

# Biju Patnaik University of Technology, Orissa

## MTech in Mechanical System Design

### First Semester:

Subject No.	Subject Name	L-T-P	Credit
MDPC101	Advanced Mechanics of Solids	3-1-0	4
MDPC102	Applied Elasticity and Plasticity	3-1-0	4
MDPC103	Machine Vibration	3-1-0	4
	Elective I	3-0-0	3
	Elective II	3-0-0	3
MDCV101	Seminar- I	0-0-3	2
HTPR101	Engineering Software Lab	0-0-3	2
MDPR101	Machine Design and Analysis Lab	0-0-3	2
	TOTAL		24

#### Elective I: Design Group

- MDPE101 Fatigue, Creep and Fracture
- MDPE102 Optimum Design of Mechanical Systems
- MDPE103 Analysis and Design of Pressure Vessels and Components
- MDPE104 Acoustics and Noise Control

#### Elective II: Dynamics Group

- MDPE105 Numerical Analysis
- MDPE106 Instrumentation and Automatic Control Systems
- MDPE107 Advanced Mechanisms of Machines
- MDPE108 Material Selection in Mechanical Design

### Second Semester:

Subject No.	Subject Name	L-T-P	Credit
MDPC201	Basic Mechanical Handling Systems	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
MDPR201	Microprocessor Applications Lab	0-0-3	2
MDPR202	Tribology Lab	0-0-3	2
MDCV201	Seminar- II	0-0-3	2
MDCV202	Comprehensive Viva Voce - I	0-0-3	2
	TOTAL		25

#### Elective – III (Any One):

- MDPE201 Machine Fault Diagnosis and Signal Processing
- MDPE202 Mechanical Drives
- 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

**Elective – V (Any One):**

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

**Third Semester:**

Subject Name	L-T-P	Credit
Open Elective	3-0-0	3
Thesis (Part-1)	0-0-0	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

**Fourth Semester:**

Subject No.	Subject Name	L-T-P	Credit
MDCV401	Seminar- III	0-0-3	2
MDPT401	Thesis (Part-2)	0-0-0	20
MDCV402	Comprehensive Viva Voce - II	0-0-3	2
	TOTAL		24

**Total = 90 credits**

# ADVANCED MECHANICS OF SOLID (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, 2<sup>nd</sup> edition, 1952.
2. Advanced Mechanics of Materials, 4<sup>th</sup> edition A. P. Boresi and O. M. Sidebottom. John Wiley 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.

# 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, Kirchhoff 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

# **MACHINE VIBRATION (3-1-0)**

Characterization of Engineering vibration problems. Model study through single degree of freedom analysis. Two degrees and Multi degree of freedom system with application. Continuous medium, Vibration measuring instruments, computational techniques like matrix iterations, Transfer Matrix method and other methods, Lagrange's Mechanics, system simulation technique.

## **Text Books**

1. Mechanical Vibration : Theory and Applications - F.S. Tse, I.E. Morse and R.T. Hinkle. CBS Publishers, 2002.
2. Theory of Vibration with Application - W.T. Thomson, PHI, 1979.

## **Reference Books**

1. Principles of Vibration Control - A. K. Mallick, East-West Press, 1990.
2. Mechanical Vibrations - S. S. Rao. Pearson, 2004.
3. Advanced Theory of Vibration - J.S. Rao. New Age Publication.
4. Introductory course on Theory and Practice of Mechanical Vibration - J.S.Rao and K. Gupta. New Age Publication, 2004.

## **Electives - I**

# **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, 2005.
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.

# OPTIMUM DESIGN OF MECHANICAL SYSTEMS (3-0-0)

Basic concepts : Unconstrained and constrained problems. The Kuhn-Tucker conditions; Function of one variable, Polynomial approximations, Golden section method. Finding the bounds on the solution, a general strategy for minimizing functions of one variable; Unconstrained functions of n variables : Zero order, first-order and second-order methods, convergence criteria; constrained functions of n variables: linear programming, Sequential unconstrained minimization techniques, Direct Methods; Approximation techniques; Duality; General design application.

