual environments.

BIOMECHANICS AND BIOTHERMODYNAMICS: Biostatic mechanics, statics of rigid bodies, upper extremity of hand, lower extremity and foot, bending, lifting and carrying, biomechanical mechanics, human body kinematics, kinematics, impact and collision; Biothermodynamics and Bioenergetics: Bio-thermal fundamentals, human operator heat transfer, human system bioenergetics, thermoregulatory physiology, human operator thermos-regularity, passive operator, active operator, heat stress.

REFERENCES:

18MD33 ROTOR DYNAMICS

ROTOR DYNAMICS AND MODELS: Co-ordinate systems: steady state rotor motion, elliptical motion, single degree of freedom systems, free and forced vibrations, total motion; The Laval-Jeffcott rotor model: the two degrees of freedom rotor system, translational motion, natural frequencies and natural modes; steady state response to unbalance, the effect of flexible support.

TORSIONAL VIBRATION IN ROTATING MACHINERY: Modeling of rotating machinery shafts of multi degree of freedom systems, determination of natural frequencies and mode shapes of branched systems.

RIGID ROTOR DYNAMICS AND CRITICAL SPEEDS: Rigid disk equation: rigid rotor dynamics, rigid rotor on flexible shaft; Whirling of an unbalanced simple elastic rotor: simple shafts with several disks, effect of axial stiffness, and determination of bending critical speeds.

BALANCING AND CONDITION MONITORING OF ROTORS: Balancing: single plane balancing, multi-plane balancing, balancing of rigid rotors, balancing of flexible rotors, Condition monitoring - noise spectrum, real time analysis, knowledge based expert systems.

REFERENCES:

18MD3 OPTIMUM DESIGN OF MECHANICAL SYSTEMS


CONSTRAINED MULTIVARIABLE OPTIMIZATION: Multivariable optimization: direct methods, cutting plane method, indirect methods, transformation techniques, and basic approach of penalty function method, Kuhn-Tucker conditions, Lagrange method; Solving design optimisation and process optimisation problems.

INTEGER AND DYNAMIC PROGRAMMING: Integer programming: solution techniques-graphical method- the branch and bound technique; Dynamic programming: Principle of optimality, computational procedure, calculus method of solution; Solving design optimisation and process optimisation problems.

NON-TRADITIONAL OPTIMIZATION: Genetic algorithms, simulated annealing, neural networks, particle swarm optimization, Teaching-learning-based optimization (TLBO); Solving design optimisation and process optimisation problems.

Total L: 45

REFERENCES:

18MD35 COMPUTATIONAL FLUID DYNAMICS

CFD AND THERMO-FLUIDS: Review to the physics of thermo-fluids, governing equations - continuity, momentum, and energy conservation - modelling, grid generation, simulation, and high-performance computing.

COMPUTATIONAL APPROACH: Finite difference method, forward, backward and central difference schemes, explicit and implicit methods, properties of numerical solution methods, stability analysis, and error estimation, difference between FDM and FVM, approximation of surface integrals, approximation of volume integrals, interpolation practices, implementation of boundary conditions, specification for a CFD simulation, requirements for accurate analysis and validation for multi scale problems.

CFD TECHNIQUES: Mathematical classification of flow, hyperbolic, parabolic, elliptic and mixed flow types, Lax - Wendroff technique, MacCormack's technique, relaxation technique, artificial viscosity, ADI technique, pressure correction technique, SIMPLE algorithm, upwind schemes, flux vector splitting.

TURBULENCE MODELING AND CFD APPLICATIONS: Turbulence energy equation, one-equation model, two-equation models (k-ω and k-ε models), review on advanced turbulence models, applications to fluid flow and heat transfer problems.

Total L: 45

REFERENCES:

18MD36 ARTIFICIAL INTELLIGENCE AND EXPERT SYSTEMS

HUMAN AND MACHINE INTELLIGENCE AND SMART SYSTEMS: Concepts of fifth generation computing, programming in AI environment, developing artificial intelligence system, natural language processing, neural networks; Forward chaining, backward chaining, use of probability and fuzzy logic, Semantic nets, rule base and objects, rule systems for semantic nets, certainty factors, automated learning.

