**SYLLABUS**

**FOR**

**TWO-YEAR M. TECH. PROGRAMME**

**IN**

**DESIGN AND DYNAMICS**



|  |
| --- |
| **NAAC – A Grade** |

**DEPARTMENT OF MECHANICAL ENGINEERING**

**COLLEGE OF ENGINEERING & TECHNOLOGY**

**(An Autonomous and Constituent College of BPUT, Odisha)**

**Techno Campus, Mahalaxmi Vihar, Ghatikia,**

**Bhubaneswar-751029, Odisha, INDIA**

[**www.cet.edu.in**](http://www.cet.edu.in)

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**COURSE: M. Tech. (ME – Design and Dynamics), Duration: 2 years (Four Semesters)**

**Abbreviations Used: U= UG, I= Integrated, P= PG**

**PC= Professional Core PE= Professional Elective OE= Open Elective**

**LC= Lab Course MC= Mandatory Course AC= Audit Course**

**L= Lectures P= Practical/Laboratory IA\*= Internal Assessment**

**T= Tutorial PA= Practical Assessment EA=End-Semester Assessment**

**\*Internal Assessment Max. Mark (30 marks) consists of Mid Semester (20 marks) and Quiz+Assignment (10 marks)**

**Subject Code Format:**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** |
| **Prog (U/I/P)** | **Type (PC/PE/OE/LC/MC/AC)** | | **Department (CE/EE/IE/ME/…)** | | **Semester (1/2/…/0)** | **Serial No. (1/2/3/…/99)** | |

**1st SEMESTER**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **S N.** | **Subject**  **Type** | **Subject**  **Code** | **Subject**  **Name** | **Teaching Hours** | | | **Credit** | **Maximum Marks** | | | |
| **L** | **T** | **P** | **IA** | **EA** | **PA** | **Total** |
| 1 | Core 1 | PPCME101 | Applied Elasticity and Plasticity | 3 | 0 | 0 | 3 | 30 | 70 | - | 100 |
| 2 | Core 2 | PPCME102 | Analysis & Synthesis of Mechanism | 3 | 0 | 0 | 3 | 30 | 70 | - | 100 |
| 3 | Professional Elective 1  (Any One) | PPEME101 | Applied Finite Element Analysis | 3 | 0 | 0 | 3 | 30 | 70 | - | 100 |
| PPEME102 | Knowledge based systems in Mechanical Engineering |
| PPEME103 | Experimental Techniques in Mechanical Engineering |
| PPEME104 | Wave propagation in solids |
| 4 | Professional Elective 2  (Any One) | PPEME112 | Composite Materials | 3 | 0 | 0 | 3 | 30 | 70 | - | 100 |
| PPEME113 | Optimization Methods in Mechanical Design |
| PPEME114 | Material Selection in Mechanical Design |
| PPEME115 | Smart Structures |
| 5 | Mandatory | PMCMH101 | Research Methodology & IPR | 2 | 0 | 0 | 2 | 30 | 70 | - | 100 |
| 6 | Lab 1 | PLCME101 | Kinematics and Dynamics Lab | 0 | 0 | 4 | 2 | - | - | 100 | 100 |
| 7 | Lab 2 | PLCME102 | Advanced Design Lab | 0 | 0 | 4 | 2 | - | - | 100 | 100 |
| **Total** | | | | **14** | **0** | **8** | **18** | **150** | **350** | **200** | **700** |
| 8 | Audit 1 | Any one subject from Appendix-I | | | | | | | | | 100 |
| **Grand Total** | | | | | | | | | | | **800** |

**2nd SEMESTER**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Sl. No.** | **Subject**  **Type** | **Subject**  **Code** | **Subject**  **Name** | **Teaching Hours** | | | **Credit** | **Maximum Marks** | | | |
| **L** | **T** | **P** | **IA** | **EA** | **PA** | **Total** |
| 1 | Core 3 | PPCME201 | Computer Aided Design and Rapid Prototyping | 3 | 0 | 0 | **3** | 30 | 70 | - | 100 |
| 2 | Core 4 | PPCME202 | Advanced Mechanical Vibration | 3 | 0 | 0 | **3** | 30 | 70 | - | 100 |
| 3 | Professional Elective 3  (Any One) | PPEME201 | Computational Techniques and Soft Computing | 3 | 0 | 0 | **3** | 30 | 70 | - | 100 |
| PPEME202 | Acoustics and Noise Control |
| PPEME203 | Nonlinear Vibration |
| PPEME204 | Rotor Dynamics |
| 4 | Professional Elective 4  (Any One) | PPEME212 | Robotics | 3 | 0 | 0 | **3** | 30 | 70 | - | 100 |
| PPEME213 | Mechatronics |
| PPEME214 | MEMS and Nanotechnology |
| PPEME215 | Machine Fault Diagnosis and Condition Monitoring |
| 5 | Common | PPRME201 | Literature Review Seminar | 0 | 0 | 4 | **2** | - | - | 100 | 100 |
| 6 | Lab 3 | PLCME201 | Robotics and Mechatronics Lab | 0 | 0 | 3 | **2** | - | - | 100 | 100 |
| 7 | Lab 4 | PLCME202 | Computational Techniques and Soft Computing Lab | 0 | 0 | 3 | **2** | - | - | 100 | 100 |
| **Total** | | | | **12** | **0** | **12** | **18** | **120** | **280** | **300** | **700** |
| 8 | Audit 2 | Any one subject from Appendix-II | | | | | | | | | 100 |
| **Grand Total** | | | | | | | | | | | **800** |