## Text Books

1. Optimization for Engineering Design - K. Deb, PHI, 2005
2. Engineering Optimization - S.S.Rao, New Age International Pvt. Ltd. 1998.

## Reference Books

1. Introduction to Optimization - J.C.Panth, Jain Brothers Publication, New Delhi, 1983

## Electives -II

### NUMERICAL ANALYSIS (3-0-0)

Transcendental and Polynomial equations: Initial approximations, First Degree Equation, Iteration Methods Based on Second Degree equation, Multipoint iteration method, Rate of Convergence, Efficiency of a method.

System of Linear Algebraic Equations: Effects of Round-off Error, Operations Counts, Standard Methods of Solutions, Convergence analysis Eigenvalues and Eigenvectors

Interpolation: Lagrange Polynomial Interpolation, Cubic Spline Interpolation,

Numerical Differentiation - Finite Differences: Construction of Difference Formulae. Accuracy of Finite Differences, Pade Approximations, Non-Uniform Grids.

Numerical Integration: Trapezoidal and Simpson's Rules, Error Analysis, Integration and Extrapolation, Quadrature.

Numerical Solution Of Ordinary Differential Equations: Initial Value Problems, Numerical Stability, Stability Analysis, Implicit, Runge-Kutta Methods, Multi-Step Methods, System Of First-Order Ordinary Differential Equations, Boundary Value Problems.

Numerical Solution of Partial Differential Equations: Semi-Discretization, von Neumann Stability Analysis, Modified Wave number Analysis, Implicit Time Advancement, Accuracy, Implicit Methods in Higher Dimensions, Approximate Factorization, Stability of the Factored Scheme, Alternating Direction Implicit Methods, Mixed and Fractional Step Methods, Elliptic Partial Differential Equations

Discrete Transform Methods: Discrete Fourier series, Applications, Finite Differenced Elliptic Equations, Fourier Spectral Numerical Differentiation, Discrete Transform and Applications, Numerical Differentiation.

## Text Books:

1. Numerical Methods for scientific & Engg Computation- M. K. Jain, S. R. K. Iyengar & Jain.
2. Numerical Methods for Engineers – S. C, Chapra and R. P. Canale. Mc GrawHill.

## Reference Books

1. Numerical Methods – S. S. Rao.
2. Numerical Methods in Science & Engg:A Practical Approach–S.Rajashekharan.Wheeler Pub.
3. Numerical Recipes – W. H. Press, S. A. Teukolosky, W. T. Vetterling and B. P. Flannery Cambridge University Press.

# **INSTRUMENTATION & AUTOMATIC CONTROL SYSTEMS (3-0-0)**

Classification and representation of control systems. Influence of type of control on steady state and transient response. Time and frequency domain analysis. Stability analysis using Routh and Nyquist criteria. Root Locus method. Modern Control theory. Sequence Control and Programmable logic controllers. Control components... Comparators, Hydraulic, Pneumatic and Electrical Type of controllers, Servo Motors. Electromechanical and Electro-optical transducers and control elements. Signal conditioning and indicating/recording elements.

Computer based data acquisition systems, A-D and D-A Converters. Microprocessor applications in measurement and control. Static and dynamic analysis of instrument systems. Signal and systems analysis. FFT analyzers. Current developments in measurement and control of motion, force, torque, pressure, temperature, flow, noise and vibration etc. Virtual instrumentation, LASER based instrumentation.

## **Text Books**

1. Mechanical Measurements - T.G. Beckwith, N.L. Buck, R.B. Marangoni. Narosa Publishing House 3<sup>rd</sup> Edition, 1982
2. Measurements System : Application and Design - Ernest O. Doebelin, Mc-Graw Hill Books Co., 1990, 4<sup>th</sup> Edition.
3. Modern Control Engineering - K. Ogata, PHI, 3<sup>rd</sup> Edition, 2000.

