Biju Patnaik University of Technology, Orissa

M.Tech in Mechanical Systems Design & Dynamics

Semester 1

Subject No.	Subject	Contact Hr L – T – P	Credits
Professional Core			
MSPC101	Machine Vibration Analysis	3 – 1 – 0	4
MSPC102	Automatic Control	3 – 1 – 0	4
MDPC102	Applied Elasticity and Plasticity	3 – 1 – 0	4
	Elective – I	3 – 0 – 0	3
	Elective – II	3 – 0 – 0	3
Sessionals			
HTPR101	Engineering Software Laboratory	0 – 0 – 3	2
MSPR101	Vibration Laboratory	0 – 0 – 3	2
MSPT101	Pre-thesis work and seminar		2
		Total credit	24

Elective – I (*Any One*):

MSPE101 Analysis and Synthesis of Mechanisms
MDPE104 Acoustics and Noise Control
MSPE102 Principle of Solid Mechanics
MSPE103 Knowledge based systems in Mechanical Engineering
MSPE104 Nonlinear Dynamics

Elective – II (*Any One*):

MDPE101 Fatigue, Creep and Fracture
MSPE105 Composite Materials
MSPE106 Engineering Design Optimization
MSPE107 Mechanics of MEMS
MDPE108 Material Selection in Mechanical Design

Semester 2

Subject No.	Subject	Contact Hours L – T – P	Credits
Professional Core			
MSPC201	Vibration of Structures	3 – 1 – 0	4
MDPC202	Bearings and Lubrication.	3 – 1 – 0	4
	Elective – III	3 – 0 – 0	3
	Elective - IV	3 – 0 – 0	3
	Elective - V	3 – 0 – 0	3
Sessionals			
MSPR201	Microprocessors Lab	0 – 0 – 3	2
MSPR202	Kinematics and Dynamics Lab	0 – 0 – 3	2
MSPT201	Pre-thesis work and seminar		2
MSCV201	Comprehensive Viva-Voce I		2
		Total credit	25

Elective – III(*Any One*):

MDPE201 Machine Fault Diagnosis and Signal Processing
MSPE201 Smart Materials and Structures
MSPE202 Stability of Elastic Systems
MDPE203 Mechatronics
MDPE204 Mechanics of Composite Materials

Elective – IV (*Any One*):

MDPE205 Finite Element Methods in Engineering
MDPE206 Computer Graphics and Visualization
MDPE207 Dynamics of Rotors
MDPE208 Modeling and Simulation of Dynamical Systems
MSPE203 Vibration and Shock Isolation

Elective – V (*Any One*):

PDPE206 Robotics
MDPE209 Experimental Stress Analysis
MSPE204 Random Vibrations
MDPE210 Nonlinear Vibration
MDPE211 Machine Tool Vibration

Semester 3

Subject	Contact Hours L – T – P	Credits
Open Elective	3 – 0 – 0	3
Thesis Part I		14
Total		17

Open Elective (Any one)

1.Research Methodology
2.Human Resource Managements
3.Project Management and Costing
4.Enterprise Resource Planning
5.Soft Computing

Semester 4

Subject No.	Subject	Contact Hours L – T – P	Credits
MSPT401	Thesis Part II		20
MSCV401	Seminar	0 – 0 – 2	2
MSCV402	Comprehensive Viva-Voce II		2
			24

Total Credits: 90

MACHINE VIBRATION ANALYSIS (3-1-0)

Module-I. **(14 hours)**

Review of vibration fundamentals for SDOF systems. Model study through single degree of freedom analysis:Un-damped free Vibration : Equilibrium method, Energy method, Raylegh's method, Stiffness of spring elements. Damped Vibrations : Viscous damping, Laws of damping, Logarithmic decrement.

Forced Vibration with Harmonic Excitation : Steady state solution with viscous damping, method of complex algebra Reciprocating and rotating unbalance. Base excitation, vibration isolation. Air springs, energy dissipated by damping. Equivalent viscous damping, structural damping, sharpness of resonance, vibration measuring instruments, whirling of rotating shafts, Rigid shafts supported by flexible bearings.

Forced Vibration with non harmonic and transient excitation of single degree freedom systems: Fourier analysis, Response to arbitrary loading (Duhamel and Convolution Integral), Impulse response, Mechanical shock, Parametric Excitation.Torsional Vibration : Single, 2- and 3-rotor systems, and geared systems

Module-II **(13 hours)**

Two degrees and Multidegree of freedom systems with applications: Two degree of freedom systems : Generalized Derivation of Equation of motion, Normal mode vibration, coordinate coupling, Langrange's equations, Dynamic Vibration absorber. Multi-degree of freedom system : Derivation of Equations, influence co-efficients, modal analysis, orthogonality of normal modes. Torsional Vibration multi-rotor systems and branched system.