LANGUAGES USED IN AI AND EXPERT SYSTEM DEVELOPMENT: Using PROLOG to design expert systems, converting rules
to PROLOG, conceptual example, introduction to LISP, function evaluation, lists, predicates, rule creation; Definition, choice of domain, collection of knowledge base, selection of inference mechanism, case studies of expert system development in design and manufacturing.

EXPERT SYSTEM TOOLS: Expert systems, controlling reasoning, rule based system, canonical systems, rules and meta rules, associative nets and frame systems, graphs trees and networks, representing uncertainty, probability in expert systems, learning, forms of learning, inductive learning, decision trees, knowledge in learning, heuristic classification, heuristic matching, case studies in expert systems, MYCN, Meta-Dendral, general structure of an expert system shell, examples of creation of an expert system using an expert system tool, fundamentals of object oriented programming, creating structure and object, object operations, invoking procedures, programming applications, object oriented expert system.

INDUSTRIAL APPLICATION OF AI AND EXPERT SYSTEMS: Robotic vision systems, image processing techniques, application to object recognition and inspection, automatic speech recognition.

REFERENCES:

Total L: 45

18MD37 ADVANCED STRENGTH OF MATERIALS

CURVED BEAMS AND BEAMS ON ELASTIC SUPPORTS: Circumferential stress at a point in a curved beam, correction of circumferential stresses in curved beams, deflection of curved Beams, Winklerbach formula-limitations, curved beam with restrained ends; Closed ring subjected to a concentrated load and uniform load: beam with a concentrated load; Use of principle of superposition, beam supported on equally spaced separate elastic supports; UDL over part of the beam, semi-infinite beam subjected to loads at its end with concentrated load near its end.

FLAT PLATES IN BENDING: Plates in which bending action is dominant, small deflections, stress in a circular plate with UDL, simply supported and fixed edges-concentrated load; Stresses in square and rectangular plates with UDL, concentrated load at center, strain energy of a plate.

ROTATING DISKS AND TORSION OF NON-CIRCULAR SECTIONS: Solid disk, disk with a central hole with external and internal pressures, disks of uniform strength, plastic collapse of rotating disks; Rotating cylinders (circular); Disk of varying thickness: torsion of bar having rectangular sections, elastic membrane (soap film) analogy hollow thin walled tubes, thin wall torsion members with restrained ends, elastic torsion of a circular cross section.

THICK WALLED CYLINDERS: Lame solution for principal stresses, maximum stresses, radial deflection, failure theories, applications, methods of increasing the elastic strength by pre-stressing, analysis of effects of stresses of shrinking a hollow cylinder made of thin walled laminations, auto frettage, stress components and radial displacements for constant temperature.

Total L: 45

18MD38 DESIGN OF PRESSURE VESSELS

CATEGORIZATION OF STRESSES IN PRESSURE VESSELS: Overview of pressure vessels, development of pressure vessel construction codes, factor of safety, design by rule, design by analysis, modes of failure, design for cyclic loading, stress intensity, stress limits, practical aspects of stress categorization, shape factor considerations.

DESIGN OF CYLINDRICAL SHELLS: Introduction, thin-shell equations, thick-shell equations, buckling of cylindrical shells, discontinuity stresses in pressure vessels, design of heads and covers, hemispherical heads under internal pressure; Stress concentration about a circular hole: cylindrical and spherical shell with a circular hole under internal pressure: Reinforcement of openings; Case Studies: Sizing of a pressure vessel, nozzle reinforcement assessment.

FATIGUE ASSESSMENT OF PRESSURE VESSELS: Introduction, exemption from fatigue analysis, S-N curves, local strain approach to fatigue, design fatigue curves, cumulative damage, cycle counting, fatigue evaluation procedure, example of fatigue evaluation, bolted flange connections, gasket joint behaviour, design of bolts, closure. Case Studies: fatigue evaluation using elastic analysis, fatigue evaluation using the simplified inelastic analysis method.