## **Reference Books**

1. Theory and Application of Automatic Controls - B.C.Nakra, New Age International Pvt. Ltd., New Delhi, 1998.
2. Transducers and Instrumentation, PHI, New Delhi, 1995.
3. Sensors and Transducers - D. Patranabis, Wheeler Publishing, ND, 1997.
4. Instrumentation-Devices and Systems - C.S.Rangan, G.R.Sarma and V.S.V.Mani, TMH, New Delhi, 1983.
5. Vibration Measurement and Analysis - B.C.Nakra, G.S.Yadava and L. Thuestad, National Productivity Council, New Delhi, 1989.

# **ADVANCED MECHANISMS OF MACHINES (3-0-0)**

Introduction to mechanism synthesis, Analytical and numerical methods in kinematics; Dynamics of Mechanisms; Matrix methods in Kinematics, Envelope theory, Optimal synthesis and analysis of mechanisms, Kinematic and Dynamic analysis of spatial mechanisms, synthesis of spatial mechanisms of path and function generations.

## **Text Books:**

1. Theory of Machines and Mechanisms – J. E. Shigley and Jr. J. J. Uicker. Mc GrawHill Inc. 1998.
2. Theory of Mechanisms and Machines – Amitava Ghosh and Mallik. EWP, New Delhi.

## **Reference Books:**

1. Mechanism Synthesis Analysis – A. H. Soni, Mc GrawHill Co, New York.
2. Kinematics Analysis of Mechanisms - J. E. Shigley. Mc GrawHill Co, New York.
3. Mechanics of Machines – V. Ramamurti. Narosa Publishing House.

# 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

## **MACHINE DESIGN AND ANALYSIS LAB (0-0-3)**

1. (a) Tensile Test (UTM)  
(b) Compression Test
2. Izod and Charpy Tests
3. Fatigue Test
4. Hardness Test
5. Vibration Mode Shape Study and determination of damping coefficient
6. Rotordynamics (Determination of dynamic response and critical speed)
7. Friction and wear monitor
8. 4 Ball tester
9. Study of bearings and bearings characteristics (Journal bearing and Roller bearing)
10. Calibration of LVDT using Indicator/CRO.



# Semester -II

## **BASIC MECHANICAL HANDLING SYSTEMS (3-0-0)**

Objectives and Principles of Material Handling. Classification of handling equipment. Quantitative techniques for analysis of material flow.

Design of basic elements like-wire ropes, chain hooks, shackles, grab, lifting electro-magnets, pulleys, sheaves, sprockets, drums, arresting gears, buffers, limit switches, rope tackle and pulley blocks, various power transmission units like gearing, belting, winches, capstans etc.

Kinematics analysis and basic design procedure of various forms of conveying and elevating equipments like scrapes, conveyors, Belt conveyor, Belt Chain, Bucket elevators, Enmasses chain conveyor, Overhead chain conveyors, crew and Ribbon conveyors, electric hoists, jibcranes, EOT cranes, Gantry cranes, Mobile Cranes etc.

### **Text Books**

1. Material Handling Equipments - N. Rudenko. Envee Publishers, ND, 1978.
2. Conveying Machines (Vol I & II) - A.O.Spivakovsky, & V.K. Dyachkav. MIR Publication
3. Mechanical Engg Design - J.E.Shiegley. Mc-Graw Hill Book Co., 1986.
4. Design of Machine Elements - M.F. Spotts and T.E. Shoup. PHI, 1998.

### **Reference Books**

1. Design of Machine Elements - V. Dobrovolsky, et al., MIR Publishers, 1977.
2. Machine Design - D.N. Reshetov. MIR Publishers, 1978.