Module-III **(13 hours)**

Computational Techniques like Rayleigh, stodala, Matrix iteration, Transfer Matrix, Myklestadt-Prohl Method and Holzer-Methods.

Vibration of continuous system. Vibration of strings, membranes, rods and beams with different end conditions Euler-Bernoulli equation for beams

Vibration Measuring Instruments, Vibration testing equipments Concept of Signature analysis for preventive maintenance, vibration signatures, standards, Field balancing of rotors

Text Books :

1. Theory of Vibration with Applications, W. T. Thomson, CBS Publ., 1990.
2. Mechanical Vibration analysis, P. Srinivasan, TMH.1995

Reference Books

1. Mechanical vibration: Theory and Applications–F.S.Tse,I.E.Morse and R.T.Hinkle, CBS Pub,
2. Introductory course on Theory and Practice of Mechanical Vibrations, J.S. Rao & K.Gupta, New Age Pub
3. Elements of Vibration Analysis, L. Meirovitch, TMH, Second edition, 2007.
4. Mechanical Vibrations: Analysis, Uncertainties, and Control, Haym Benaroya, Prentice Hall
5. Vibrations, Balakumar Balachandran and Edward B. Magrab, Thomson Learning
6. Textbook of Mechanical Vibrations, R.V.Dukkipati and J.Srinivas
7. Mechanical Vibration, S.S.Rao, Pearson, 2004
8. Advanced Therory of Vibration – J.S.Rao, New Age Publication
9. Principles of Vibration, Benson H.Tongue, Oxford University Press
10. Schaum's Outline Series: Theory and Problems of Mechanical Vibrations, Willam W.Seto, TMH
11. Principles of Vibration Control, A.K.Mallick, East-West Press, 1990

Automatic Control (3-1-0)

Module I **(10 hours)**

Introduction: Basic concept of control system, Open loop and Close loop control systems. Control System and components.

Laplace Transform: Laplace transformation, Laplace transforms theorems, inverse Laplace transform.Mathematical model of physical systems: modeling of fluid systems and thermal systems Liquid level systems, pneumatic systems, hydraulic systems, thermal systems. Feedback Characteristics of control systems, Types of feedback, effects of different feedbacks on control systems.

Module II **(16 hours)**

Time response analysis:

Standard input signals, Step, ramp, parabolic and impulse inputs. Time response of fist and second order systems to input signals. Time response specifications, Steady state error and error constants of different types of control systems.

Concept of stability , Necessary condition for stability, Routh's stability criterion, application of Routh's criterion for linear feed back system, relative stability.

Root-locus analysis : Root locus concepts, rules for construction of root loci, root contours, systems with transportation lead and lag.

Module III **(16 hours)**

Frequency response analysis : Bode diagrams, polar plots, Nyquist stability criterion, Stability analysis, relative stability in frequency domain.

Controllers: Proportional, derivative and integral control actions, PD, PI and PID controllers and their applications to feed back control systems.

Mathematical modeling of Dynamic systems in state space, state-space representation of mechanical and electrical systems. State equation and transfer functions, Characterisic equation , Eigenvalue and eigenvector of state matrix. Design of control systems in state space.

Books

1. Modern Control Engineering, K, Ogata
2. Automatic Control system, B. C. Kuo
3. Control Systems Engineering, L. J. Nagrath, M. Gopal

Applied Elasticity and Plasticity (3-1-0)

Module-I **(14 hours)**

Stress-strain relations for linearly elastic solids, Generalized Hooke's law. Analysis of three dimensional stresses and strains. Tensor character of stress. Strain-displacement relations, equilibrium equations, compatibility conditions and Airy's stress function,. Plane stress and plane strain, simple problems in cartesian and polar co-ordinates,

Module-II **(13 hours)**

Solution of axisymmetric problems, Bending of beams and plates, Kirkhhof and Mindlin concept. Torsion problem with St.Venant's approach-Prandtl's approach - Torsion of thin walled open and closed sections & thermal stress.

.

Module-III **(13 hours)**

Theoretical concepts of plasticity, Yield criteria - Tresca and Von Mises criterion of yielding, Plastic stress strain relationship, Elastic plastic problems in bending and torsion.

Text Books

1. Timoshenko, S. and Goodier J.N. Theory of Elasticity, McGraw Hill Book Co., Newyork, 1988.
2. J. Chakrabarty, Theory of Plasticity, McGraw-Hill Book Company, New York 1990

Reference Books

1. Irving H.Shames and James,M.Pitarresi, Introduction to Solid Mechanics,Prentice Hall of India Pvt. Ltd., New Delhi -2002.
2.E.P. Popov, Engineering Mechanics of Solids, 2nd Ed., Prentice Hall India, 1998.
3 W.F.Chen and D.J.Han., Plasticity for structural Engineers., Springer-Verlag., NY., 1988.
4. Hoffman and Sachs, *Theory of Plasticity* - McGraw Hill., 2nd ed. 1985
5. Johnson and Mellor, *Engineering Plasticity*- Van-Nostrand., 1st edition, 1983

(Elective - I)

ANALYSIS AND SYNTHESIS OF MECHANISMS 3-0-0

Module I **(12 hours)**

Introduction: Review of fundamentals of kinematics – mobility analysis –D.O.F. – mixed mobility, total partial and fractional DOF, multi loop kinematic chains.

