I SEMESTER

15MD01 APPLIED NUMERICAL ANALYSIS

2 2 0 3

REVISION: Error analysis

SYSTEM OF EQUATIONS AND EIGENVALUE PROBLEMS: Solving set of equations - Gauss elimination method, LU - Choleski method, successive over relaxation method, system of non-linear equations - Newton Raphson method, power method and inverse power method. (8+8)

CURVE FITTING AND APPROXIMATION OF FUNCTIONS: Concept of least square approximations, linear regression, non-linear regression, error and standard deviation, multiple linear regression, applications of cubic splines - Bezier curves and B-splines.(6+6)

BOUNDARY VALUE PROBLEMS: Shooting method, solution through a set of equations, derivative boundary conditions, Rayleigh-Ritz method. (4+4)

ELLIPTIC PARTIAL DIFFERENTIAL EQUATIONS: Laplace's equation, Poisson equation - difference equation, Liebmann method - derivative boundary conditions, alternating direct implicit method, irregular and non-rectangular grids, matrix patterns, sparseness, applications to steady heat flow problems. (4+4)

PARABOLIC PARTIAL DIFFERENTIAL EQUATIONS: Explicit method, Crank-Nicholson method, derivative boundary condition, stability and convergence criteria, parabolic equations in two or more dimensions, applications to heat flow problems. (4+4)

HYPERBOLIC PARTIAL DIFFERENTIAL EQUATIONS: Solving wave equation by finite differences, stability of the solution, wave equation in two dimensions. (4+4)

Note: Exposure to softwares. Design problems will be given to the students and they have to submit assignments/term papers using programs.

Total L: 30 + T: 30 = 60

REFERENCES:

1. Curtis F Gerald and Patrick O Wheatley, “Applied Numerical Analysis”, Pearson Education, New Delhi, 2011.
2. Steven C Chapra and Raymond P Canale, “Numerical Methods for Engineers”, Tata Mcgraw Hill, New Delhi, 2007.
3. John H Mathews and Kurtis D Fink, “Numerical Methods using MATLAB”, Prentice Hall, New Delhi, 2005.
4. Ward Cheney and David Kincaid, “Numerical Mathematics and Computing”, Cengage Learning, New Delhi, 2013.
5. Richard T Burden and Douglas Faires J, “Numerical Analysis”, Cengage Learning, New Delhi, 2012.

15MD02 CONCEPTS OF ENGINEERING DESIGN

3 0 0 3

DESIGN CONSIDERATIONS: Review of basics of work, energy, torque, power, load analysis, equilibrium equations, free-body diagrams, internal loads, force flow concept, locating critical sections, practical considerations (3+1)

MANUFACTURING CONSIDERATIONS IN DESIGN: Fits and tolerances, surface roughness, weld symbols, process capability (3)

MATERIALS AND THEIR PROPERTIES : Stress – strain diagram – brittle, ductile, ceramic, polymer materials – moduli of elasticity, Poisson’s ratio, shear modulus – material strength, resilience & toughness, thermal conductivity, linear thermal expansion coefficient, specific heat capacity (3+2)

DESIGN PRINCIPLES: Occam’s Razor, Saint-Venant’s Principle, Golden Rectangle, Abbe’s Principle, Maxwell’s Reciprocity Theorem, Self-Principles, Stability, Symmetry, Parallel Axis theorem, Accuracy, Repeatability, Resolution, Sensitivity direction, Fool Proofing, mind maps (2+1)

TYPES OF LOADING, STRESSES AND STRAIN - Normal stress & strain, torsion, power transfer, bending stress & strain, curved member, transverse shear stress & strain, stress concentration. (3+3)

FRACTURE MECHANICS – Modes of crack displacement, fracture toughness, failure prediction – maximum shear-stress theory, distortion – energy theory, maximum normal stress theory, modified Mohr theory. (4+2)

CYCLIC AND IMPACT LOADING – Fatigue, cyclic stress, fatigue strength, S-N diagram, low – cycle fatigue, 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, contact fatigue theory, contact stresses, linear impact stress & deformations (5+3)

COLUMNS AND PRESS FITTED ASSEMBLIES: – Euler Equation, Johnson equation. Thin – walled cylinders, Thick – walled cylinders, Press fits – force & torque (3+1)

LIGHT CONSTRUCTION – comparison of materials, material saving by form design, possible weight and cost reduction, design concepts for light engineering products (2+1)

GREEN DESIGN PROCESS: Material life cycle, embodied energy, 80-20 rule, carbon footprint, green design in industry, sustainability, biomimetics. (2+1)

Total L: 30 +T: 15=45

REFERENCES:

1. Michael Ashby, Hugh Shercliff and David Cebon, “Materials Engineering, Science, Processing and Design”, Butterworth-Heinemann, 2009.
2. Gustav Niemann, “Machine Elements: Design & Calculation in Mechanical Engineering”, Springer-Verlag, 1978.
3. Myer Kutz, “Environmentally Conscious Mechanical Design”, Wiley, 2007.
4. Bernard J Hamrock, Steven R Schmid, Bo O Jacobson, “Fundamentals of Machine Elements”, McGraw-Hill, 2007.
5. Robert C Juvinall, “Fundamentals of Machine Component Design”, Wiley, 2011.

15MD03 MACHINERY VIBRATION AND DIAGNOSTICS

3 0 0 3

INTRODUCTION: Harmonic analysis, transient time function, random time function, frequency spectrum, single degree of freedom systems, free and forced vibration with damping. (5)

TWO DEGREES OF FREEDOM SYSTEMS: Normal mode vibration, co-ordinate coupling, Lagrange’s equation, free harmonic vibration, tuned undamped vibration absorbers. (6)

MULTIDEGREE OF FREEDOM SYSTEMS: Influence coefficients, orthogonality, matrix iteration, Holzer method, branched system, geared system, Rayleigh's principle, Dunkerley's principle. (7)

TRANSIENT VIBRATION: Impulse and arbitrary excitation, base excitation, laplace transform formulation, response spectrum. (5)

RANDOM VIBRATION: Frequency response function, spectral density, probability distribution, correlation, fourier transform. (5)

NON-LINEAR VIBRATION: Phase plane, conservative systems, stability of equilibrium, method of isoclines, slope line numerical method, self excited oscillations. (5)

VIBRATION MEASUREMENT AND CONTROL: Measurement of vibration, 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. (7)

NOISE SOURCES AND CONTROL: Noise in centrifugal fans and blowers, gears, chain drives and bearings, reduction measures, machine enclosures, silencers and mufflers. (5)

Total L: 45

REFERENCES:

1. Thomson W T, "Theory of Vibration with Applications", Prentice Hall of India, 1997.
2. Singiresu S Rao "Mechanical Vibrations", Prentice Hall, 2010
3. Ashok Kumar Mallik, "Principles of Vibration Control", Affiliated East-West Press Pvt. Ltd, 1990.
4. Lewis H Bell, “Industrial Noise Control Fundamentals and Applications”, Marcel Dekkev Inc. 1993.
5. Tse Hinkle and Morse, "Mechanical Vibrations", OBS Publishers and Distributors, 1983.

15MD04 MECHANISMS AND ROBOT KINEMATICS

3 2 0 4

KINEMATIC ANALYSIS: Introduction, Kinematic analysis of complex mechanisms, Goodman analysis, auxiliary point method. (6)

DYNAMICS OF MECHANISMS: Introduction, inertia force in linkages, kinetostatic analysis by complex numbers, superposition and matrix methods, virtual work. (7)

KINEMATIC SYNTHESIS: Introduction, 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 centre point circles, ground pivot specification, Freudenstein's equation. (9)

CURVATURE THEORY: Inflection points and inflection circles, Euler-Savary equation, Bobillier's constructions, Hartmann's construction, the cubic of stationary curvature or Burmester's circle point and centre point curves for four infinitesimally close positions of the moving plane. (6)

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. (7)

PARALLEL KINEMATIC MACHINES (PKM) : Serial and parallel systems, need of PKM, configurations and characteristics, degrees of freedom, design principles, kinematic modeling (3)

ROBOTICS: Introduction, topology arrangements of robotic arms, forward kinematics, elementary treatment of inverse position analysis and inverse velocity and acceleration analysis, robot, actuator force analysis. (7)

Total L: 45 + T: 30 =75

REFERENCES:

1. Uicker G R, Pennock J J and Shigley J E, "Theory of Machines and Mechanisms", Oxford University Press, 2003.
2. Parviz E Nikravesh, "Computer Aided Analysis of Mechanical Systems", Prentice Hall International Inc., 1988.
3. Dan B Marghitu , "Mechanisms and Robots Analysis with MATLAB", Springer, 2009.
4. Asok Kumar Mallik, Amitabha Ghosh and Günter Dittrich, "Kinematic Analysis and Synthesis of Mechanisms", CRC Press, 1994.
5. Rao V Dukkipati, "Solving Engineering System Dynamics Problems with MATLAB", New Age International, 2007.