## **BEARING & LUBRICATION (3-0-0)**

Introduction, Surfaces: Nature, Characterization and effects, Friction : Mechanisms and Types, Wear : Nature, Mechanism and types, Surface Temperature Formulation and Measurements, Friction and wear of metals, polymers and composites, Methods of improving tribological behavior,

Lubricants : Friction control and wear prevention, Characterization, types and selection, effects and testing of lubricants. Mechanisms of fluid flow : Reynolds equations and its applications to infinite long and short journal bearings and its limitations

Lubrifications : Reigms; Hydrodynamics, Hydrostatics, Elastohydrodynamic lubrication, etc. Bearing Design and design considerations

### **Text Books**

1. Introduction to Tribology of Bearings - B.C.Majumdar, Wheeler Publication, 1999.

### **Reference Books**

1. Friction & Wear of Materials-E. Rabinowicz, John Wiley & Sons Inc. ISBN 0-471-83084-4, 1995.
2. Tribology : Friction, Lubrication and Wear - Z. Andras Szeri, ISBN 0070626634, 1980
3. Principles and Applications of tribology - Bharat Bhusan, Hardcover, 1999.
4. Engineering Tribology(Tribology Series,24)-G.W. Stachowiak, A.W.Batchelor, ISBN 0444892354, 1993
5. Engineering Tribology - Prasant Sahoo, PHI Pvt. Ltd.
6. Fundamentals of Tribology - S.K.Basu, S.N.Sengupta, B.B.Ahuja, PHI Pvt. Ltd.
7. Tribology in Industries – S. K. Srivastava. S. Chand and Company Ltd., New Delhi.

## Elective -III

# MACHINE FAULT DIAGNOSTICS AND 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. Vibration 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.

# MECHANICAL DRIVES (3-0-0)

Transmission and its requirements. Matching of load and prime mover. Design of transmission elements. Clutches and brakes. Coupling of different type. Uniform and variable speed transmission. Toothed gears; kinematic requirements of tooth geometry, cycloid and involutes. Involute trigonometry. Various gears – Helical, Herringbone, Bevel, spiral bevel, Skew Helical and Worm Gearing. Programmed Motion and intermittent motion. Mechanisms of various types.

### Text Books

1. Machine Elements - V. Dobrovolsky, et al., MIR Publication, 1977.
2. Materials Handling Equipment - N. Rudenko, Envee Publishers, ND, 1978.
3. Design of Machine Elements - M. F. Spotts and T. E. Shoup, PHI, 1998.

### Reference Books

1. Machine Design - D. N. Reshetov, MIR Publication, 1978.
2. Mechanical Engineering Design - J. E. Shigley, Mc GrawHill Book Co., 1986.
3. Theory of Machines and Mechanisms - J. E. Shigley and Jr. J. J. Uicker, Mc GrawHill Book Co. Inc, 1995.

# Mechatronics

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 (3-1-0)

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 McGrawHill.

# Elective -IV

## FEM IN ENGINEERING (3-1-0)

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. Elsevier, 2005.
2. Finite Element Methods – J. N. Reddy. Tata Mc GrawHill.
3. Introduction to the Finite Element Method – C. S. Desai and J. F. Abel. East West Pvt. Ltd., 1972.

### Reference Books:

1. Concepts & Applications of finite Element Analysis–R. D. Cook, John Wiley & Sons.
2. The Finite Element Method in Engineering –S.S.Rao.Butterworth-Heinemann, 1999.
3. Finite Element Analysis – H. V. Lakshminarayan, University Press.
4. Finite Element Methods vs. Classical Methods–H.S.Govind Rao,New Age Pub.,2007.
5. Finite Element Analysis – T. Chandrupatla, University Press.
6. Energy & 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, 3<sup>rd</sup> 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 Book Co.
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.

# ROBOTICS

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) Acquaintance 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) Acquaintance with 8086 microprocessor kit and use of assembler  
(ii) Simple programming involving data transfer, arithmetic, logical and branching instructions
7. (i) Acquaintance with 8051 microcontroller kit.  
(ii) Simple programmes using 8051 instructions and I/O lines

**Semester –III**

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