**3rd SEMESTER**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Sl. No.** | **Subject**  **Type** | **Subject Code** | **Subject**  **Name** | **Teaching Hours** | | | **Credit** | **Maximum Marks** | | | |
| **L** | **T** | **P** | **IA** | **EA** | **PA** | **Total** |
| 1 | Professional Elective 5  (Any One) | PPEME301 | Control system Engineering | 3 | 0 | 0 | 3 | 30 | 70 | - | 100 |
| PPEME302 | Design of Material Handling Equipment |
| PPEME303 | Fatigue, creep and Fracture of Engineering Components |
| 2 | Open Elective | Any one subject from Appendix-III | | 3 | 0 | 0 | 3 | 30 | 70 | - | 100 |
| 3 | Project 1 | PPRME301 | Phase-I Dissertation | 0 | 0 | 20 | 10 | - | - | 100 | 100 |
| **Total** | | | | **6** | **0** | **20** | **16** | **60** | **140** | **100** | **300** |

**4th SEMESTER**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Sl. No.** | **Subject**  **Type** | **Subject**  **Code** | **Subject**  **Name** | **Teaching Hours** | | | **Credit** | **Maximum Marks** | | | |
| **L** | **T** | **P** | **IA** | **EA** | **PA** | **Total** |
| 1 | Project 2 | PPRME401 | Phase-II Dissertation | 0 | 0 | 32 | **16** | - | - | 100 | 100 |
| **Total** | | | | 0 | 0 | 32 | **16** |  |  |  | **100** |

**Abstract of Credit and Marks Distribution**

|  |  |  |  |
| --- | --- | --- | --- |
| **Sl. No.** | **Semester** | **Maximum Credits** | **Maximum Marks** |
| 1 | 1st Semester | 18 | 800 |
| 2 | 2nd Semester | 18 | 800 |
| 3 | 3rd Semester | 16 | 300 |
| 4 | 4th Semester | 16 | 100 |
| **Total** | | **68** | **2000** |

**NB:**

* **Any one of the Courses in Appendix-I is to be Decided by the Concerned Department for Audit-1 (1st Sem)**
* **Any one of the Courses in Appendix-II is to be Decided by the Concerned Department for Audit-2 (2nd Sem)**
* **Any one of the Courses in Appendix-III is to be Decided by the Concerned Department for Open Elective (3rd Sem)**

**Semester-1**

**Core 1: Applied Elasticity and Plasticity (PPCME101)**

**Module-I**

Elasticity, Fundamental Assumptions in Elementary Elasticity, Stress, Strain, Plane Stress and Plane Strain. Stress-strain relations for linearly elastic solids, Generalized Hooke’s law. Stress and Strain at a point, measurement of surface strains, equilibrium equations, compatibility conditions, boundary conditions and Airy’s stress function.

Analysis of Stress and Strain in Three Dimensions: Principal Stresses, Determination of the Principal Stresses and Maximum Shear Stresses, Stress Invariants. Tensor character of stress.

**Module-II**

Two-dimensional problems in Rectangular Coordinates: Solutions by Polynomials, Determination of displacements, Bending of a Cantilever Loaded at the end, Bending of a Beam by Uniform Loading. Kirkhhof and Mindlin concept. Two-dimensional problems in Polar Coordinates: General Equations in Polar Coordinate, Stress Distributions Symmetrical about an Axis, Pure bending of Curved Bars, Strain Components in Polar Coordinates, Displacements for Symmetrical Stress Distributions, Rotating Disks.

**Module-III**

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., New York, 1988.
2. Johnson and Mellor, *Engineering Plasticity-* Van-Nostrand., 1st edition, 1983
3. J. Chakrabarty, Theory of Plasticity, McGraw-Hill Book Company, New York 1990

**Reference Books**

1. Irving 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

**Core 2: Analysis and Synthesis of Mechanism (PPCME102)**

**Module I**

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**

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**

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.

**Text Books:**

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
3. 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

**PE 1: Applied Finite Element Analysis (PPEME101)**

**Module I**

**Introduction to Finite Element Method:** Basic Steps in Finite Element Method to solve mechanical engineering (Solid, Fluid and Heat Transfer) problems: Functional approach and Galerkin approach, Displacement Approach: Admissible Functions, Convergence Criteria: Conforming and Non-Conforming elements, Co, C1and Cn Continuity Elements. Basic Equations, Element Characteristic Equations, Assembly Procedure, Boundary and Constraint Conditions

**One-Dimensional Finite Element Formulations and Analysis in Solid Mechanics** For Bars (uniform, varying and stepped cross section). Basic(Linear) and Higher Order Elements Formulations for Axial, Torsional and Temperature Loads. (Linear) Element Formulation for uniform, varying and stepped cross section, for different loading and boundary conditions with problems. Trusses, Plane Frames and Space Frame Basic (Linear) Elements Formulations for different boundary condition in Axial, Bending, Torsional, and Temperature Loads.