Kinematic Analysis: Basic concepts of kinematics and mechanisms-type, number and dimensions, kinematic pairs, chains and inversions, accuracy point and error analysis, velocity and acceleration analysis of different complex mechanism.

Dynamics of Mechanisms: Static force analysis with friction – inertia force analysis – slider crank mechanism, four bar mechanism, crank – shaper mechanism – combined static and inertia force analysis, twin cylinder engine.

Module II **(13 hours)**

Synthesis of Mechanisms: Type, Number and Dimensional Synthesis; Function generation, path generation and body guidance; two-position synthesis of slider crank mechanism; two-position synthesis of crank and rocker mechanism; crank-rocker mechanisms with optimum transmission angle; three position synthesis; four-position synthesis, point precision reduction; Precision position; structural error; Chebychev spacing; the Overlay method; copular curves synthesis; Cognate linkages – The Roberts-Chebychev Theorem; Bloch's Method of Synthesis; Freudenstein's equation; Inflection Circle and Euler -Savary equation; Center-point and center-point Circles, The Inflection circle for the relative motion of two moving planes.

Introduction to Spatial Mechanisms and Robotics: Vector methods in plane kinematics, Matrix Methods in Kinematics, analysis of space mechanisms, Kinematic analysis of spatial RSSR mechanism – Denavit – Hartenberg parameters – Forward and Inverse kinematics of robotic manipulators.

Module III **(11 hours)**

Cam Mechanism: Synthesis of cam profiles, Analysis of follower motion, Analysis of Cam Design, Practical Design Consideration

Mechanism Trains: Parallel Axis Gear Trains; Epicyclic Gear Trains; Bevel Gear Epicyclic Trains; Analysis of Planetary Gear Trains; Adders and Differentials; All Wheel Drive Train

Balancing: Balancing Linkages – Complete Force Balancing of Linkages; Effect of Balancing on Shaking and pin Forces; Effect of Balancing on Input Torque; Balancing of I-C engines.

Test Book:

1. A. Ghosh & A.K. Mallik, *Theory of Mechanism &Machines*, Affiliated East-West Press: 1998
2. R.S. Hartenberg & J. Denavit, Kinematic Synthesis of Linkages, TMH, New York, 1964.
3. A. S. Hall (Jr.) : Kinematics and linkage Design, Prentice Hall, Englewood Cliffs, New Jersey.
4. Theory of Machines and Mechanisms, Shigley J. E., Pennock G.R., and Uicker J.J. Oxford.

Reference Books:

1. Kinematic and Dynamics of Machinery: Norton R. L., TMH
2. Advaced Mechanism Design: Analysis and Synthesis, Sandor G.N. and Erdman A.G. PHI
2. Mechanism Design, Vol –1 & II, George N Sandor and Arthur G Erdman, PHI

4. Mechanism and Machines (Analysis & Synthesis) Arthur G Erdman, PHI
5. Robotics Technology and Flexible Automation, Deb S. R., TMH

PRINCIPLES OF SOLID MECHANICS (3-1-0)

Shear center and unsymmetrical bending. Beam columns; Beams on elastic foundations; curved beams, rotating discs and thick cylinders, virtual work; Minimum potential energy; Hamilton's Principle. Plate theory: Formulation by Hamilton's principle : Bending and buckling of homogenous and Sandwich Plates. Shell theory : Introduction to theory of surface; Formulation by Hamilton's Principle; membrane, bending and buckling analysis of shells of revolution.

Text Books

1. Advanced Mechanics of Materials - F. B. Seely and J. O. Smith. John Wiley and Sons Inc, 2nd edition, 1952.
2. Advanced Mechanics of Materials, 4th edition A. P. Boresi and O. M. Sidebottom. John Wiliey and Sons, 1985.
3. Advanced Mechanics of Solids - L. S. Srinath. Tata Mc-Graw Hill Co., 2005

Reference Books

1. Elementary Mechanics of Solids - P.N. Singh and P.K. Jha. New Age International, 2002.
2. Mechanics of Solids (Vol. 1& 2) - R. Baidyanathan, P.Perumal and S. Lingeswari. Scitch Publications.