15MD05 MECHATRONICS SYSTEM DESIGN

3 2 0 4

INTRODUCTION TO MODELING AND SIMULATION: Definition, Key elements, Mechatronics approach for design process, Transfer functions, Frequency response of systems, Bode plot. Software and hardware in loop simulation. (5)

SENSORS, ACTUATORS & CONTROL VALVES: Sensors for motion and position measurement, proximity & range sensors, force sensors, torque sensors, temperature sensors, gyro sensors, magneto strictive actuators, Memory-metal actuators, Shape memory alloys. Selection of sensors for different applications. Pneumatic, hydraulic and electrical actuators - working principles, control valves – directions, pressure and flow proportional valves, control of servo valves. (15)

FLUIDIC SYSTEM DESIGN: Design of fluid power circuits – Cascade, KV-map and step counter method. PLC ladder logic diagram, programming of PLC, Fringe condition modules, Sizing of components in pneumatic and hydraulic Systems. Analysis of hydraulic circuits, fluidic muscles. (15)

REAL TIME INTERFACING: Introduction to data acquisition and control systems, overview of I/O process, virtual instrumentation, interfacing of various sensors and actuators with PC, Condition monitoring, adaptive control, SCADA systems. (5)

MECHATRONIC SYSTEMS: Microcontrollers and micro processors, embedded systems, Case studies of intelligent systems such as automated material handling, CNC machines, consumer mechatronic products. (5)

Total L: 45 + T: 30 =75

REFERENCES:

1. Devdas Shetty and Richard A Kolk, "Mechatronics System Design", PWS Publishing Company, USA, 1997
2. Ramesh S Gaonkar, "Microprocessor Architecture, Programming, and Applications with the 8085", Penram International, India, 2000.
3. Kenneth J Ayala, "8051 Microcontroller, Architecture, Programming and Applications" Penram International, India, 1996.
4. Anthony Espisito, "Fluid Power with Application", Prentice Hall, New Jersey, 2003.
5. Sanjay Gupta and Joseoh John, "Virtual Instrumentation using Lab VIEW", Tata McGraw Hill Publications Co. Ltd., 2005.

15MD51 VIBRATION AND NOISE ENGINEERING LABORATORY

0 0 4 2

1. Introduction to LabVIEW and Data Acquisition (DAQ) systems.
2. Determination of vibration response of a given structure using free and forced vibration test.
3. Determination of frequency response function (FRF) of a given structure using free vibration test
4. Determination of damping ratio of a given structure using piezoelectric patches/accelerometers.

5. Determination of the natural frequencies and the damping ratio of a given structure using sine sweep test and half power point method.
6. Determination of the quality factor (Q) of a given member for different boundary conditions.
7. Determination of vibration response of a balanced and unbalanced system.
8. Characterization of magneto rheological fluid damper for vibration control.
9. Determination of shock response of a system subjected to impact loading.
10. Determination of the standard deviation, mean and median of a specified input random vibration profile.
11. Sound level measurement using (a) Sound level meter and (b) Microphone and Labview software.

Total P: 45

15MD61 INDUSTRIAL VISIT & TECHNICAL SEMINAR

0 0 4 2

The student will be required to visit atleast two industries and observe the industry functions.

The student will be required to present at least two technical presentations during this course on current topics related to his or her specialization. The same will be assessed by a committee appointed by the department. The student is expected to submit atleast two reports based on the above guidelines.

Total L: 15 + P: 45 = 60

II SEMESTER

15MD06 INDUSTRIAL TRIBOLOGY

3 0 0 3

INTRODUCTION TO TRIBODESIGN: Specific principles, Tribological problems in machine design, Surface topography, Tribological processes: Contact process-contact mechanics, friction process-sliding and rolling friction, wear process-wear mechanisms, Stick-slip effects, Friction and wear test methods, Tribological materials. (5)

LUBRICATION: Purpose of lubrication, Basic modes of lubrication-Stribeck curve, hydrodynamic lubrication, Elastodynamic lubrication, Mixed lubrication, Boundary lubrication; Hydrostatic lubrication, Properties of lubricant, Additives, Choice of lubricant, oil, grease and solid lubricants, lubrication systems and their selection, oil conservation. (5)

SELECTION OF ROLLING ELEMENT BEARINGS: Nominal life, static and dynamic capacity, equivalent load, probabilities of survival - cubic mean load, Selection of ball and roller bearings, bearing mounting details, preloading of bearings. (4)

HYDRODYNAMIC BEARINGS: Fundamentals of fluid film formation, Mechanisms of pressure development in oil film, Reynold's equation, Hydrodynamic journal bearing-Sommerfeld number, bearing performance, temperature rise; Hydrodynamic thrust bearings - Raimondi and Boyd Method, fixed and tilting pads, single and multiple pad bearings, (6)

COMPUTATIONAL HYDRODYNAMICS: Finite difference equivalent of the Reynolds equation, Numerical analysis of hydrodynamic lubrication in idealized journal and partial arc bearings, Vibrational stability in journal bearings-determination of stiffness and damping coefficients (4)

HYDROSTATIC BEARINGS: Arrangement, advantages and limitations, Hydrostatic step bearing analysis-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. (6)

ELASTO-HYDRODYNAMIC LUBRICATION: Pressure-viscosity term in Reynold's Equation - Hertz theory- Ertel-Grubin Equation, lubrication of spheres, introduction to thermo-hydrodynamic lubrication. (5)

SURFACE ENGINEERING: Surface modifications - transformation hardening, surface fusion - thermo chemical processes - surface coatings - plating and anodizing - fusion processes - vapour phase processes. (5)

SEALS: Different types - mechanical seals, lip seals, packed glands, soft piston seals, mechanical piston rod packing, labyrinth seals and throttling bushes, oil flinger rings and drain grooves - selection of mechanical seals. (5)

Total L: 45

REFERENCES:

1. Neale M J,"Tribology Handbook", Neumann Butterworths, 1975.
2. Connor J J O and Boyd, "Standard Handboook of Lubrication Engineers", ASLE, McGraw Hill Book Co., 1966.
3. Basu S K, Sengupatha S N and Ahuja D B, "Fundamentals of Tribology", Prentice Hall of India Pvt. Ltd., 2005.
4. Hutchings I M, "Tribology-Friction and Wear of Engineering Material", Edward Arnold, London, 1992.
5. Phakatkar H G and Ghorpade R R, "Tribology", Nirali Prakashan, 2009.

15MD07 APPLIED ELASTICITY AND PLASTICITY

3 0 0 3

ANALYSIS OF STRESS AND STRAIN: Stress at a point, stress tensor, stress transformations, principal stresses, octahedral stress, equations of equilibrium, strain tensor, principal strains, strain-displacement relations, compatibility conditions, strain gages and rosettes (10+3)

CONSTITUTIVE EQUATIONS: General theory, generalized Hooke's law, equations of elasticity, formulation of the general elasticity problem, boundary conditions, two dimensional problems in rectangular and polar co-ordinates, Airy's stress function. (9+3)

MEMBRANE STRESSES: Membrane stresses in axisymmetric shells, meridonial stress and circumferential stress. (5+2)

CONTACT STRESSES: Introduction, geometry of contact surfaces, notation and meaning of terms, expressions for principal stresses, method of computing contact stresses – Hertzian, JKR, DMT models. (5+2)

PLASTICITY: Plastic flow and its microscopic and macroscopic descriptions, stress-strain curves of real materials, definition of yield criterion, concept of a yield surface in principal stress space, Yield criteria - Tresca - von Mises. (6+2)

PLASTIC STRAIN ANALYSIS: Prandtl-Reuss and Levy-Mises equations, deformation in plane stress-yielding of thin sheet in biaxial and uniaxial tension. Plane strain deformation-stress tensor, hydrostatic and deviatoric components, plastic potential, plastic instability, effect of strain rates and temperature effects on flow stress. Introduction to slip line theory. (10+3)

Total L: 45 + T: 15 = 60

REFERENCES:

1. Timoshenko S P and Goodier J N, "Theory of Elasticity", McGraw Hill International Editions, 1970.
2. Chakrabarthy J, "Theory of Plasticity", McGraw Hill Co, 1987.
3. Durelli A J, Phillips E A and Tsao C H, "Introduction to the Theoretical and Experimental Analysis of Stress and Strain", McGraw Hill, New York, 1958.
4. Dieter G E, "Mechanical Metallurgy", McGraw Hill, 1988.
5. Sokolnikoff I S, "Mathematical Theory of Elasticity", McGraw Hill International Editions, 1956.

15MD08 ADVANCED FINITE ELEMENT ANALYSIS

3 0 0 3

INTRODUCTION: Historical background, Concept of finite element method, boundary, initial and eigen value problems, Finite element formulation starting from governing differential equations – Weighted residual method, Finite element formulation based on stationary of a functional. Review of static analysis using 1D elements (8+3)

STATIC ANALYSIS USING 2D AND 3D ELEMENTS: Triangular and quadrilateral elements, Isoparametric formulation, problems using 2D elements, shape functions for axisymmetric and 3D elements, shape functions for higher order elements. Introduction to plates and shells (9+3)

DYNAMIC ANALYSIS: Equations of motion for dynamic problems. Consistent and lumped mass matrices. Formulation of element mass matrices. Free vibration problem formulation, Solution of Eigen value problems using 1D elements, Time dependent one-dimensional bar analysis (8+3)

HEAT TRANSFER ANALYSIS: Basic differential equations of heat transfer, one dimensional and two dimensional finite element formulation using variational method and Galerkin's method, one dimensional steady state heat transfer problems involving conduction and convection. Analysis of tapered fin, Formulation of thermal stress problems and examples, transient thermal analysis (10+3)

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, Geometric non-linearity-Basic continuum mechanics concepts, Governing differential equations and weak forms, Introduction to contact problems. (10+3)

Total L: 45 + T: 15 = 60

REFERENCES:

1. Chandrupatla T R and Belegundu A D, "Introduction to Finite Elements in Engineering", Pearson Education, New Delhi, 2007.
2. Logan D L, "A First Course in the Finite Element Method", Thomson Learning, 2007.
3. Rao S S, "The Finite Element Method in Engineering", Elsevier, 2005.
4. Rajasekaran S, "Finite Element Analysis in Engineering Design", S Chand, 2008.
5. Seshu P, "A Text book on Finite Element Analysis", Prentice Hall of India, New Delhi, 2003.