**Module II**

**Two-Dimensional Finite Element Formulations for Solid Mechanics Problems:** Triangular Element, Four-Noded Quadrilateral Element Formulations for in-plane loading. Triangular and Quadrilateral Axi-symmetric basic and higher order Elements formulation for axi-symmetric loading.

**Description about Three-Dimensional Finite Element Formulations for Solid Mechanics Problems:** Finite Element Formulation of Tetrahedral Element and Hexahedral Element for different loading conditions. Serendipity and Lagrange family Elements.

**Module III**

**Finite Element Formulations for Structural Mechanics Problems:** Basics of plates and shell theories: Classical thin plate Theory, Shear deformation Theory and Thick Plate theory. Finite Element Formulations for triangular and quadrilateral Plate elements.

**Dynamic Analysis:** Finite Element Formulation for point/lumped mass and distributed masses system, Finite Element Formulation of one-dimensional dynamic analysis: bar and beam element. Finite Element Formulation of Two-dimensional dynamic analysis: triangular, quadrilateral and axisymmetric element. Evaluation of eigen values and eigen vectors applicable to bars, shaft, beams.

**Text Books:**

1. T. R. Chandrupatla and A. D. Belegundu, Introduction to Finite Elements in Engineering, Prentice Hall,

**Reference Books:**

1. Concepts and Applications of Finite Element Analysis", (4th edition), by Cook, Robert Davis et al", Wiley, John & Sons

2. A first course in the finite element method” (4th edition), by Daryl L. Logan, Cengage Learning India

3. J.N.Reddy, Introduction to Finite Element Method, McGraw -Hill,

4. Bathe K. J., Finite Element Procedures, Prentice-Hall,.

5. Cook R. D., Finite Element Modeling for Stress Analysis, Wiley,1995.

**PE 1: Knowledge Based Systems in Mechanical Engineering (PPEME102)**

**PE 1: Experimental Techniques in Mechanical Engineering (PPEME103)**

**Module I**

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.

**Module II**

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

**Module III**

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. McGraw Hill, 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.

**PE 1: Wave Propagation in Solids (PPEME104)**

**Module-I**

Waves and vibrations in strings

Waves in long strings, The D’Alembert solution, Reflection and transmission at boundaries, Free and forced vibrations of a finite string, The string on an elastic base-dispersion, Pulses in a dispersive media, Group velocity.

Longitudinal waves in thin rods

Waves in long rods, Reflection and transmission at boundaries, Waves and vibrations in a finite rod, longitudinal impact, dispersive effects in rods, torsional vibrations, Experimental studies in longitudinal waves, The split Hopkinson pressure bar.

**Module –II**

Flexural waves in thin rods

Propagation and reflection characteristics, Free and forced vibrations of finite beams, Effects of shear and rotary inertia, Experimental studies on beams, Beam vibration experiments.

Waves in membranes

Transverse motion in membranes, Plane waves, The initial-value problem, Forced vibration of a membrane, Reflection of waves from membrane boundaries, Vibrations of finite membranes.

Flexural waves in thin plates

Plane waves in an infinite plate, An initial-value problem, Forced motion of an infinite plate, Reflection of plane waves from boundaries, Free vibrations of finite plates.

**Module-III**

Waves in infinite media

Dilatational and distortional waves, plane waves, certain classical solutions of waves generated by body forces.

Waves in semi-infinite media

Propagation and reflection of waves in a half-space, Surface waves, Waves in layered media, Love waves, Experimental studies on waves in semi-infinite media.

**Text Books:**

1. Wave motion in elastic solids, Karl F. Graff, Dover Publications, 1991

**Reference Books:**

1. Wave motion in elastic solids, J. D. Achenbach, North Holland, 1984
2. Introduction to elastic wave propagation, A. Bedford and D. S. Drumheller, Wiley, 1994

**PE 2:** **Composite Materials (PPEME112)**

**Module I**

Review on definition, classification & fabrication technologies of composites. Principles of composites, micromechanics of composites. Various types of reinforcements and their properties. Role of interfaces.

**Module II**

Fabrication of metal matrix composites: insitu, dispersion hardened, particle, whisker and fibre reinforced; composite coatings by electro deposition and spray forming. ; Fabrication of polymeric and ceramic matrix composites.

**Module III**

Mechanical physical properties of composites. Mechanisms of fracture in composites. Property evaluation and NDT of composites. Wear and environmental effects in composites.

**Text Books:**

1. Mechanics of composite materials, R. M. Jones, Mc Graw Hill Book Co.
2. Mechanics of composite materials & structures, M Mukhopadhay, Universities Press.
3. Fiber-Reinforced composite materials, Manufacturing & Design, P. K. Mallick, Marcel Dekken, Inc. New York & Basel.

**Reference Books:**

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

**PE 2: Optimization Methods in Mechanical Design (PPEME113)**

**Module I**

Optimization problem formulation - Design variables, constraints, objective function and variable; bounds. Single-Variable.; Single Variable Optimization Algorithm: Bracketing

**Module II**

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.