(Elective - II)

FATIGUE, CREEP AND FRACTURE (3-0-0)

Fatigue: Types of fatigue loading and failure, Fatigue test, endurance limit; Fatigue under combine stresses; Influence of stress concentration on fatigue strength, Notch sensitivity, Factors influencing fatigue behavior.
Creep : Creep-stress-time temperature relations, Mechanics of creep in tension, bending, torsion, creep buckling. Members subjected to creep and combined stresses.
Fracture : Basic modes of fracture, Griffith of brittle fracture, Irwin's theory of fracture in elastic-plastic materials. Theories of linear elastic fracture mechanics, stress intensity factors, fracture toughness testing.

Text Books

1. Strength and Resistance of Metals - J. M. Lessels, John Wiley and Sons, Inc., 1954.
2. Mechanical Behaviour of Engineering Materials - Joseph Marin, PHI, 1966.
3. Fatigue Testing and Analysis - Y. Lee, J.Pam, R.B. Hathaway & M.E. Barkey Elsevier Press
4. Engineering Fracture Mechanics - S. A. Meguid, Elsevier Press, 1989.

Reference Books

1. Mechanical Metallurgy - G. E. Dieter, Mc-Graw Hill Book Co., 1961.
2. Mechanical Behaviour of Materials - N. E. Dowling, PHI, 1997.
3. Introduction to Fracture Mechanics - Kare Hellan, Mc-Graw Hill Book Co., 1985.
4. The Practical Use of Fracture Mechanics - David Broek, MN Publishers, 1982.

COMPOSITE MATERIALS (3-0-0)

Review on definition, classification & fabrication technologies of composites. Principles of composites, micromechanics of composites. Various types of reinforcements and their properties. Role of interfaces. Fabrication of metal matrix composites: insitu, dispersion hardened, particle, whisker and fibre reinforced; composite coatings by electrodeposition and spray forming. ; Fabrication of polymeric and ceramic matrix composites. Mechanical physical properties of omposites. Mechanisms of fracture in composites. Property evaluation and NDT of composites. Wear and environmental effects in composites.

Supplementary Reading:

1. *Composites, Engineered Materials Handbook*, Vol.1, ASM International, Ohio, 1988.
2. F.L. Matthews and R.D. Rawlings, *Composite Materials: Engineering and Science*, Chapman & Hall, London, 1994.
3. Weinheim, *Structure and Properties of Composites, Materials Science &Technology,* Vol. 13, VCH, Germany, 1993.
4. J.Prasad /CGK Nair, *NDT and Evaluation of Materials*, Mc Graw Hill

ENGINEERING DESIGN OPTIMIZATION (3-0-0)

Optimization problem formulation - Design variables, constraints, objective function and variable ; bounds. Single-Variable. ; Single Variable Optimization Algorithm: Bracketing Melliotls Exhaustive Search Method and bounding ; Phase Method. ; Region Elimination Methods: Fibonacci Search method and Golden section search method. Gradient based ; methods, Newton - Raphson method, Bisection Method, Secant Method, and Cubic Search Method. Computer programs for bounding phase method and golden section search method. ; Multivariable Optimization Algorithms: Direct search methods. Simplex search method and Hooke- Jeeves pattern search method. Gradient based methods- Cauchy's (steepest descent) method and Newton's method. Constrained Optimization Algorithms- Kuhn- Tucker conditions, penalty function. Method, method of multipliers, cutting plane method, Generalized Reduced Gradient method, computer program for penalty function method. Integer programming - penalty function method. Global optimization using the steepest descent method, genetic algorithms and simulated annealing.

Essential Reading:

1. K.Deb, *Optimization in Engineering Design* -, PHI.

Supplementary Reading:

1. S. S. Rao, *Optimization methods* - PHI.

Mechanics of MEMS (3-0-0)

Materials properties; crystal growth; Basic fabrication techniques- Doping, Diffusion, Oxidation, Deposition of films using CVD, LPCVD and Techniques, chemical and plasma etching; Anisotropic Etching; cleaning; Lithographic process; Electro-plating; surface and bulk micro-machining; LIGA; Release of micro-structures. MEMS Design principles and tools MEMS Devices; capacitive, Electrostatic, Piezo-resistive, Piezo-electric, Thermal, Magnetic transduction, micro-fluidics.

MEMS packing Technologies

MEMS Design and Application case studies,

TEXT BOOKS

1. M. J. Madou – Fundamentals of microfabric action Second Edition, CRC,2002
2. M. Bao, Analysis and Design principal of MEMS Devices, Elsevier, 2005

Reference Books

1. C. Liu, Fundamentals of MEMS, Pearson / PH,2006
2. G. M. Rcbiz, RFMEMS, Theory Design and Technology, wiley-2003
3. V. Varadan, K. J. Vinoy and S. Gopalkrishna, Smart materials system and MEMS; Design and Development methodologies, Wiley-2006

Materials Selection in Mechanical Design (3-0-0)

Module I **(12 hours)**

Introduction: Materials properties – chemical, physical, mechanical, dimensional; Materials categories; Design process, conceptual design, embodiment design, detail design; Ideology of optimization, materials selection charts.