15MD09 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. (6)

MATERIAL SELECTION FOR SUSTAINABILITY: Material life cycle assessment and energy – selecting materials for eco design (2)

FRACTURE MECHANICS: Ductile fracture, brittle fracture, cleavage-fractography, ductile-brittle transition, fracture mechanics approach to design-energy criterion, stress intensity approach, time dependent crack growth and damage. (3)

LINEAR ELASTIC FRACTURE MECHANICS: Griffith theory, energy release rate, Instability and R-curve, stress analysis of cracks-stress intensity factor, K-threshold, Crack growth instability analysis, crack tip stress analysis. (6)

ELASTIC PLASTIC FRACTURE MECHANICS: Crack tip opening displacement (CTOD), J-integral, relationship between J and CTOD. (5)

DYNAMIC AND TIME-DEPENDENT FRACTURE: Dynamic fracture, rapid loading of a stationary crack, rapid crack propagation, dynamic contour integral, creep crack growth-C Integral, visco elastic fracture mechanics, viscoelastic J integral . (6)

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. (6)

WEAR FAILURES AND ELEVATED TEMPERATURE FAILURES: Types of wear, different methods of wear measurement, analysis wear failures, wear at elevated temperatures, wear on different materials, role of friction on wear, stick slip friction, creep, stress rupture, elevated temperature fatigue, metallurgical instabilities, environmental induced failure. (4)

FAILURE ANALYSIS TOOLS: Reliability concept and hazard function, life prediction, life extension, application of poisson, exponential and Weibull distribution for reliability, bath tub curve, parallel and series system, MTBF,MTTR, FMEA definition-Design FMEA, process FMEA, analysis causes of failure, modes, ranks of failure modes, fault tree analysis, microscopic failure analysis, industrial case studies / Projects on FMEA. (7)

Total L: 45

REFERENCES:

1. Anderson T L, “Fracture Mechanics: Fundamentals and Applications”, Taylor and Francis, 2005.
2. ASM Metals Handbook, "Failure Analysis and Prevention", ASM Metals Park, Ohio, USA, Vol. 10, 1995.
3. Michael F Ashby, “Materials Selection in Mechanical Design”, Butterworth – Heinemann, 2005.
4. Michael F Ashby, Hugh Shercliff and David Cebon, “Materials – Engineering, Science, Processing and Design”, Butterworth – Heinemann, 2007.
5. Shigley and Mische, "Mechanical Engineering Design", McGraw Hill, 1992.

15MD10 DESIGN FOR MANUFACTURE AND ASSEMBLY

3 2 0 4

PROCESS CAPABILITY AND TOLERANCES: Geometric tolerances: applications, 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. Process capability, mean, process capability metrics, Cp, Cpk, cost aspects. Tolerances: Limits and Fits, tolerance Chains and identification of functionally important dimensions, Statistical tolerance indication in mechanical drawings population parameter zone in the μ, σ plane defined using C_p, C_{pk}. (4+1)

TOLERANCE STACK UP ANALYSIS: Dimensional chain analysis-equivalent tolerances method, equivalent standard tolerance grade method, equivalent influence method. (3)

SELECTIVE ASSEMBLY: Interchangeable part manufacture and selective assembly. Deciding the number of groups- Model-I: Group tolerances of mating parts equal; Model-II: total and group tolerances of shaft equal. Control of axial play - introducing secondary machining operations, laminated shims, selective assembly, examples. (5+2)

DATUM SYSTEMS AND FIXTURE DESIGN: Degrees of freedom, grouped datum systems - different types, two and three mutually perpendicular grouped datum planes; Grouped datum system with spigot and recess, pin and hole; Grouped datum system with spigot and recess pair and tongue - slot pair - computation of translational and rotational accuracy, geometric analysis and applications. (4)

TRUE POSITION THEORY: Comparison between co-ordinate and convention 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. (6+2)

FUNCTIONAL INSPECTION TECHNIQUES: Functional inspection techniques using CMM, optical comparators and paper layout gauging, gauge repeatability and reproducibility (GR & R) calculations. (2)

FORM DESIGN OF CASTINGS, WELDMENTS AND SHEET METAL COMPONENTS: Redesign of castings based on parting line considerations, minimising core requirements, redesigning cast members using weldments, form design aspects of sheet metal components. (6+2)

TOLERANCE CHARTING TECHNIQUE: Operation sequence for typical shaft type of components. Preparation of process drawings for different operations, tolerance worksheets and centrality analysis, examples. (6+2)

REDESIGN FOR MANUFACTURE: Design features to facilitate machining: datum features - functional and manufacturing. Component design - machining considerations, redesign for manufacture, examples. (4)

DESIGN FOR THE ENVIRONMENT: Introduction-environmental objectives-global issues-regional and local issues-basic DFE methods-design guidelines-example application. (1)

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; design for manual assembly; design for automatic assembly; computer-aided design for assembly using software. (4+1)

Total L: 45 + T: 30 = 75

REFERENCES:

1. Harry Peck, "Designing for Manufacture", Pitman Publications, 1983.
2. Matousek, "Engineering Design - A Systematic Approach", Blackie and Son Ltd., London, 1974.
3. Spotts M F, "Dimensioning and Tolerance for Quantity Production", Prentice Hall Inc., 1983.
4. Oliver R Wade, "Tolerance Control in Design and Manufacturing" Industrial Press Inc., New York, 1967.
5. Boothroyd G, Dewhurst P and Knight W, “Product Design for Manufacture and Assembly”, Marcell Dekker.

15MD52 COMPUTER AIDED ENGINEERING LABORATORY

0 0 2 1

1. Part modeling, assembly modeling and drafting
2. Static analysis using 1D/2D elements using FEA software.
3. Static analysis of typical industrial components using 3D elements.
4. Dynamic analysis of mechanical systems
5. Steady state thermal analysis of engine/compressor parts
6. Transient thermal analysis of elements such as fins, engine parts, electronic parts, etc.
7. Thermo mechanical analysis of component such as spindle, brake, etc.
8. Estimation of fatigue life of mechanical/automotive components
9. Static structural analysis of composite parts
10. Analysis of internal and external fluid flow (pipes, ducts, aerofoil etc) using CFD software
11. Solution to problems involving plates and shells using MATHEMATICAL MODELING SOFTWARE.
12. FEA for sustainable design using Autodesk Inventor

Total P: 45

III SEMESTER

15MD53 SENSOR INTERFACE AND ROBOTICS LABORATORY

0 0 4 2

1. Development of strain gauge set up to measure strain in a statically loaded machine structure and calibration of the same.
2. Measurement of damping ratio of a machine tool base from free vibration studies using an impact hammer and an accelerometer pick up with data acquisition system.
3. Interfacing of Proportional flow control valve (PFCV) & hot wire anemometer with data acquisition system to measure the air flow rate and calibration of the same.
4. Interfacing a stepper motor with PC for controlling speed, direction and number of steps using Virtual instrumentation platform.
5. Co-ordinated motion of multiple actuator, electro – pneumatic systems in a desired sequence using Virtual instrumentation platform.
6. Development of an intelligent conveyor system to sort metallic & non-metallic components
7. Development of a pick and place robot
8. Development of an obstacle avoidance robot
9. Development of a path following robot
10. Determining the response time of a control system using PI and PID controllers
11. Determining the positioning accuracy of a linear slide using open loop and closed loop controls

12. Development of embedded system using RIO cards

Total P: 60

15MD71 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
- Finalisation 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

IV SEMESTER

15MD72 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

ELECTIVE THEORY COURSES

(Six to be opted-out of which two may be an open elective from other M.E/M.Tech programmes)

15MD21 DESIGN OF MECHANICAL DRIVES

3 0 0 3

INTRODUCTION: To Power Transmission systems: General considerations, principal types, comparative study of different drives, applications, limitations. (5)

DESIGN OF SPEED DRIVES: Design of spur, helical, bevel and worm gears; Design of speed gear boxes for machine tool and automotive applications, standardization of spindle speeds, speed diagrams, selection of bearings, design of housings, lubrication considerations, selection of servo and stepper motors, timing belts. (14)

DESIGN OF FEED DRIVES: Requirements, types, feed drive using feed boxes, design of power screws, lead screws, selection of recirculating ball screws, LM guide ways, rotary indexing drives, cam drives, applications, feeding mechanisms in automated plants, pneumatic feed units, Principles. (12)

DESIGN OF FRICTION DRIVES: Partial friction drives, couplings, clutches, toothed clutches, unidirectional clutches, safety clutches, drum, disk brakes, design principles. (9)

VARIABLE SPEED DRIVES: Need, different types, applications. (5)

LABORATORY COMPONENT:

1. Design of feeding mechanisms for automation
2. Design of headstock for PSG 141 lathe
3. Design of cam drive for automate
4. Selection of timing belt for a CNC machine

Total L: 45

REFERENCES:

1. Maitra G M, “Hand Book of Gear Design”, Tata McGraw Hill, 1994.
2. Shigley, “Mechanical Engineering Design”, McGraw Hill, 2010.
3. Faculty of Mechanical Engineering, PSG College of Technology, “Design Data Book ", DPV Printers, 1993.
4. Reshetov N, “Machine Design”, MIR Publishers, 1982.
5. HMT, “Mechatronics”, Tata McGraw Hill, 1998.