DESIGN OF VESSEL SUPPORTS: Lug support, support skirts, saddle supports, simplified inelastic methods in pressure vessel design, Elastic analysis incorporating modified Poisson's ratio, Elastic analysis to address plastic strain intensification. Case Studies: Structural evaluation of a reactor vessel support.
REFERENCES:

18MD39 FRACTURE MECHANICS

FRACTURE MECHANISMS IN METALS AND NONMETALS: Linear elastic fracture mechanics, elastic plastic fracture mechanics, fracture toughness testing; Fracture mechanisms in metals: Ductile fracture, cleavage, the ductile-brittle transition, intergranular fracture, Fracture mechanisms in non-metals: Structure and properties of polymers, yielding and fracture in polymers, fiber-reinforced plastics, ceramics and ceramic composites, concrete and rock.

CREEP: Mechanics of creep, inter-granular, trans-granular creep, creep test, creep strain rate-time curves, deformation mechanism map, high temperature properties of materials long time creep-stress-time relations creep contribution to the fracture mechanism; DVM, DVI, German-standard, halffield time yield test.

APPLICATION TO STRUCTURES: Linear elastic fracture mechanics, CTOD design curve, failure assessment diagrams - original concept, Jobased FAD, application to welded structures, probabilistic fracture mechanics.

18MD40 EXPERIMENTAL STRESS ANALYSIS

OVERVIEW OF EXPERIMENTAL STRESS ANALYSIS: Optical methods work as optical computers, multi-scale analysis in experimental mechanics; Stress, strain and displacement fields; Physical principle of strain gauges, photoelasticity and Moiré; Brittle coatings and holography; Hologram interferometry and speckle methods; Introduction to shearography, TSA, DIC and caustics, fringe patterns – richness of qualitative information, multi-scale analysis in experimental mechanics; selection of an experimental technique.

TRANSMISSION PHOTOLEASTICITY: Ordinary and extraordinary rays, light ellipse, passage of light through a crystal plate, retardation plates, stress-optic law, plane polariscope, Jones calculus, circular polariscope, determination of photoelastic parameters at an arbitrary point, Tardy’s method of compensation, calibration of photoelastic materials, fringe thinning methodologies, fringe ordering in photoelasticity: Miscellaneous topics in transmission photoelasticity: Resolving the ambiguity on the principal stress direction, determination of the sign of the boundary stress, compatibility conditions, role of elastic constants on stress field, model to prototype relations, properties of photoelastic model materials.


STRAIN GAUGES: Introduction to strain gauges, strain sensitivity of a strain gauge, bridge sensitivity, rosettes, strain gauge alloys, carriers and adhesives, performance of strain gauge system, temperature compensation, two-wire and three-wire circuits; Strain gauge selection, bonding of a strain gauge, Applications: soldering, accounting for transverse sensitivity effects, correction factors for special applications; Special gauges - environmental effects, torque gauge, stress gauge, single element strain gauge as stress gauge; Evaluation of SIF by strain gauges, strip gauge, single element strain gauge to evaluate SIF.

REFERENCES:

**18MD41 DESIGN OF PRESS TOOLS**

**3 0 0 3**

**SHEET METAL BEHAVIOR AND FUNDAMENTALS OF DIES:** Sheet metal and its behavior in metal stamping process, plasticity theories, external influences on the part and their impact on plastic deformation, shear of metal in cutting operation, bending and forming of sheet metal material - movement of metal. Metal stamping die: description of a die, dies according to their construction, dies according to their effect on the structure of material, new methods in metalworking, fine blanking.

**METALWORKING MACHINERY AND CONSTRUCTION OF DIES:** Parts of the press, press operating parameters, classification of presses, press mounting, performance and productivity, electro-erosive machining, Metal stamping dies: tolerancing systems, fabrication and assembly of die components, mounting of blocks, machining of blocks, heat treatment.

**BLANKING AND PIERCING OPERATIONS:** Sheet metal cutting process, forces involved in the sheet metal cutting process, alignment of cutting tools, design of sheet metal cutting tools, cutting clearances, punching and blanking pressure, cutting forces with inclined cutting surfaces, stripping pressure, scrap and hole size recommendations, practical advices and restrictions, progressive die design.

**BENDING AND FORMING OPERATIONS:** Stress, strain, elongation and compression during bending, bend radius, radius of forming tools, edge formability, types of bending operations, spring back, surface flatness after bending, forming, bending and forming pressure calculations.