Performance indices: Performance, objective function, constraints, performance index; Calculational Model, Measure of Performance, Equations for constrained variables; Design-fixed parameters, free parameters.

Optimization of selection without considering shape effects: Recipe for optimization, Applying performance indices to selection charts; Primary constraints; Reality Check; Case studies – mirrors for large telescopes, table legs, structural materials for buildings, flywheels, springs, elastic hinges and couplings, pressure vessels, Vibration effects, stiff and high damping materials; Thermal effects, insulations, solar heating, heat exchangers.

Module II **(14 hours)**

Manufacturing and process selection: Classification of manufacturing processes, review of shaping, joining and finishing processes, Strategy for processes selecting, translation, screening, ranking; Selection charts, process-material matrix, process-shape matrix, mass bar-chart, thickness bar-chart, tolerance and surface-roughness bar-charts; Manufacturing cost; Case studies: forming a fan, fabricating a pressure vessel, economical casting.

Multiple Constraints in Materials Selection – Overconstrained Design: Decision matrices, selection stages, coupling equations, value functions; Multiple Selection Stage Method, Active Constraint Method, Coupling Equation Method; CES Software; Fully determined design; Massively overconstrained designs; Conflicting objectives, penalty functions and exchange constants; Case studies – shipbuilding, con-rods for high-performance engines, windings for high-field magnets, casing for mini-disk player or cell phone, disk-brake caliper.

Module II **(10 hours)**

Optimization of selection considering shape effects: Shape factors, Microscopic or micro-structural shape factors; Limits to shape efficiency, stiffness-limited design, strength-limited design, material indices that include shape, elastic bending of beams and twisting of shafts, failure of beams and shafts, co-selection of material and shape; Case studies – choosing optimal I-beam, spars for man-powered planes, ultra-efficient springs, forks for a racing bicycle.

Designing hybrid materials: Families of configurations of hybrid materials - composites, sandwiches, lattices and segmented; method “A+B+configuration+scale”; Anisotropy; Case studies – metal matrix composites, refrigerator walls, natural materials.

Text book

1. M. F. Ashby, MATERIALS SELECTION IN MECHANICAL DESIGN, Third Edition

Reference books

1. J. E. Gordon, *The New Science of Strong Materials, or Why You Don't Fall Through the Floor*, Princeton University Press, Princeton, NJ.
2. J.E. Gordon, *Structures, or Why Things Don’t Fall Down,* Da Capo Press.
3. M. F. Ashby and D. R. H Jones, *Engineering Materials Parts 1, 2, and 3*, Pergamon Press, Oxford, UK.
4. F. A. A. Crane and J. A. Charles, *Selection &Use of Engineering Materials*, Butterworths, London, UK.

ENGINEERING SOFTWARE LAB (0-0-3)

C, C++, MATLAB, AutoCAD, Pro-E, CATIA, MasterCAM, UniGraphics, SolidWorks, ANSYS, IronCAD, Ms Project

2nd Semester

VIBRATION OF STRUCTURES

Force-Deflection properties of structure (Generalized Co-ordinates, virtual, influence coefficients, strain energy, stiffness method and Flexibility method) Principle of dynamics:- D'Alembert's principle, Hamilton's principle and Lagrange's Equations Natural modes of vibration:- Solution of the Eigenvalues problems and matrix Iteration, Energy Methods:- Rayleigh's method, The Rayleigh- Ritz method Effect of Retatory international shear on Beam vibrations. Vibration of rotating beams

Torsional and Bending Vibrations of beams: The Holzer method, The Myklestad-Thomson method Transfer matrix techniques, Finite elements techniques,
Damping: Nature of Damping, Lagrange's equations with damping and for structural damping, viscous damping, concept of critical viscous damping frequency response analysis for SDFS and MDFS with damping.

Text Books:

1. Walter C. Hurty & Moshe F. Rubinstein, "dynamic of structures", PHI,
2. Ray W. Clough And Joseph Pencine, "Dynamic of structures", International Student Edition.