**Module III**

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.

**Text Book:**

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

**Reference Book:**

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

**PE 2: Materials Selection in Mechanical Design (PPEME114)**

**Module I**

*Introduction:* Materials properties – chemical, physical, mechanical, dimensional; Materialscategories; 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, Applyingperformance 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**

*Manufacturing and process selection:* Classification of manufacturing processes, review ofshaping, 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 III**

*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.

**PE 2: Smart Structures (PPEME115)**

**Module-I**

**OVERVIEW OF SMART MATERIALS**

Introduction to Smart Materials, Principles of Piezoelectricty, Perovskyte Piezoceramic Materials, Single Crystals vs Polycrystalline Systems, Piezoelectric Polymers, Principles of Magnetostriction, Rare earth Magnetostrictive materials, Giant Magnetostriction and Magneto-resistance Effect, Introduction to Electro-active Materials, Electronic Materials, Electro-active Polymers, Ionic Polymer Matrix Composite (IPMC), Shape Memory Effect, Shape Memory Alloys, Shape Memory Polymers, Electro-rheological Fluids, Magneto Rhelological Fluids

**Module –II**

**HIGH-BAND WIDTH, LOW STRAIN SMART SENSORS**

Piezeoelctric Strain Sensors, In-plane and Out-of Plane Sensing, Shear Sensing, Accelerometers, Effect of Electrode Pattern, Active Fibre Sensing, Magnetostrictive Sensing, Villari Effect, Matteuci Effect and Nagoka-Honda Effect, Magnetic Delay Line Sensing, Application of Smart Sensors for Structural Health Monitoring (SHM), System Identification using Smart Sensors

**SMART ACTUATORS**

Modelling Piezoelectric Actuators, Amplified Piezo Actuation – Internal and External Amplifications, Magnetostrictive Actuation, Joule Effect, Wiedemann Effect, Magnetovolume Effect, Magnetostrictive Mini Actuators, IPMC and Polymeric Actuators, Shape Memory Actuators, Active Vibration Control, Active Shape Control, Passive Vibration Control, Hybrid Vibration Control

**Module-III**

**SMART COMPOSITES**

Review of Composite Materials, Micro and Macro-mechanics, Modelling Laminated Composites based on Classical Laminated Plate Theory, Effect of Shear Deformation, Dynamics of Smart Composite Beam, Governing Equation of Motion, Finite Element Modelling of Smart Composite Beams

**ADVANCES IN SMART STRUCTURES & MATERIALS**

Self-Sensing Piezoelectric Transducers, Energy Harvesting Materials, Autophagous Materials, Self-Healing Polymers, Intelligent System Design, Emergent System Design

**Text Books:**

1. Smart Structures, P.Gauenzi, Wiley, 2009
2. Engineering Analysis of Smart Material Systems, Donald J. Leo, Wiley, 2007

**Reference Books (For additional reading):**

1. Smart Structures and Materials, Brian Culshaw, Artech House, 2000
2. Smart material systems: model development, R.C. Smith, SIAM.
3. Self-Healing Materials: Fundamentals, Design Strategies, and Applications, Swapan Kumar Ghosh, Wiley, 2009.
4. Piezoelectricity, W.G.Cady, Dover Publication
5. Roark’s Formulas for Stress and Strain, R. J. Roark, W. C. Young, R. G. Budynas, A. M. Sadegh, McGraw-Hill, 2012.
6. Piezoelectric Transducers and Applications, A.A. Vives, Springer, 2008.
7. Microsystem Design, S. D. Senturia, Kluwer Academic Publishers, 2001.
8. Handbook of Modern Sensors, Jacob Fraden, Springer Verlag, 2010.

**MC: Research Methodology & IPR (PMCMH101)**

**Module I:**

Introduction to RM: Meaning and significance of research. Importance of scientific research in decision making. Types of research and research process. Identification of research problem and formulation of hypothesis. Research Designs.

Types of Data: Primary data Secondary data, Design of questionnaire; Sampling fundamentals ad sample designs, Methods of data collection, Measurements and Scaling Techniques, Validity & Reliability Test.

**Module II:**

Data Processing and Data Analysis-I, Data editing, Coding, Classification and Tabulation, Descriptive and Inferential Analysis, Hypothesis Testing- Parametric Test (z test, t test, F test) and non-parametric test (Chi square Test, sign test, Run test, Krushall-wallis test).

**Module III:**

Data Analysis II: Multivariate Analysis- Factor Analysis, Multiple Regression Analysis. Discriminant Analysis, Use of Statistical Packages.

**Reference Books:**

1. Research Methodology, Chawla and Sondhi, Vikas

2. Research Methodology, Paneerselvam, PHI

**Course Outcomes:**

**CO1:** Understood the Meaning of research problem, Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem.

**CO2:** Got the knowledge of How to get new ideas (Criticizing a paper) through the Literature Survey (i.e. Gap Analysis).

**CO3:** Understood the Filing patent applications- processes, Patent Search, Various tools of IPR, Copyright, Trademarks.

**CO4:** Understood How to apply for Research grants and Significance of Report Writing, Steps in Report Writing, Mechanics and Precautions of Report Writing, Layout of Research Report.