15MD22 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. (6)

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. (5)

CONTROL SYSTEMS AND COMPONENTS: Linear approximation of non-linear systems, stepper motors, hydraulic systems, pneumatic systems . (6)

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, robotic control systems, state variable analysis, approximation of higher-order systems by lower order systems, concept of stability, necessary conditions, Routh stability criterion, relative stability analysis . (8)

FREQUENCY RESPONSE ANALYSIS AND STABILITY IN FREQUENCY DOMAIN: Correlation between time and frequency response, polar plots, bode plots, all-pass 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. (8)

INTRODUCTION TO DESIGN: Preliminary considerations, realization of basic compensators, cascade compensation in time domain and frequency domain, feedback compensation, robust control system design. (5)

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. (7)

Total L: 45

REFERENCES:
1. Nagrath I J and Gopal M, “Control Systems Engineering”, New Age International Publishers, 2005.
2. Okata K, “Modern Control Engineering”, Pearson/Prentice Hall of India Pvt. Ltd., New Delhi, 1997.
3. Gopal M, "Control Systems – Principles and Design", Tata McGraw Hill Co. Ltd., 2002.
4. Norman S Nise, “Control System Engineering”, John Wiley and Sons Inc., 2001.
5. Sergey Edward Lyshevski, “Control Systems – Theory with Engineering Applications”, Springer-Verlag, New York Inc., 2002.

15MD23 MECHANICAL SYSTEM DESIGN

3 0 0 3

INTRODUCTION: The design process, morphology of design, statistical consideration in design- frequency distribution-histogram and frequency polygon – normal distribution – units of measurement of central tendency and dispersion, statistical analysis of tolerances. (9+3)

OPTIMUM DESIGN: Objectives of optimum design, optimum design with normal specifications of simple machine elements like tension bar, transmission shaft, helical spring, design space exploration-design of experiments, introduction to robust design, probabilistic methods in mechanical design. (9+3)

ADVANCED MACHINE DESIGN: Design of machine elements under shock, impact, inertial forces, initial and residual stresses, corrosion environments, wear, elevated temperatures and low temperatures. Design of bolted and bonded joints. (9+3)

DESIGN AND ANALYSIS OF STRUCTURES: Design of box type structures, design of weldments, design of curved beams-stress distribution in curved beams, design of stiffeners . (8+3)

DESIGN OF COMPOSITE STRUCTURES: Classification of composites, micro mechanical behavior of lamina-evaluation of elastic modulus and strength of unidirectional lamina, macro mechanical behavior of lamina, stress-strain relation for a lamina at arbitrary orientation, macro mechanical behavior of laminate. (10+3)

Total L: 45 + T: 15 = 60

REFERENCES:
1. Franklin E Fisher, “Probability Application in Mechanical Design”, CRC Press, 2000.
2. Omer W Blodgett and James F Lincoln, “Design of Weldments”, James F. Lincoln Arc Welding Foundation, 1963.
3. Patil S P, “Mechanical System Design” Jaico Publishing House, 2005.
4. Rao S S, “Engineering Design Optimization-Theory and Practices”, New Age International, 2000.
5. Autar K Kaw, "Mechanics of Composite Materials", CRC Press, NY, 2005.

15MD24 MECHANICS OF COMPOSITES AND SMART MATERIALS

3 0 0 3

INTRODUCTION: Modern materials in design, types, metals, polymers, ceramics, composites, Classification of composites, advantages, applications and limitations, Matrix and reinforcement-their roles, principal types of fibre and matrix materials. (6)

MANUFACTURE OF COMPOSITE COMPONENTS: Lay up and curing, open and closed mould processes, bag moulding, filament winding, pultrusion, pulforming, thermoforming, injection moulding, blow moulding,an overview of metal matrix composite processing and ceramic matrix composite processing. (6)

MICRO MECHANICAL BEHAVIOUR OF A LAMINA: Volume and mass fractions, evaluation of elastic moduli, strength of unidirectional lamina. (7)

MACRO MECHANICAL BEHAVIOUR OF A LAMINA: Hooke's law for different types of materials, engineering constants for orthotropic materials. Stress, strain relations for plane stress in an orthotropic materials and in a lamina of arbitrary orientation, strength of an orthotropic lamina, basic strength theories. (7)

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. (7)

ANALYSIS OF COMPOSITE STRUCTURES: Fatigue, Fracture mechanics-basic principles, fracture initiation, crack growth and crack growth modes, toughening mechanisms, Environmental effects, Composite joints-bonded, bolted and bonded-bolted joints. (6)

SMART MATERIALS: Rheological, piezoelectric, shape-memory and magnetostrictive materials. Material characteristics of smart materials. Application of smart materials for design of intelligent structures. (6)

Total L: 45

REFERENCES:
1. Autar K Kaw, "Mechanics of Composite Materials", CRC Press, NY, 2006.
2. Matthews F L and Rawlings R D, “Composite Materials: Engineering and Science”, Woodhead Publishing, 1999.
3. Srinivasan A V and Michael McFarland, “Smart Structures: Analysis and Design”, Cambridge University Press, UK, 2001.

4. Ronald F Gibson, “Principles of Composite Material Mechanics", McGraw Hill Book Co, 2007.
5. Robert M Jones, "Mechanics of Composite Materials", Taylor and Francis, 1999.

15MD25 GEOMETRIC MODELING

3 0 0 3

OVERVIEW OF CAD SYSTEMS AND GRAPHICS TRANSFORMATIONS: Conventional and computer aided design processes, subsystems of CAD-CAD 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 and synthetic), curve manipulation, surface models, types of surfaces, introduction to parametric representation of surfaces, design examples. (9)

MATHEMATICAL REPRESENTATION OF SOLIDS: Fundamentals of solid modeling, boundary representation, constructive solid geometry, solid manipulations, solid modeling based applications. (8)

VISUAL REALISM AND COMPUTER ANIMATION: Model cleanup, hidden line removal, shading, computer animation, animation systems, design applications. (8)

MASS PROPERTY CALCULATIONS: Introduction, geometrical property formulation, mass property formulation, design and engineering applications. (8)

Total L: 45

REFERENCES:

1. Ibrahim Zeid, "CAD/CAM Theory and Practice", McGraw Hill Inc., New Delhi, 2003.
2. Radhakrishnan P, Subramanyan S and Raju V, “CAD/CAM/CIM”, New Age Internationals, 2012.
3. Radhakrishnan P and Kothandaraman C P, "Computer Graphics and Design", Dhanpat Rai and Sons, 1997.
4. Radhakrishnan P, “Computer Numerical Control Machines and Computer Aided Manufacture”, New Age International (P) Ltd, New Delhi, 2012.
5. Michael E Mortenson, "Geometric Modeling", John Wiley and Sons Inc., 1997.

15MD26 PRODUCT DEVELOPMENT AND REVERSE ENGINEERING

3 0 0 3

INTRODUCTION: Product design, importance of product design, considerations of a good design, phases of design process, challenges of product development, use if IT in product design, concept of CPC, PDM/PLM. (6)

PRODUCT DESIGN APPROACHES AND REVERSE ENGINEERING: Product development versus design, types of design and redesign, quality function deployment, axiomatic design, failure mode and effect analysis concurrent engineering, reverse engineering, scanning methods for reverse engineering, cloud points, NURBS surfaces, reengineering, tear down approach, bench marking. (9)

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/6-3-5 method, morphological analysis. Concept selection, technical feasibility, ranking, measurement theory. (9)

MATERIAL 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, (9)

RAPID PROTOTYPING: Prototype basics, principles of prototyping, prototyping technologies, concepts of virtual prototyping. (6)

INTELLECTUAL PROPERTY AND PRODUCT DEVELOPMENT ECONOMICS: Intellectual property, steps in patenting, elements of economic analysis, economic analysis; process. (6)

Total L: 45

REFERENCES:

1. Kevin Otto and Kristin Wood, “Product Design”, Pearson, 2001.
2. Chitale A K and Gupta R C, “Product Design and Manufacturing”, Prentice Hall of India, 2005.
3. Michael Grieves, “Product Life Cycle Management”, Tata McGraw Hill, 2006.
4. Nigel Cross, “Engineering Design Methods: Strategies for Product Design”, John Wiley and Sons, 2000.
5. Karl T Ulrich and Steven D Eppinger, “Product Design and Development”, Tata McGraw Hill, 2004.