Reference Books:

1. Tees, Mores and Hincle, Mechanical vibrations and it's applications, Students Edition.
2. A. H. Nayfeh and P. F. Pai, liner and Non-liner Structural Mechanics, Wiley-Interscience,2004

BEARINGS AND LUBRICATION (3-0-0)

Introduction-Historical background, Bearing concepts and typical applications. Viscous flow concepts-Conservation of laws and its derivations: continuity, momentum (N-S equations) and energy, Solutions of Navier-Strokes equations. Order of magnitude analysis, General Reynolds equation-2D and 3D (Cartesian and Cylindrical), Various mechanisms of pressure development in an oil film, Performance parameters. ; Boundary Layer Concepts-Laminar and turbulent flow in bearings, mathematical modeling of flow in high-speed bearings. Elastic Deformation of bearing surfaces-Contact of smooth and rough solid surfaces, elasticity equation, Stress distribution and local deformation in mating surfaces due to loadings, methods to avoid singularity effects, Estimation of elastic deformation by numerical methods-Finite Difference ; Method (FDM), Governing equation for evaluation of film thickness in Elasto Hydrodynamic Lubrication (EHL) and its solution, Boundary conditions. Development of computer. ; Programs for mathematical modeling of flow in bearings, Numerical simulation of elastic deformation in bearing surfaces by FDM.

Supplementary Reading:

1. B.C.Majumdar, *Introduction to Tribology of Bearings.*

2. Dr S.P.Srivastava, *Lubricants Additives & Tribology*, 2008, Tech book international,New Delhi

Elective -III

MACHINE FAULT DIAGNOSTICS & SIGNAL PROCESSING (3-0-0)

Introduction. Maintenance Principles. Basics of Machine Vibration. Signal Analysis. Computer based data acquisition. Time domain Signal analysis. Introduction to MATLAB. Signal Processing Exercises with MATLAB. Fault detection transducers and instrumentation. Vibartion monitoring. In- Situ field balancing of rotors. Condition monitoring of rotating machines. Noise monitoring. Wear and debris analysis.Thermography. Electrical Motor Current Signature Analysis. Ultrasonics in Condition Monitoring.NDT Techniques in Condition monitoring.

Text Books:

1. Introduction to Machinery Analysis and Monitoring – J. S. Mitchell. Pennwell Publishers.

Reference Books

1. Engineering Vibration – D. Inman. Tata Mc GrawHill.
2. Vibration Monitoring and Diagnosis – Ralph A. Collocott. Chapman and Hall.
3. Shock and Vibration Handbook – Harris and Crede. Mc GrawHill.

MECHATRONICS (3-0-0)

Fundamental of Mechantronics: Definition and concepts of Mechatronics, Conventional system vs. mechatronic system, Need and Role of Mechantronics in Design, Manufacturing and Factory Automation. Hardware components for Mechatronics Number system in Mechatronics, Binary Logic, Karnaugh Map Minimization, Transducer signal conditioning and Devices for Data conversion programmable controllers. ; Sensors and Transducers: An introduction to sensors and Transducers, use of sensor and transducer for specific purpose in mechatronic. ; Signals, systems and Actuating Devices: Introduction to signals, systems and control system, representation, linearization of nonlinear systems, time Delays, measures of system performance, types of actuating devices selection. ; Real time interfacing: Introduction, Element of a Data Acquisition and control system, overview of the I/O process. Installation of the I/O card and software. ; Application of software in Mechatronics: Advance application in Mechantronics. Sensors for conditioning Monitoring, Mechatronic Control in Automated Manufacturing, Micro sensors in Mechatronics. Case studies and examples in Data Acquisition and control. Automated manufacturing etc.

Essential Reading:

1. C.W.De Silva, *Mechatronics: An Integrated Approach,* Publisher: CRC;

MECHANICS OF COMPOSITE MATERIALS (3-0-0)

Classification and characterization of composite materials; fibrous, laminated and particulate composites; laminae and laminates; manufacture of laminated fiber reinforced composite material. Macromechanical behaviour of lamina; stress strain relations, engineering constraints for orthotropic materials. Stress strain relations for lamina of arbitrary orientation. Strength and stiffness of an orthotropic lamina; Biaxial strength theories. Micromechanical behaviour of laminae. Rule of mixtures. Micromechanical behaviour of laminates: single layered configurations, symmetric laminates, anti-symmetric laminates, known symmetric laminates; strength of laminates; Interlaminar stresses; Design of laminates. Buckling and vibration of laminated beams, plates and shells.

Text Books:

1. Mechanics of Composite Materials – R. M. Jones. Taylor & Francis.

Reference Books:

1. Mechanics of Laminated Composite Plates and Shells – J. N. Reddy. CRC Press .
2. Stress Analysis of Fiber- Reinforced Composite Materials – M. W. Hyer. WCB Mc-GrawHill.

Elective -IV

FEM IN ENGINEERING (3-0-0)

Basic Concepts: The standard discrete system, Finite Elements of an elastic continuum-displacement approach, Generalization of the finite element concepts-weighted residual and variational approaches, Element types: triangular, quadrilateral, sector, curved, isoparametric elements and numerical integration. Automatic mesh generation schemes. Application to structural mechanics problems: plane stress and plane strains, Axisymmetric stress analysis, three dimensional stress analysis, bending of plates. Introduction to the use of FEM in steady state field problems – heat conduction, fluid flow and nonlinear material problems, plasticity, creep etc. Computer procedures for Finite element analysis.