**CO5:** Got the knowledge of How to write scientific paper & Research Proposal - Structure of a conference and journal paper, how (and How Not) to write a Good Systems Paper:

**Lab 1: Kinematics and Dynamics Lab (PLCME101)**

**List of Experiments:**

**Lab 2: Advanced Design Lab (PLCME102)**

**List of Experiments:**

**Audit-1**

**[To be decided by the Department]: Refer Appendix-I**

**Semester-2**

**Core 3:** **Computer Aided Design and Rapid Prototyping (PPCME201)**

**Module I**

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.

**Module II**

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.

**Module III**

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.

**Core 4: Advanced Mechanical Vibration (PPCME202)**

**Module-I**

Review of vibration fundamentals for SDOF system, 2-DOF System and MDOF Systems: SDOF Systems: Equilibrium method, Energy method, Raylegh’s method, Laws of damping, Free Vibration, Logarithmic decrement, Forced Vibration with Harmonic Excitation, Base Excitation and Rotating Unbalance, Frequency Response, Transmissibility and Vibration Isolation, Vibration Measuring Instruments, Forced Vibration with non-harmonic and transient excitation: Fourier analysis, Response to arbitrary loading (Duhamel and Convolution Integral), Impulse response. 2-DOF and MDOF Systems: Generalized Derivation of Equation of motion, Normal mode vibration, coordinate coupling, Langrange’s equations, influence coefficients, modal analysis, orthogonality of normal modes, Free and Forced Vibration.

**Module-II**

Vibration of Continuous Systems:

Generalized Co-ordinates, Principle of dynamics: D’Alembert’s principle, Hamilton’s principle; Transverse Vibrations of Strings, Axial and Torsional Vibrations of Bars, Variational Formulation, Modal Analysis, Properties of Eigenvalue Problem, Modal Analysis, Energy Methods: Rayleigh’s method, Rayleigh- Ritz method, Initial Value Problem, Forced Vibration Analysis.

Axially Translating Strings, D’Alembert’s Solution, Harmonic Waves and Energetics of Wave Motion, Scattering of Waves, Applications of Wave Solution; Beam Models: Euler Bernouli Beam and Timoshenko Beam, Modal Analysis of Beams, Application of Modal Solution, Approximate Methods: Matrix Iteration Method, Stodola Method, Holzer method, Myklestad Thomson method, Transfer matrix method.

**Module-III**

Topics in Beam Vibrations, Wave Propagation in Beams, Vibration of Rotating Beams, Dynamics of Membranes, Vibrations of Rectangular Membrane, Vibrations of Circular Membrane, Dynamics of Plates, Vibrations of Rectangular Plates, Vibrations of Circular Plates.

**Text Books:**

1. Theory of Vibration with Applications, W. T. Thomson, CBS Publ., 1990
2. Vibrations and Waves in Continuous Mechanical Systems, Peter Hagedorn and Anirban DasGupta, Wiley, 2007
3. Dynamic of structures, Walter C. Hurty and Moshe F. Rubinstein, PHI

**Reference Books:**

1. Elements of Vibration Analysis, L. Meirovitch, TMH, Second edition, 2007.
2. Analytical Methods in Vibrations, Leonard Meirovitch, The Macmillan Co., 1967
3. Mechanical Vibrations: Analysis, Uncertainties, and Control, Haym Benaroya, Prentice Hall
4. Dynamic of structures, Ray W. Clough and Joseph Penzien, International Student Edition.
5. Advanced Theory of Vibration – J. S. Rao, New Age Publication
6. Vibration of Continuous Systems, S. S. Rao, Wiley, 2007
7. Linear and Non-linear Structural Mechanics, A. H. Nayfeh and P. F. Pai,2004

**PE 3: Computational Techniques and Soft Computing (PPEME201)**

**Module-1:**

Neural Networks: Artificial Neural Network and Introduction, Learning Rules, Knowledge Representation and Acquisition, Different Methods of Learning. Algorithms of Neural Network: Feed-forward Error Back Propagation, Hopfield Model, Kohonen’s Featrure Map, K-Means Clustering, ART Networks, RBFN, Application of Neural Network to the relevant field.

**Module-2:**

Fuzzy Logic: Basic Concepts of Fuzzy Logic, Fuzzy vs Crisp Set, Linguistic variables,Membership Functions, Operations of Fuzzy Sets, Fuzzy If-Then Rules, Variable Inference Techniques, Defuzzification, Basic Fuzzy Inference Algorithm, Fuzzy System Design, FKBC and PID Control, Antilock Breaking System(ABS), Industrial Applications.

**Module-3:**

NON-LINEAR Programming: Newton’s Method, Augmented Langrange Multiplier Method, Dynamic Programming

Genetic Algorithm: GA and Genetic Engineering, Finite Element based Optimization, Hybridization of Optimization Technique, Application of Optimization Technique for Solving Projects (Project solutions)

**Books:**

1. Neural Networks- by Simon Haykin
2. Fuzzy Logic with Engineering Application- by ROSS J.T (Tata Mc)
3. Neural Networks and Fuzzy Logic – by Bart Kosko
4. Ashok D. Begundu & chandrapatla T.R “Optimization concept and application in engineering”, Prentice Hall,1999
5. Rao S.S “Engineering Optimization”
6. Gill, Murray and Wright,” Practical Optimization”
7. Optimization Research; Prabhakar Pai, Oxford University Press.