**REFERENCES:**

**18MD42 HUMAN BODY VIBRATION DIAGNOSTICS**

**3 0 0 3**

**WHOLE BODY VIBRATION:** Vibration and human response, Categorization of vibration (deterministic, random), effects of vibration-criteria, limits, vibration analysis procedure, human vibration-definition, types; standardization bodies-ISO, CEN, National, BSI, Sources-Road, off-road, marine, rail transports; Exposure to whole body vibration-Vibration discomfort Measurement parameters and quantification of the vibration level, frequency response of human whole body vibration, vibration measurement—setup and stimuli, transducers used, vehicle human interface mathematical model-half car, quarter car, equation of motion (multi degree of freedom)-Lagrange’s approach, matrix approach.

**BIODYNAMICS, SEATING DYNAMICS AND HAND ARM VIBRATION:** Body transmissibility- apparent mass, models, Transmissibility, SEAT value, Seat Testing, Biomechanical models; Sources, exposure to hand arm vibration-White finger syndrome, frequency response of hand arm vibration, vibration measurement—setup and stimuli, transducers used, machine human interface model, equation of motion (Multi degree of freedom)-Lagrange’s approach, matrix approach.

**MEASUREMENT EVALUATION AND ASSESSMENT OF HUMAN VIBRATION:** Frequency analysis, digital frequency weighting, amplitude analysis, IS0 evaluation of human exposure to whole body vibration - fatigue decreased proficiency boundary, exposure limit, reduced comfort boundary-BS 6841, ISO 2631, standards for assessment of hand arm vibration-BS 6842 (1987) and ISO 5349 (1996), ISO 5349 (2001) (standards for determining the vibration emission value of tools and hand-guided machines-ISO 682(1, 2, 3…14), standards for testing the dynamic performance of antivibration gloves-ISO 13753, ISO10819, 1/3 octave frequency analysis.

**HEALTH EFFECTS OF VIBRATION, THEIR DIAGNOSIS, AND PREVENTION:** Vascular disorders-primary Raynaud’s disease, secondary Raynaud’s phenomenon, trauma, Occlusive vascular disease, neurogenic, Stockholm workshop scale, preventative measures-managerial, technical, medical, and individual, treatments for injury and disease.

**REFERENCES:**

**18MD43 ADVANCED FINITE ELEMENT ANALYSIS**

**3 0 0 3**

**REFERENCES:**
1. 0 /1
**BENDING OF PLATES AND SHELLS**: Review of elasticity equations; Bending of plates and shells – finite element formulation of plate and shell elements, conforming and non-conforming elements, C, and C. continuity elements, degenerated shell elements, application and examples. (11)

**NON-LINEAR ANALYSIS**: Introduction, non-linear differential equation, solution procedures for non-linear problems, linearization and directional derivative; Material non-linearity: Analysis of axially loaded bars, significance of sampling rate, material models for isotropic, orthotropic, anisotropic, hyper-elastic, hardening rules; Geometric non-linearity: Basic continuum mechanics concepts, governing differential equations and weak forms; Introduction to contact problems. (12)

**TIME-DEPENDENT ANALYSIS**: Numerical integration in time, natural frequencies of one dimensional bar, time dependent one-dimensional bar analysis; Time dependent heat transfer - transient thermal analysis; Solution of one dimensional problems. (10)

**ERROR, ERROR ESTIMATION AND CONVERGENCE**: Sources of error, ill-conditioning, the condition number, diagonal decay test, residuals, discretization error, convergence rate, multi-grid extrapolation, mesh revision methods, gradient recovery and smoothing, A-Posteriori error estimate, adaptive meshing. (5)

**Total L**: 45

**REFERENCES**:

**18MK01 PRESSURE VESSEL AND PIPING**

1 0 0 1

Rationale behind development of codes and standards, highlights of national and international codes, Theoretical background of pressure vessel and piping design as per ASME codes, Unique features of nuclear codes, Accumulated experience of ASME Codes, Case studies and sample problems

**Total L**: 15

**REFERENCES**:

**AUDIT COURSES**

18MD81 ENGLISH FOR RESEARCH PAPER WRITING
vide Automotive Engineering 18AE81

18MD82 RESEARCH METHODOLOGY AND IPR
vide Automotive Engineering 18AE82