Text Books:

1. Finite Element Method: Its Basis and Fundamentals. O. C. Zienkiewicz, R. L. Taylor and J. Z. Zhu. Elseiver, 2005.
2. Finite Element Methods – J. N. Reddy. Tata Mc Graw Hill.
3. Introduction to the Finite Element Method–C.S. Desai & J.F.Abel .East West Pvt. Ltd., 1972.

Reference Books:

1. Concepts and Applications of finite Element Analysis–R.D.Cook, John Wiley & Sons.
2. The Finite Element Method in Engineering–S.S. Rao. Butterworth-Heinemann, .
3. Finite Element Analysis – H. V. Lakshminarayan, University Press.
4. Finite Element Methods vs. Classical Methods – H. S. Govind Rao, New Age Pub,
5. Finite Element Analysis – T. Chandrupatla, University Press.
6. Energy and Finite Element Methods in structural Mechanics – Irving H. Shames & Clive Dym, New Age Publications, 2006.

COMPUTER GRAPHICS & VISUALIZATION (3-0-0)

Raster graphics and volume graphics. Video basics. Display devices and interactive devices; 2-D and 3-D graphics primitives. Clipping in 2-D and 3-D; Generation and projection of 3-D wire frame solid models, polygonal models. Space curves and surface models. Intersection of surfaces and blending; hidden line and hidden surface elimination algorithms. Ray-surface intersection and inverse mapping algorithms. Ray tracing for photo realistic rendering. Illumination models. Shading, Transparency, Shadowing and Texture mapping; Representation of colours.

Visualization of experimental and simulated data. Surface construction from scattered data, 3-D data arrays and 2-D cross sections. Elevation maps, topological maps, contour maps and intensity maps; fractals for visualization of complex and large data sets. Algebraic stochastic and Geometrical fractals. Modeling of natural forms and textures using fractals; Visualization of multi variate relations . Flow visualization and hyper streamlines; visualization of Metrological, cosmological, seismic, biological data for scientific decision making.

Animation, Modeling issues in dynamic visualization. Behavioral animation; walk through coordinate transformation and view transformation; virtual reality interfaces. Interactive and immersive systems for prototyping and visualization; Visualization in concurrent engineering. Interactive multimedia technology and standards for Video-Graphics-Audio integration and tele-video conferencing

Text Books

1. CAD/CAM : Computer-Aided Design and Manufacturing - M. P. Groover and E.W. Zimmer, PHI, 1995

Reference Books

1. AutoCAD 2002 - New Riders, Techmedia
2. Computer Aided Analysis and Design of Machine Elements - V. D. Rao, M. Ananda Rao and Rama Bhat. New Age International.

DYNAMICS OF ROTORS (3-0-0)

Rudiments of Rotor Dynamics, Rotor Dynamic considerations in machinery design, critical speeds and unbalance response. Factors affecting them such as gyroscopic action, internal damping, fluid film bearings. Methods for analysis such as Transfer Matrix, FEM etc. Vibration of Discs, disc gyroscopics, synchronous and non synchronous whirl, analysis of rotors mounted on hydrodynamic bearings, application to two spool and multispool rotors. Analysis of asymmetric shafts.Parametric excitation and instability due to fluid film forces and hysteresis. Effect of support nonlinearities. Rigid rotor balancing. Torsional vibration. Balancing of rotors. Concepts of condition monitoring.

Text Books:

1. Rotor Dynamics – J. S. Rao. New Age International Publications, 3rd Edition.

Reference Books:

1. Dynamics of Rotor Bearings Systems – M. J. Goodwin. Unwin Hyman
2. A Matrix Method in Elastomechanics – E. C. Petal and F. A. Leckie. Mc Graw Hill.
3. Rotor Dynamics – E. K. Kramer. Springer Verlag.
4. Rotor Dynamics – H. D. Nelson and E. J. Guntur. Mc Graw Hill Book Co.
5. Rotor Dynamics – J. S. Vance. Mc Graw Hill Book Co.
6. Some Problems of Rotordynamics – A. Tondol. House of Czechoslovakia Academy of Science, Prague.

VIBRATION AND SHOCK ISOLATION (3-0-0)

Vibration under general forcing conditions: Response under general periodic force, Periodic force of irregular from and non-periodic force response spectrum (for Base excitation, Earth quake response spectra and design under a shock environment) response to irregular forcing conditions using numerical methods,

Vibration Control: Vibration monograph, and vibration criteria, reduction of vibration at the source, Balancing of rotating machines, whirling of rotating shaft, Balancing of reciprocating engines, controls of vibration and natural frequencies.