15MD27 DESIGN OF AUTOMOTIVE SYSTEMS

3 0 0 3

INTRODUCTION : Fundamentals of designing automobiles, general layout of the automobile, types of chassis layout, various types of frames, constructional details, materials, unitized frame body construction. (8)

DESIGN OF ENGINE COMPONENTS: Choice of material for various engine components, design of cylinder, design of piston assembly, design of connecting rod, design of crankshaft under bending and twisting, balancing weight calculations, design of valves, valve springs and design of flywheel. (5)

DESIGN OF CLUTCH & BRAKES:

CLUTCHES: Introduction-design diagrams of clutch, calculation of critical parameters of clutches, design calculation of standard elements of friction clutches. (5)

BRAKES: Pressure distribution along shoe length, determining braking torque, design of drum brakes-internally expanding brakes, design of disc brakes. (9)

DESIGN OF TRANSMISSION SYSTEMS: Determining main parameters of transmission, differential, axle shafts, gear box, design of universal joint and propeller shaft, location determination of universal joint and propeller shaft. (6)

SUSPENSION AND STEERING SYSTEM: Oscillation and smoothness of ride, fundamentals of designing and calculating steering control linkage, steering gears, hydraulic booster. (6)

AUTOMOTIVE ELECTRONICS: Sensors in automobiles, engine management system. (2)

ENGINE ARCHITECTURE: Selection of engine pump design, Hydraulic unit – master cylinder, fluid reservoir, valves and actuators, Air conditioning and Radiator system in automobile. (4)

Total L: 45

REFERENCES:

1. Lukin P, Gasparyants G and Rodionov V, “Automobile Chassis Design and Calculations”, Mir Publishers, Moscow, 1989.
2. Heinz Heisier, “Vehicle and Engine Technology”, SAE, New York, 1999.
3. Gillespie T D, “Fundamentals of Vehicle Dynamics”, SAE Inc., New York, 1992.
4. Schwaller A E, “Motor Automotive Technology”, Delman Publishers, New York.
5. Steed W, “Mechanics of Road Vehicles”- Illiffe Books Ltd., London- 1960.

15MD28 DESIGN AND ANALYSIS OF THERMAL SYSTEMS

3 0 0 3

INTRODUCTION: Design Principles, workable systems, optimal systems, matching of system components, economic analysis, depreciation, gradient present worth factor. (6)

MATHEMATICAL MODELLING: Equation fitting, nomography, empirical equation, regression analysis, different modes of mathematical models, selection, computer programmes for models. (6)

MODELLING THERMAL EQUIPMENTS: Modeling heat exchangers, evaporators, condensers, absorption and rectification columns, compressor, pumps, simulation studies, information flow diagram, solution procedures. (12)

SYSTEMS OPTIMIZATION: Objective function formulation, constraint equations, mathematical formulation, Calculus method, dynamic programming, geometric programming, linear programming methods, solution procedures. (15)

DYNAMIC BEHAVIOUR OF THERMAL SYSTEM: Steady state simulation, laplace transformation, feedback control loops, stability analysis, non-linearities. (6)

Total L: 45

REFERENCES:

1. Stoecker W F, “Design of Thermal Systems”, McGraw Hill, 1980.
2. Kapur J N, “Mathematical Modeling”, Wiley Eastern Ltd., New York, 1989.
3. Stoecker W F, “Refrigeration and Air-conditioning”, TMH, 1985.
4. Fanger P O, “Thermal Comfort”, McGraw Hill, USA 1972.
5. McQuiston F C and Parker T D, “Heating, Ventilating and Air conditioning, Analysis and Design”, John Wiley and Sons, USA.

15MD29 BIOMECHANICS OF TISSUES AND JOINTS

3 0 0 3

INTRODUCTION OF MECHANICS: Review of the principles of mechanics, Vector mechanics- Resultant forces of Coplanar & Non-coplanar and Concurrent & non-concurrent forces, parallel force in space, Equilibrium of coplanar forces, Newton's laws of motion, Work and energy, Moment of inertia. (9)

HARD TISSUE MECHANICS: Bone structure & composition, mechanical properties of bone, cortical and cancellous bones, viscoelastic properties, Maxwell & Voight models- anisotropy, Electrical properties of bone, fracture mechanisms. (8)

SOFT TISSUE MECHANICS: Pseudo elasticity, nonlinear stress-strain relationship, Viscosity, Structure, Function and mechanical properties of skin, ligaments and tendons. (8)

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 knee, mechanics of ankle. **(**10)

LOCOMOTION: Human locomotion, gait analysis and goniometry, Ergonomics, Foot Pressure measurements – Pedobarograph, Force platform, mechanics of foot. Total Hip Prosthesis: requirements, different types of components, Stress analysis & instrumentation, Knee Prosthesis. (10)

Total L: 45

REFERENCES:

1. Nihat Ozkaya and Margareta Nordin, "Fundamentals of Biomechanics: Equilibrium, Motion, and Deformation", Springer- Verlag; 1999.
2. Susan J Hall, "Basic Biomechanics", McGraw Hill, Columbus- OH, 1995.
3. Fung Y C, "Biomechanics: Mechanical Properties of Living Tissues", Springer-Verlag, 1993.
4. Author T Johnson, "Biomechanics & Exercise Physiology", John Wiley & Sons, NY, 1991.
5. Ghista D N, "Biomechanics of Medical Devices", Macel Dekker, 1982.

15MD30 MICRO ELECTRO MECHANICAL SYSTEMS

3 0 0 3

MEMS AND MICROSYSTEMS: MEMS and microsystem products. Evaluation of microfabrication. Microsystems and microelectronics. Applications of microsystems. Working principles of microsystems-microsensors, microactuators, MEMS and microactuators, microaccelerometers (5)

SCALING LAWS IN MINIATURIZATION: Introduction. Scaling in geometry. Scaling in rigid body dynamics. The trimmer force scaling vector-scaling in electrostatic forces, electromagnetic forces, scaling in electricity and fluidic dynamics, scaling in heat conducting and heat convection. (5)

MATERIALS FOR MEMS AND MICROSYSTEMS: Substrates and wafers-silicon as a substrate material, ideal substrates for MEMS. Single crystal Silicon and wafers crystal structure. Mechanical properties of Si. Silicon compounds-SiO2, SiC, Si3N4 and polycrystalline Silicon. Silicon piezoresistors. Gallium arsenside. Quartz-piezoelectric crystals. Polymers for MEMS. Conductive polymers. (8)

ENGINEERING MECHANICS FOR MICROSYSTEMS DESIGN: Introduction. Static bending of thin plates-circular plates with edge fixed, rectangular plate with all edges fixed and square plates with all edges fixed. Mechanical vibration. Resonant vibration. Microaccelerometers-design theory and damping coefficients. Thermomechanics. Thermal stresses. Fracture mechanics-stress intensity factors, fracture toughness and interfacial fracture mechanics. (6)

BASICS OF FLUID MECHANICS IN MACRO AND MESO SCALES: Viscosity of fluids-flow patterns, reynolds number. Basic equation in continuum fluid dynamics. Laminar fluid flow in circular conduits. Computational fluid dynamics. Incompressible fluid flow in microconducts-surface tension, capillary effect and micropumping. Fluid flow in submicrometer and nanoscale-rarefied gas, Kundsen and Mach number and modelling of microgas flow. Heat conduction in multilayered thin films. Heat conduction in solids in submicrometer scale. Thermal conductivity of thin films, heat conduction equation for thin films. (6)

MICROSYSTEM FABRICATION PROCESS: Photolithography. Photoresist and applications. Light sources. Ion implanation. Diffusion process. Oxidation-thermal oxidation. Silicon diode. Thermal oxidation rates. Oxide thickness by colour. Chemical vapour deposition-principle, reactants in CVD. Enhanced CVD physical vapour deposition. Sputtering. Deposition by epitaxy. Etching-chemcial and plasma etching. (7)

MICROMANUFACTURING AND MICROSYSTEM PACKAGING: Bulk micromachining. Isotropic and anisotropic etching-wet etchants, etch stops, dry etching comparison of wet and dry etching. Surface micromachining-process in general, problems associated in surface micromachining. The LIGA process-description, materials for substrates and photoresists, electroplating, the SLIGA process. Microsystem packaging-general considerations. The three levels of microsystem packaging-die level, device level and system level. Essential packaging technologies-die preparation-surface bonding, wire bonding and sealing. Three dimensional packaging. Assembly of microsytems-selection of packaging materials. (8)

Total L: 45

REFERENCES:
1. Tai-Ran Hsu, "MEMS and Microsystems Design and Manufacture", Tata McGraw Hill Publishing Co. Ltd., New Delhi, 2002.
2. Mark Madou, "Fundamentals of Microfabrication", CRC Press, New York, 1997.
3. Julian W Gardner, "Microsensors: Principles and Applications", John Wiley and Sons, New York, 2001.
4. Sze S M, "Semiconductor Sensors", McGraw Hill, New York, 1994.
5. Chang C Y and Sze S M, "VLSI Technology", McGraw Hill, New York, 2000.