**PE 3: Acoustics and Noise Control (PPEME202)**

**Module-I**

**Sound:** Concepts of source, pathway and receiver; Sound power and sound power level; Sound intensity and sound intensity level; Sound pressure, rms and peak values, and sound pressure level; Addition and averaging of the levels; Relationship between sound pressure and sound intensity at a location in a free field; Equations to predict the sound pressure level (and sound intensity level) due to point, line and plane sources under free field conditions. Façade effect; Source directivity, directivity index, directivity factor. Indices of time-varying sound; Physical principles of the propagation of a travelling compression wave: frequency, wavelength, speed (including effects of temperature); Equation for a one-dimensional travelling pressure wave as a function of time and position; Reflection and the laws of reflection, reflection coefficient; absorption and absorption coefficient. Porous, panel and resonant absorbers; Refraction, including meteorological effects; Diffraction, including infinite-length barriers; Absorption during propagation through the medium; Coherent and incoherent sources; Principle of superposition of waves, interference, beats, standing waves (and standing wave ratio). Principle of active noise control. Doppler effect.

**Module-II**

**Sound propagation within and between spaces**

Reverberation time, its measurement, prediction and control. Sabine equation; Diffuse sound fields, energy density, room constant, reverberant sound pressure level and its measurement, prediction and control. Sound intensity at the boundary of a diffuse field. Total sound pressure level in an enclosed space due to a directional source. Room radius; Sound transmission through single-leaf, homogeneous partitions; transmission coefficient, sound reduction index, mass law, coincidence effect. Composite (but single-leaf) partitions, effects of holes and gaps and flanking. Level difference, Standardised level difference; Sound transmission between enclosed spaces; Sound transmission between an enclosed space and free field conditions; and vice versa; Impact noise: impact sound pressure level; standardized impact sound pressure level.

**Human response to sound and vibration; and psychoacoustics:**

Human auditory system; Range of audible sound pressure levels and frequencies, infra sound, ultra sound. Pitch; Loudness: equal loudness contours and loudness level. Loudness calculations. Masking; Frequency weightings; Hearing disorders: effects of age, health and noise exposure on hearing acuity; Individual noise susceptibility; Audiometry; basic procedures of manual and automatic audiometry; audiograms; Assessment of noise dose, hearing protectors and their use; Regulatory issues; Effects of noise and vibration on humans and human activity; Indices and methods of assessment of noise and vibration exposures.

**Module-III**

**Measurement of sound and vibration:**

Measurement microphones: construction and mode of operation, sensitivity, linearity, frequency response, polar response, dynamic range; Relevant standards for sound level meters; Calibration and calibrators. The role of reference microphones; Primary and secondary standards; traceability of standards; Uncertainties in measured values, tolerance; Sound level meter features, including: frequency weightings; fast, slow, impulse and peak time weighting; octave and one-third-octave band filters; windshields; Measurement of sound pressure level (including indices for time-varying sounds and in diffuse and free fields), sound power level, sound intensity level, reverberation time. Measurement of impact noise. Using frequency weighting networks and octave and one-third-octave band filters where appropriate; Introduction to Fourier techniques; Principles of vibration measurement: displacement, velocity and acceleration; Vibration transducers and the principles of associated instrumentation.

**Text Books:**

1. Fundamentals of Acoustics by L. E. Kinsler, A. R. Frey, A. B. Coppens and J. V. Sanders, John Wiley & Sons (2000). 2. Acoustics and Noise Control,
2. [B. J. Smith](https://www.amazon.com/B.-J.-Smith/e/B000AQ3ZF6/ref=dp_byline_cont_book_1), [R. J. Peters](https://www.amazon.com/s/ref=dp_byline_sr_book_2?ie=UTF8&text=R.+J.+Peters&search-alias=books&field-author=R.+J.+Peters&sort=relevancerank), [Stephanie Owen](https://www.amazon.com/s/ref=dp_byline_sr_book_3?ie=UTF8&text=Stephanie+Owen&search-alias=books&field-author=Stephanie+Owen&sort=relevancerank), Addison-Wesley Longman Ltd (1982)

**Reference Books:**

1. Foundations of Engineering Acoustics by F. H. Fahy, Academic Press (2001).
2. Acoustics of ducts & Mufflers by M. L. Munjal, Wiley (2014)
3. Engineering Acoustics: An Introduction to Noise Control, [Michael Möser](https://www.amazon.com/Michael-M%C3%B6ser/e/B0034Q7EMY/ref=dp_byline_cont_book_1), [Stefan Zimmermann](https://www.amazon.com/s/ref=dp_byline_sr_book_2?ie=UTF8&text=Stefan+Zimmermann&search-alias=books&field-author=Stefan+Zimmermann&sort=relevancerank), [Rebecca Ellis](https://www.amazon.com/s/ref=dp_byline_sr_book_3?ie=UTF8&text=Rebecca+Ellis&search-alias=books&field-author=Rebecca+Ellis&sort=relevancerank), Springer (2009)

**PE 3: Nonlinear Vibration (PPEME203)**

**Module-I**

**Introduction**

Mechanical vibration: Linear nonlinear systems, types of forces and responses; Conservative and non-conservative systems, equilibrium points, qualitative analysis, potential well, centre, focus, saddle-point, cusp point; Commonly observed nonlinear phenomena: multiple response, bifurcations, and jump phenomena.