Vibration Isolation: Vibration isolation systems with rigid foundation, isolation of science of vibration from surroundings, vibration isolation system with flexible foundation and with partially flexible foundation, shock isolation, active vibration control, vibration absorbers both damped and undamped.

TEXT BOOKS:-

1. Mechanical Vibrations-S. S. Raa. Pearson Theory of
2. Vibrations with applications W. T. Thomason, CBS Publication
3. Mechanical Vibration- J. S. Rau and K. N. Gupta, New-Age intimation

Electives – V

ROBOTICS (3-0-0)

Robotics: Historical back ground, Definitions. Laws of Robotics, Robotics systematic robot anatomy ; Common Robot configurations, coordinate system, work envelop. Elements of robotic system and effector, actuators, controller, teach pendant, sensors Specification of robots. Applications, Safety measures. ; Robot Kinematics: Forward and reverse Kinematics of 3 DOF Robot arms. Homogeneous transformations. Kinematics equation using homogeneous transformations. ; Actuators: Hydraulic actuators. Pneumatic actuator, Electrical actuators, Directional control, Servo ; Control Flow control valves. ; End effectors: Classification, Drive systems. Magnetic, Mechanical, Vacuum and Adhesive Grippers, force analysis in Grippers. ; Sensors: Need for sensing systems, Sensory devices, Types of sensors, Robot vision system Robot Languages and Programming: Types of Programming, Motions Programming, Robot Languages - VAL systems. ; Flexible automation: Technology, FMS, Function of Robot in FMS flexible manufacturing cell.

Essential Reading:

1. S.R Deb, *Robotic technology and flexible automation* - TMH.

Supplementary Reading:

1. Lee, Fu, Gonzalez, *Robotics* - Mc Graw Hill.
2. Groover, *Industrial Robot* - Mc Graw Hill.
3. Paul Afonh, *Robots manufacturing and application* - John Wiley.

EXPERIMENTAL STRESS ANALYSIS (3-0-0)

Basic elasticity theory.

Strain Measurement Methods: Various types of strain gauges, Electric Resistance strain gauges, semiconductor strain gauges, strain gauge circuits, transducer applications, recording instruments for static and dynamic applications.

Photoelasticity: Theory of photoelasticity, Analysis techniques, Three dimensional photoelasticity, Reflection Palanscope and application.

Brittle coating methods of strain indication.

Grid method of strain analysis.

Computer interfacing and on-line monitoring of strain and stress fields.

Text Books:

1. Experimental Stress Analysis – J. W. Dally and W. F. Riley. Mc GrawHill, 1965.

Reference Books:

1. Experimental Stress Analysis and Motion Measurement – R. C. Dove and P. H. Adams. PHI, 1965.
2. Applied Stress Analysis – A. J. Durelli. PHI, 1970.

NONLINEAR VIBRATION (3-0-0)

Introduction, Linear vibration, Free vibrations of undamped systems with nonlinear restoring forces, Free oscillations with damping and the geometry of integral curves – a) study of singular points, b) applications using the notion of singularities, Forced oscillations of systems with nonlinear restoring force, self sustained oscillations – a) free oscillations, b) forced oscillations in self-sustained systems, Hill's equation and its application to the study of the stability of nonlinear oscillations.

Essential Reading:

1. A.H. Nayfeh, *Applied nonlinear dynamics: analytical, computational, and experimental methods*, Wiley-Interscience, Jan. 1995.
2. Ali H. Nayfeh, *Nonlinear interactions: analytical, computational, and experimental methods*, Wiley-Interscience, June 2000.

Supplementary Reading:

1. A.H. Nayfeh and P.F. Pai, *Linear and nonlinear structural mechanics*, Wiley-Interscience, May 2004.
2. A.H. Nayfeh and D. T. Mook. *Nonlinear oscillations.*
3. A.H. Nayfeh. *Perturbation technique.*

MICROPROCESSOR APPLICATION LAB (0-0-3)

1. (i) Acquintance with Intel 8085 kit.
   (ii) Simple programs involving arithmetic, data transfer logical, branching instructions.
2. 8085 assembly language programming for
   (i) Cumulative addition of data bytes result 2 bytes.
   (ii) Block move of data bytes
   (iii) Bit reversal of a data byte
   (iv) Hexadecimal to BCD and grey code conversion
   (v) Finding the largest/smallest data byte from a given data array
3. 8085 interfacing with
   (i) 8255 PDI (ii) 8253 Timer
   (iii) 8259 PIC Controller (iv) A/D and D/A converter
4. Stepper motor control using 8085 microprocessor
5. Study of EPROM programmer
6. (i) Acquintance with 8086 microprocessor kit and use of assembler
   (ii) Simple programming involving data transfer, arithmetic, logical and branching instructions
7. (i) Acquintance with 8051 microcontroller kit.
   (ii) Simple programmes using 8051instructions and I/O lines

****