15MD31 NANOMATERIALS AND NANOTECHNOLOGY

3 0 0 3

ZERO – DIMENSIONAL NANOSTRUCTURES: Nanoparticles through homogenous nucleation, nanoparticles through the heterogeneous nucleation, kinetically confined synthesis of nanoparticles, epitaxial core – shell nanoparticles. (5)

ONE DIMENSIONAL NANOSTRUCTURE- NANOWIRES AND NANORODS: Spontaneous growth, template based synthesis, electro spinning, and lithography. (5)

TWO-DIMENSIONAL NANOSTRUCTURES-THIN FILMS: Fundamentals of film growth, vacuum science, physical vapor deposition(PVD), Chemical Vapor Deposition(CVD), Atomic Layer Deposition (ALD), Electrochemical Deposition, Sol-Gel films. (6)

NANOSTRUCTURES FABRICAITON: Lithography, nano manipulation and nanolithography, soft lithography, assembly of nanoparticels and nanowires, other methods of micro fabrication. (5)

NANOMECHANICS: A high speed review of motion: Displacement, velocity, acceleration and force, nano mechanical oscillation, feeling faint forces. (6)

NANO ELECTRONICS: Electron energy bands, electrons in solids: conductors, insulation and semi conductors, fermi energy, the density of states for solids, quantum confinement, tunneling, single electron phenomenon, molecular electronics. (5)

NANOSCALE HEAT TRANSFER: Nanoscale heat, conduction, convection, radiation. (4)

NANOPHOTONICS: Photonics properties of nanomaterials, near-field light, optical tweezers, photonic crystals. (4)

NANOSCALE FLUID MECHANICS: Fluids at the nanoscale: major concepts, flow fluids flow at the nanoscale, applications of nanofludics. (5)

Total L: 45

REFERENCES:
1. Rogers, Pennathur and Adams, "Nanotechnology: Understanding Small System", CRC Press, 2008.
2. Guozhong Cao, "Nanostructures and Nanomaterials", Imperial College Press, 2006.

15MD32 PRODUCTION TOOL DESIGN

3 0 0 3

INTRODUCTION: Tool engineering and role of tool engineer in design and manufacturing of products. (1)

DESIGN OF CUTTING TOOLS: Cutting tool materials, properties, classification, selection, tool wear, tool life. Single point tools: nomenclature , types and styles, design and manufacture of tools in HSS and carbides, tools for turning, boring, shaping, planning and slotting operations, form tools, tools and holders for CNC applications. Multipoint cutters, nomenclature, classification and selection, construction methods, design and manufacture of drills, reamers, taps, dies, thread chassers, milling cutters, broachers, hobs and gear shaping cutters. (10)

DRILL JIGS: Design of drill jigs and fixtures for conventional, SPM and CNC machining centers, jig bushes, quick change tool holders, calculation of drilling forces, dowel and diamond pin locations, different type of jigs, true position theory and material conditions, process capabilities in drilling, modular concepts, chip disposal. (5)

FIXTURES: Estimation of milling forces, deformation of the component under clamping forces using CAE, clamping methods-pneumatic and hydraulic systems, variable clamping force vices, hydraulic work supports, swing clamps, poke-yoke, chip disposal, tool setting gauges, modular fixturing. Turning fixtures, fixtures for surface, cylindrical and internal grinding machines, vacuum chucks, chucks for grinding bearing races, fixtures for silicon wafer processing. Fixtures for inspection, assembly, welding and heat treatment. Gauge design principles. (6)

DESIGN OF PRESS TOOLS: Study of CNC shearing, press brake, mechanical and hydraulic power presses, accessories for power presses-coiler and de-coiler, straightening, feed units, fundamentals of blanking and piercing, tool clearances, estimation of tonnage, centre of pressure, standard die sets, design of simple and compound tools, design of progressive tools with manual and auto feed, die materials, Single minute exchange of dies(SMED), deep drawing and forming tools, analysis of forming using CAE, use of CNC wire cutting and spark erosion in manufacturing of tools. (9)

DESIGN OF PLASTIC MOLDING DIES: Plastic materials, shrinkage, two and three plate mold design, standard mold plates, parting line, core and cavity generation in CAD, runner and gate design, mold cooling, ejection methods, tool materials, runner less molds, microstructure injection molding for MEMs, multi color injection molding, mold flow analysis using CAE, introduction to thermo setting dies, texturing. (9)

DESIGN OF MISCELLANEOUS DIES: Blow molding and extrusion dies for plastic, forging dies, pressure die casting dies, powder metallurgy dies, rubber molding dies. (5)

Total L: 45

REFERENCES:

1. Joshi P H, “Jigs and Fixtures”, Tata McGraw Hill, 1988.
2. Kempster M H A, “An Introduction to Jig and Tool Design”, Viva Books Pvt. Ltd, 1998.
3. Ostergaurd D E, “Basic Die Making”, McGraw Hill, 1963.
4. Pye R C W, “Injection Mold Design”, East West Press, 2000.
5. Grant H E, "Non Standard Clamping Devices", Tata McGraw Hill, 2001.

15MD33 INDUSTRIAL DESIGN

3 0 0 3

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. (6)

INFORMATION INPUT: Input and processing, text, graphics, symbols, codes, visual display of dynamic information, auditory, tactual, olfactory displays, speech communications. (6)

HUMAN OUTPUT AND CONTROL: Physical work, manual material handling, motor skill, human control of systems, controls and data entry devices, hand tools and devices. (6)

WORKPLACE DESIGN: Applied anthropometry, workspace design and seating, 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. (6)

ENVIRONMENTAL CONDITIONS: Illumination, climate, temperature, noise, motion, sound, vibration. (5)

BIOMECHANICS : Biostatic mechanics, statics of rigid bodies, upper extremity of hand, lower extremity and foot, bending, lifting and carrying, biodynamic mechanics, human body kinematics, kinetics, impact and collision. (6)

BIOTHERMODYNAMICS AND BIOENERGITICS: Biothermal fundamentals, human operator heat transfer, human system bioenergetics, thermoregulatory physiology, human operator thermo regularity, passive operator, active operator, heat stress. (5)

HUMAN FACTORS APPLICATIONS: Human error, accidents, human factors and the automobile, organizational and social aspects, steps according to ISO/DIS6385, OSHA’s approach, virtual environments. (5)

Total L: 45

REFERENCES:

1. Chandler Allen Phillips, “Human Factors Engineering”, John Wiley and Sons, New York, 2000.
2. Mark S Sanders, “Human Factors in Engineering and Design”, McGraw Hill, New York, 1993.
3. Bridger R S, “Introduction to Ergonomics”, Taylor and Francis, London, 2003.

15MD34 ROTOR DYNAMICS

3 0 0 3

INTRODUCTION: Co-ordinate systems, steady state rotor motion, elliptical motion, single degree of freedom systems, free and forced vibrations, total motion. (5)

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. (8)

TORSIONAL VIBRATION IN ROTATING MACHINERY: Modeling of rotating machinery shafting multi degree of freedom systems. Determination of natural frequencies and mode shapes Branched systems Holzer method. (8)

RIGID ROTOR DYNAMICS: Rigid disk equation rigid rotor dynamics rigid rotor on flexible rotor. (6)

BENDING CRITICAL SPEEDS OF SIMPLE SHAFTS: Whirling of an unbalanced simple elastic rotor, simple shafts with several

disks, effect of axial stiffness, determination of bending critical speeds. (7)

BALANCING OF ROTORS: Single plane balancing, multi-plane balancing, balancing of rigid rotors, balancing of flexible rotors (6)

CONDITION MONITORING: Noise spectrum, real time analysis, knowledge based expert systems. (5)

Total L: 45

REFERENCES:

1. Rao J S, "Rotor Dynamics", New Age International Publishers, New Delhi, 2004.
2. Timoshenko S, Young D H and Weaver W, "Vibration Problems in Engineering", John Wiley, 1974.
3. Weng Jeng Chen and Edger J Gunter, "Introduction to Dynamics of Rotor – Bearing Systems", Trafford Publishing Ltd., London.
4. Yamamoto T and Ishida Y, "Linear and Nonlinear Rotordynamics: A Modern Treatment with Applications", John Wiley and Sons Inc, New York, 2001.
5. Tondl A, "Some Problems of Rotor Dynamics", Chapman and Hall limited, New York, 1965.

15MD35 OPTIMUM DESIGN OF MECHANICAL SYSTEMS

3 0 0 3

NONLINEAR OPTIMIZATION: Introduction, unconstrained optimization, one-dimensional optimization, elimination methods, dichotomous Search Method, fibonacci method, golden section methods, quadratic interpolation method, direct root methods, multivariable optimization, direct search methods, univariate method, pattern search methods, hooks and jeeves method, descent methods, steepest descent, newton methods. (10)

CONSTRAINED NONLINEAR OPTIMIZATION: Direct methods, cutting plane method, indirect methods, transformation techniques, basic approach of the penalty function method, khun-tucker conditions, lagrangian method. (6)

INTEGER AND DYNAMIC PROGRAMMING: Introduction to integer programming, solution techniques, graphical method, the branch and bound technique, examples on the application in design systems, introduction to dynamic programming, computational procedure, calculus method of solution. (7)

NON-TRADITIONAL OPTIMIZATION: Introduction to non-traditional optimization, working principles of genetic algorithms, simulated annealing, neural networks. (6)

ENGINEERING APPLICATIONS: Structural applications, design of simple truss members. Design applications, design of simple axial, transverse loaded members for minimum cost, maximum weight, design of shafts and torsionally loaded members, design of springs, dynamic applications, optimum design of single, two degree of freedom systems, vibration absorbers. Application in mechanisms, optimum design of simple linkage mechanisms. (16)

Total L: 45

REFERENCES:

1. Singiresu S Rao, "Engineering Optimization: Theory and Practice", Wiley-Interscience, 1996.
2. Kalyanmoy Deb, "Optimization for Engineering Design", Prentice-Hall India Pvt. Ltd., New Delhi, 2000.
3. David E Goldberg, "Genetic Algorithms in Search, Optimization and Machine Learning", Addison-Wesley Pub Co., 1989.
4. Dimitri P Bertsekas, "Dynamic Programming: Deterministic and Stochastic Models", Prentice Hall, 1987.
5. Harvey M Salkin, "Integer Programming", Addison-Wesley Pub. Co. 1975.