**Derivation of nonlinear equation of motion:**

Force and moment based approach; Lagrange Principle; Extended Hamilton’s principle; Multi body approach; Linearization techniques; Development of temporal equation using Galerkin’s method for continuous system; Ordering techniques, scaling parameters, book-keeping parameter. Commonly used nonlinear equations: Duffing equation, Van der Pol’s oscillator, Mathieu’s and Hill’s equations.

**Module-II**

**Approximate solution method**

Straight forward expansions and sources of nonuniformity; Harmonic Balancing method; Linstedt-Poincare’ method; Method of Averaging

**Perturbation analysis method**

Method of Averaging; Method of multiple scales; Method of multiple scales; Method of normal form; Incremental Harmonic Balance method; Modified Lindstedt-Poincare’ method

**Stability and Bifurcation Analysis**

Lyapunov stability criteria; Stability analysis from perturbed equation; Stability analysis from reduced equations obtained from perturbation analysis; Bifurcation of fixed point response, static bifurcation: pitch fork, saddle-node and trans-critical bifurcation; Bifurcation of fixed point response, dynamic bifurcation: Hopf bifurcation; Stability and Bifurcation of periodic response, Monodromy matrix, Poincare’ section

**Module-III**

**Numerical techniques**

Time response, Runga-Kutta method, Wilson- Beta method; Frequency response curves: solution of polynomial equations, solution of set of algebraic equations, Basin of attraction: point to point mapping and cell-to-cell mapping; Poincare’ section of fixed-point, periodic, quasi-periodic and chaotic responses; Lyapunov exponents; FFT analysis, Fractal Dimensions

**Applications**

SDOF Free-Vibration: Duffing Equation; SDOF Vibration: Van der pol’s Equation; Parametrically excited system- Mathieu-Hill’s equation, Floquet Theory; Parametrically excited system- Instability regions; Multi-DOF nonlinear systems; Continuous system: Micro-cantilever beam analysis

**Text Book:**

1. Nonlinear Oscillations, A.H.Nayfeh and D.T.Mook, Wiley-Interscience, 1979.

**Reference Books:**

1. Nonlinear Oscillations in Physical Systems, C. Hayashi, McGraw-Hill, 1964.
2. Resonance Oscillations in Mechanical Systems, R.M. Evan-Ivanowski,Elsevier, 1976.
3. Applied Nonlinear Dynamics, A.H.Nayfeh and B.Balachandran, Wiley, 1995.
4. From Equilibrium to Chaos: Practical Bifurcation and Stability Analysis, R.Seydel, Elsevier, 1988.
5. Chaotic & Fractal Dynamics: An Introduction for Applied Scientists and Engineers, F.C.Moon, Wiley, 1992.
6. Advanced Theory of Vibration: Nonlinear Vibration and Onedimensional Structures, J.S.Rao, New Age International, 1992.
7. Nonlinear interactions: analytical, computational, and experimental methods, Ali H. Nayfeh, Wiley-Interscience, June 2000.

**PE 3: Rotor Dynamics (PPEME204)**

**Module-I**

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.

**Module-II**

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.

**Module-III**

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 Rotor dynamics – A. Tondol. House of Czechoslovakia Academy of Science, Prague.

**PE 4: Robotics (PPEME212)**

**Module-I**

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.

**Module-II**

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.;

**Module-III**

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.

**Text Book:**

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

**Reference Books:**

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

**PE 4: Mechatronics (PPEME213)**

**Module-I**

Fundamental of Mechatronics: Definition and concepts of Mechatronics, Conventional system vs. mechatronic system, Need and Role of Mechatronics 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.;

**Module-II**

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.

**Module-III**

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;

**PE 4: MEMS and Nanotechnology (PPEME214)**

**Module-I**

Materials properties; crystal growth; Basic fabrication techniques- Doping, Diffusion,Oxidation, Deposition of films using CVD, LPCVD and Techniques, chemical and plasma etching;

**Module-II**

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,

**Module-III**

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

**PE 4: Machine Fault Diagnosis and Condition Monitoring (PPEME215)**

**Module-I**

Principles of Maintenance, Fault analysis planning and system availability: Failure modes, effects and criticality analysis (FMECA), Failure effects assessment (FEA), Critical areas assessment, Fault tree method, Availability concepts, Failure prediction/reliability assessment Data Processing and Signal Analysis: Computer-Aided Data Acquisition, Time Domain Analysis, Frequency Domain Analysis - Fast Fourier Transform Performance trend monitoring: Primary monitoring – performance, Primary and secondary performance parameters, Performance trend analysis

**Module-II**

Vibration Analysis: Vibration monitoring equipment, System monitors and vibration limit detectors, vibration monitoring experience Discrete frequencies: Introduction, Simple vibrations, Gear excitation, Rolling element bearings, Blade vibration, Fans and Pumps and Case Studies on Vibration Monitoring