15MD36 COMPUTATIONAL FLUID DYNAMICS

3 0 0 3

INTRODUCTION: Basic concepts of fluid flow-derivation of the governing equations, conservation of mass, momentum and energy. Mathematical classification of flow - hyperbolic, parabolic, elliptic and mixed flow types. (7+2)

DISCRETISATION: Finite difference method - forward, backward and central difference schemes, explicit and implicit methods. Properties of numerical solution methods - stability analysis, error estimation, difference between the FDM and FVM methods. (9+3)

INTRODUCTION TO GRID GENERATION: Choice of grid – structured, unstructured grid, Irregular structured grids, unstructured grids, staggered and collocated arrangements, adaptive grids. (7+2)

CFD TECHNIQUES: Lax - Wendroff technique - MacCormack's technique, relaxation technique. Artificial viscosity, ADI technique, Pressure correction technique, simple algorithm. Upwind schemes - flux vector splitting. (9+3)

TURBULENCE MODELING: Need for turbulence modeling, Direct Numerical Simulation (DNS), RANS equation, Large Eddy Simulation, Turbulence energy equation- one-equation model, Two equation models - the k-ω model, the k- ε model. (7+2)

WALL BOUNDED FLOWS: Velocity profiles – inner, outer and overlap layers, Dimensionless profiles, Applications – channel and pipe flow, Separated flow. (6+2)

Total L: 45 + T: 15 = 60

REFERENCES:

1. John D Anderson, "Computational Fluid Dynamics – The Basics with Applications", TATA McGraw Hill, New Delhi, 2012.
2. Muralidhar K and Sundararajan T, "Computational Fluid Flow and Heat Transfer", Narosa Publications, 2003.
3. Chung T J, "Computational Fluid Dynamics", Cambridge University Press, London, 2010.
4. David C Wilcox, "Turbulence Modeling for CFD", DCW Industries, Inc., 2006.
5. Oleg Zikanov, "Essential Computational Fluid Dynamics", Wiley India Pvt. Ltd., 2010.

15MD37 CREATIVITY AND INNOVATION MANAGEMENT

3 0 0 3

CREATIVITY AND INNOVATION: Practical experience, innovation In brief benefit of innovation for companies, innovation SWOT, rewarding innovation, lateral thinking, weakness of creativity, mechanics of innovation, creativity culture, future of creativity, creative organization-mapping Innovation-model of strategic innovation, types of innovation, incremental innovation, semi-radical innovation, ersatz radical innovation-risk management and innovation strategy, innovation strategy-a case study- strategy and the innovation rules. (12)

INNOVATION RULES: Measure innovation - roles of a measurement system - measurement and the innovation rules - rewarding innovation- the importance of incentives and rewards - motivation - performance evaluation and incentive contracts. (11)

INCENTIVES: delivery of compensation - key considerations in designing incentives systems for innovation - the negative effect on intrinsic motivation - incentives and rewards, and the innovation rules -learning innovation - the importance of learning - a model of learning - learning systems for innovation. (11)

INNOVATION MANAGEMENT: An introduction- Macro factors and innovation - managing innovation within firms- innovation and operations management-managing Intellectual property managing technology and knowledge- managing organisational knowledge- strategic alliances and networks- the role of technology transfer in innovation new product development- product & brand strategy - packaging and product development. (11)

Total L: 45

REFERENCES:

1. Tom Kelley, Jonathan Littman and Tom Peters, "The Art of Innovation", Random House Inc, 2001.
2. Brain Clegg, "Creativity and Innovation for Managers", Butterworth Heinmann Publishers, 2005.
3. Marc J Epstein, Robert Shelton and Tony Davila, "Making Innovation Work", Wharton School Publishing, 2005.
4. Paul Trott, "Innovation Management and New Product Development", Pearson Education, 2004.

15MD38 ARTIFICIAL INTELLIGENCE AND EXPERT SYSTEMS

3 0 0 3

HUMAN AND MACHINE INTELLIGENCE: Concepts of fifth generation computing , programming in AI environment, developing artificial intelligence system, natural language processing, neural networks. (8)

KNOWLEDGE REPRESENTATION FOR SMART SYSTEMS: Forward chaining, backward chaining, use of probability and fuzzy logic. Semantic nets, structure and objects, ruled systems for semantic nets; certainty factors, automated learning. (8)

LANGUAGES USED IN AI: Using PROLOG to design expert systems, converting rules to PROLOG, conceptual example, introduction to LISP, function evaluation, lists, predicates, rule creation. (8)

EXPERT SYSTEM DEVELOPMENT: Definition, choice of domain, collection of knowledge base, selection of inference mechanism, case studies of expert system development in design and manufacturing. (6)

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 uncertainity, probability in expert systems-learning, forms of learning, inductive learning, decision trees, knowledge in learning, heuristic classification, heuristic matching, case studies in expert systems, MYCIN, 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. (9)

INDUSTRIAL APPLICATION OF AI AND EXPERT SYSTEMS: Robotic vision systems, image processing techniques, application to object recognition and inspection, automatic speech recognition. (6)

Total L: 45

REFERENCES:
1. Robert Levine et al, "A Comprehensive Guide to AI and Expert Systems", McGraw Hill Inc, 1988.
2. Henry C Mishkoff, "Understanding AI", BPB Publication, New Delhi, 1986.
3. Peter Jackson, “Introduction to Expert Systems”, Addison Wesley, 2000.
4. Stuart Russell and Peter Norvig, “Artificial Intelligence: A Modern Approach”, Prentice Hall, 1995.
5. Elaine Rich et al, “Artificial Intelligence”, McGraw Hill, 1995.

15MD39 ADVANCED STRENGTH OF MATERIALS 3 0 0 3

CURVED BEAMS : Circumferential stress at a point in a curved beam, Correction of Circumferential stresses in CureveD Beams, Deflection of Curved Beams, Wrinkler Bach formula-limitations, curved beam with restrained ends. Closed ring subjected to a concentrated load and uniform load. (7)

BEAMS ON ELASTIC SUPPORTS: 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 (7)

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 (7)

ROTATING DISKS: 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. (7)

TORSION OF NON CIRCULAR SECTIONS: Torsion of bar having a rectangular sections, elastic membrane (soap film) analogy hollow thin walled tubes, thin wall torsion members with restrained ends, in elastic torsion of a circular cross section (7)

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 frottage, stress components and radial displacements for constant temperature (7)

Total L: 42

REFERENCES:
1. Cook R D and Young, “Advanced Mechanics of Materials”, John Wiley Co., New Delhi, 1987.
2. Den Hartog, “Advanced Strength of Materials”, McGraw Hill Inc., New Delhi, 1975.
3. Rajput R K, “Strength of Materials’, S. Chand & Co. Ltd, New Delhi, 2010
4. Boresi A P and Sidebottom O M, “Advanced Mechanics of Materials”, John Wiley and Sons, New Delhi, 1985.

15MD40 DESIGN OF PRESSURE VESSELS

3 0 0 3

INTRODUCTION: Overview of pressure vessel, Development of Pressure vessel construction codes, pressure vessel design philosophy- general overview, structure and material considerations, factor of safety, design by rule, design by analysis. (3)

STRESSES IN PRESSURE VESSELS: Modes of failure, Theories of failure, Theories of failure and allowable stress limits in ASME boilers and pressure vessel, service limits, design for cyclic loading, protection against fracture, stress intensity, categorization of stresses, stress limits, special stress limits, practical aspects of stress categorization, shape factor considerations. (8)

DESIGN OF CYLINDRICAL SHELLS: Introduction, thin-shell equations, thick-shell equations, approximate equations, buckling of cylindrical shells, discontinuity stresses in pressure vessels, design of heads and covers, hemispherical heads under internal pressure, ASME equation for- hemispherical heads, ellipsoidal heads, torispherical heads, conical heads, toriconical heads, flat heads and covers, unstayed flat heads and covers. (8)

DESIGN OF NOZZLES AND OPENINGS: Introduction, stress concentration about a circular hole, cylindrical shell with a circular hole under internal pressure, spherical shell with a circular hole under internal pressure, reinforcement of openings, nozzles in pressure vessels. (8)

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 behavior, design of bolts, closure. (8)

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. (5)

CASE STUDIES: SIZING of a pressure vessel, nozzle reinforcement assessment, fatigue evaluation using elastic analysis, fatigue evaluation using the simplified inelastic analysis method, structural evaluation of a reactor vessel support. (5)

Total L: 45

REFERENCES:

1. Somnath Chattopadhyay, "Pressure Vessels Design and Practice", CRC Press, 2004.
2. John F. Harvey, "Theory and Design of Pressure Vessels", CBS Publishers and Distributors, 1987.
3. Henry H. Bedner, "Pressure Vessels", Design Hand Book, CBS publishers and Distributors, 1987.
4. Stanley, M. Wales, "Chemical process equipment, selection and Design", Buterworths series in Chemical Engineering, 1988.
5. William. J., Bees, "Approximate Methods in the Design and Analysis of Pressure Vessels and Piping", Pre ASME Pressure Vessels and Piping Conference, 1997.

15MD41 FRACTURE MECHANICS

3 0 0 3

INTRODUCTION: Ductile fracture, brittle fracture, cleavage-fractography, ductile-brittle transition, the fracture mechanics approach to design, effect of material properties on fracture, an atomic view of fracture, stress concentration effect of flaws, the Griffith energy balance, the energy release rate, instability and the R curve, stress analysis of cracks-stress intensity factor, K-threshold, crack growth instability analysis, crack tip stress analysis. (10)

ELASTIC-PLASTIC FRACTURE MECHANICS: Crack tip opening displacement (CTOD), J-integral, relationship between J and CTOD, crack growth resistance curves. (5)

FRACTURE TOUGHNESS TESTING OF METALS: General considerations, K_{IC} testing, K-R curve testing, CTOD testing, dynamic and crack-arrest toughness, fracture testing of weldments, testing and analysis of steel in the ductile-brittle transition region, qualitative toughness tests. (8)

APPLICATION TO STRUCTURES: Linear elastic fracture mechanics, the CTOD design curve, failure assessment diagrams-original concept, J-based FAD, application to welded structures, probabilistic fracture mechanics. (8)

FATIGUE CRACK PROPAGATION: Similitude in fatigue, empirical fatigue crack growth equations, crack closure, growth of short cracks, micro-mechanisms of fatigue, fatigue crack growth experiments, damage tolerance methodology. (8)

COMPUTATIONAL FRACTURE MECHANICS: Overview of numerical methods, traditional methods in computational fracture mechanics, the energy domain integral, mesh design, linear elastic convergence study, analysis of crack growth. (6)

Total L: 45

REFEENCES:

1. Anderson T L, "Fracture Mechanics: Fundamentals and Applications", Taylor and Francis, 2005.
2. ASM Handbook- Vol.10, "Failure Analysis and Prevention", Metals Park, Ohio, USA,1995.

15MD42 EXPERIMENTAL STRESS ANALYSIS

3 0 0 3

INTRODUCTION: 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, Introduction to Moiré, Brittle Coatings and Holography, Hologram Interferometry, 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. (10)

TRANSMISSION PHOTOELASTICITY: Introduction to Transmission Photoelasticity, 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 Photo elastic Materials, Fringe Thinning Methodologies, Fringe Ordering in Photoelasticity, Miscellaneous Topics in Transmission Photoelasticity. (13)

THREE DIMENSIONAL PHOTOELASTICITY AND DIGITAL PHOTOELASTICITY: Three Dimensional Photoelasticity, Overview of Digital Photoelasticity. (3)

PHOTOELASTIC COATINGS AND BRITTLE COATINGS: Introduction to Photoelastic Coatings, Correction Factors for Photoelastic Coatings, Coating Materials, Selection of Coating Thickness, Industrial Application of Photoelastic Coatings, Calibration of Photoelastic Coatings, Introduction to Brittle Coatings, Analysis of Brittle Coatings. (7)

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. (8)

APPLICATIONS: Soldering, Accounting for Transverse Sensitivity Effects, Correction Factors for Special Applications, Special Gauges- Environmental effects contd., 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. (4)

Total L: 45

REFERENCES:

1. Ramesh K., e-Book on "Experimental Stress Analysis", IIT Madras, 2009.
2. Ramesh K., "Digital Photoelasticity Advanced Techniques and Applications, Springer, 2000.
3. W.N. Sharpe (Ed.), Springer Handbook of Experimental Solid Mechanics", Springer, 2008.
4. Dally J.W. and Riley W.F., "Experimental Stress Analysis", McGraw-Hill, 1991.
5. Srinath L.S., Raghavan M.R., Lingaiah K., Gargesa G., Pant B., and Ramachandra K., "Experimental Stress Analysis", Tata Mc Graw Hill, 1984.

15MD43 DESIGN OF PRESS TOOLS

3 0 0 3

THE THEORY OF SHEET METAL BEHAVIOR : 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,variation of stock thickness. (7)

METAL STAMPING DIES AND THEIR FUNCTION : 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. (6)

CONSTRUCTION AND ASSEMBLY OF METAL STAMPING DIES : Tolerancing systems, fabrication and assembly of die components, mounting of blocks, machining of blocks, heat treatment. (7)

METALWORKING MACHINERY : Parts of the press, press operating parameters, classification of presses, digital control of pressworking operations using sensors. (5)

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 force with inclined cutting surfaces, stripping pressure, scrap and hole size recommendations, practical advices and restrictions. (7)

BENDING AND FORMING OPERATIONS : Stress, strain, elongation and compression during bending, bend radius, radius of forming tools, edge formability, types of bending operations, springback,surface flatness after bending, forming, bending and forming pressure calculations. (6)

PRACTICAL DIE DESIGN : Basic approach to die design, progressive die design, samples of die design work. (7)

Total L: 45

REFERENCES :

1. Die design handbook by David A Smith, Society of Manufacturing Engineers, 1990.
2. Handbook of die design by Ivana Suchy, McGraw Hill, 2006.
3. Tool Design by Cyril Donaldson, George H.Lecain, V.C. Goold, Joyjeet Ghose, Tata McGraw Hill Publishers, 2012.

15MD44 HUMAN BODY VIBRATION DIAGNOSTICS

3 0 0 3

INTRODUCTION: Vibration and human response, Categorization of vibration (deterministic, random), Effectsof vibration-criteria, limits, Vibration analysis procedure, Human vibration-definition, types, Standardization bodies-ISO, CEN, National, BSI. (6)

WHOLE BODY VIBRATION: 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. (8)

BIODYNAMICS AND SEATING DYNAMICS: Body transmissibility- apparent mass, models, Transmissibility, SEAT value, Seat Testing, Biomechanical models. (5)

HAND ARM VIBRATION: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. (5)

MEASUREMENT EVALUATION AND ASSESSMENT OF HUMAN VIBRATION: Frequency analysis, Digital frequency weighting, Amplitude Analysis,ISO 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 (1986),ISO 5349 (2001)Standards for determining the vibrationemission value of tools and hand-guided machines-ISO 8662(1, 2, 3…14). Standards for testing the dynamic performance of antwbration gloves-ISO 13753, ISO10819, 1/3 Octave frequency analysis. (12)

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. (9)

Total L: 45

REFERENCES:

1. Fahy F.J., Walker J.G.,"Fundamentals of Noise and Vibration", E&FN SPON,1998.
2. Thomson W. T., "Theory of Vibration with Applications", Prentice Hall of India, 1997.
3. Coles, B, "Regulatory impact assessment of the Physical Agents (Vibration) Directive",Health and Safety Executive,(2002).
4. ISO 2631/1."Evaluation of human exposure to whole-body vibration: part 1-general requirements", Geneva: International Organization for Standardization, 1985.

15MD45 ROBOT MODELING AND CONTROL

3 0 0 3

ROBOTICS TECHNOLOGY: Introduction- Basic components of robot-Laws of robotics- classification of robot-work space accuracy-resolution –repeatability of robot. Power transmission system: Rotary to rotary motion, Rotary to linear motion, Harmonic drives (6)

ROBOTIC MANIPULATORS : Introduction to robots, types of robots and manipulators, rigid body motions, representation of position and orientation of a rigid body - Position vector - Rotation matrix - Homogeneous transformations Denavit - Hartenberg (D-H) presentation, frame arrangement - Kinematic (DH) parameters - Position analysis - Direct and reverse kinematics - Examples. (6)

VELOCITY AND STATIC FORCE ANALYSIS : Velocity analysis, representation of linear and angular velocity of manipulator links-Skew symmetric matrix representation-Velocity forward propagation-Velocity/manipulator Jacobian static force analysis, force transformation of robotic manipulators-Force Jacobian-Singularity analysis. (8)

ROBOT DYNAMIC ANALYSIS: Introduction to robot dynamics, equations of motions for robotic manipulators - Lagrangian formulation method, dynamic modeling, state space representation of dynamic equations of robotic manipulators. (6)

UNDERWATER ROBOTICS : Introduction to underwater robot - working in water - Structure and materials - Pressure hulls and canisters - Buoyancy, stability and ballast - moving and maneuvering - navigation and control - power systems in under water robot. (7)

MODELLING AND CONTROL OF UNDERWATER ROBOTICS : Modeling of underwater robots - kinematic control- dynamic control - interaction control - stability analysis of underwater robot and state space method - fault detection/tolerance strategies of underwater robots (6)

DESIGN OPTIMIZATION OF ROBOT : Introduction to optimization techniques - design optimization - optimization algorithms - trajectory optimization - stability and design optimization of underwater robot. (6)

Total L: 45

REFERENCES:

1. Craig J.J., "Introduction to robotics, mechanics and control", Prentice hall, 2005.
2. Jazer.R.N., "Theory of applied robotics", Springer, 2010.
3. Ghosal. A., "Robotics fundamental concepts and analysis", Oxford university press, 2006.
4. Gerald J.KOST and Judith Welsh., "Handbook of clinical automation, robotics and optimization", Wiley, 1996.
5. Shabana.A.A., "Computational dynamics", John wiley & sons, 2001.