Contaminant analysis: Contaminants in used lubricating oils, Carrier fluid degradation, Contaminant monitoring techniques (Wear processes), Oil degradation analysis, Abrasive particles in lubrication oil, Abrasive particle in bearings, Abrasive particle in hydraulic systems, Dissolved gas fault monitoring

**Module-III**

Electric Motor Current and Signature Analysis Non-Destructive Test and Evaluation technology: Overview: Radiography, Ultrasonics: Principle, transducers, equipments and testing Liquid Penetrant Test, Magnetic Particle Test, Eddy Current Test. Other Topics: Thermal Infrared Imaging, Acoustic Emission, Leak Testing Industrial Applications of NDE

**Text Book:**

1. Mechanical Fault Diagnosis and Condition Monitoring by Ralph Albert Collacott, Wiley (1977)

**Reference Books:**

1. Condition Based Maintenance and Machine Diagnostics, John W Williams, Alan Davies, Paul R Drake, Springer, (2006)
2. Rotating Machinery Vibration; From Analysis to Troubleshooting, Maurice L. Adams, Jr., CRC Press
3. Lubrication and Maintenance of Industrial Machinery; Best Practices and Reliability, R.M.Gresam and G.E.Totten, CRC Press
4. Vibration, Monitoring and Diagnosis: Techniques for Cost-effective Plant Maintenance by Ralph Albert Collacott, 1979, Wiley
5. Vibratory Condition Monitoring of Machines”, J.S.Rao, CRC Press, 2000
6. Non-destructive Test and Evaluation of Materials, J.Prasad and C.G.K.Nair, TataMcGraw-Hill

**Mini Project with Seminar (PPRME201)**

**[To be decided by the Department]**

**Lab 3: Robotics and Mechatronics Lab (PLCME201)**

**List of Experiments:**

**Lab 4: Computational Techniques and Soft Computing Lab (PLCME202)**

**List of Experiments:**

**Audit-2**

**[To be decided by the Department]: Refer Appendix-II**

**Semester-3**

**PE 5: Control System Engineering (PPEME301)**

**Module-I**

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**

Time Response Analysis

Standard input signals, Step, ramp, parabolic and impulse inputs. Time response of first 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 feedback 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**

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, Characteristic equation, Eigenvalue and eigenvector of state matrix. Design of control systems in state space.

**Text Books:**

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

**PE 5: Design of Material Handling Equipment (PPEME302)**

**Module-I**

Introduction: Objectives of material handling system, Principal groups of materials handling equipment and classification, Scope of Material Handling, Criteria for selection of Material Handling Equipment’s, Basic kind of material handling problems, Various methods to analyze material Handling problems.

Conveyor Design: Introduction to apron conveyors, Pneumatic conveyors, Belt Conveyors, Screw conveyors and vibratory conveyors and their applications, Design of Belt conveyor- Belt selection procedure and calculation of drop energy, Idler design.

**Module-II**

Design of Hoists: Design of hoisting elements: Welded and roller chains - Hemp and wire ropes - Design of ropes, pulleys, pulley systems, sprockets and drums, Load handling attachments. Design of forged hooks and eye hooks – crane grabs - lifting magnets - Grabbing attachments - Design of arresting gear -Brakes: shoe, band and cone types.

Design of Cranes: Hand-propelled and electrically driven E.O.T overhead Traveling cranes; Traveling mechanisms of cantilever and monorail cranes; design considerations for structures of rotary cranes with fixed radius; fixed post and overhead traveling cranes; Stability of stationary rotary and traveling rotary cranes.

**Module-III**

Design of bucket Elevator: Introduction, Types of Bucket Elevator, Design of Bucket Elevator- loading and bucket arrangements, Cage elevators, shaft way, guides, counter weights.

Packaging and storage of bulk materials: Steps for design of packages, protective packaging, testing the physical characteristics of packaging, container testing, types of storage and industrial containers, Automatic guided vehicles, Automatic storage and retrieval system.

**Reference Books:**

1. Conveyor Equipment Manufacturer’s Association, “Belt conveyors for bulk materials” 6th edition, The New CEMA Book
2. Rudenko N., “Materials handling equipment”, Elnvee Publishers, 1970
3. Ishwar G Mulani and Mrs. Madhu I Mulani, “Engineering Science and application design for belt conveyor”, Madhu I. Mulani, 2002.
4. Spivakovsy A.O. and Dyachkov V.K., “Conveying Machines, Volumes I and II”, MIR Publishers, 1985.
5. Alexandrov, M., “Materials Handling Equipments”, MIR Publishers, 1981.
6. Boltzharol, A., “Materials Handling Handbook”, The Ronald press company 1958.

**PE 5: Fatigue, Creep and Fracture of Engineering Components (PPEME303)**

**Module-I**

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.

**Module-II**

Creep: Creep-stress-time temperature relations, Mechanics of creep in tension, bending, torsion, creep buckling. Members subjected to creep and combined stresses.

**Module-III**

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

**Open Elective**

**[To be decided by the Department]: Refer Appendix-III**

**Project 1: (PPRME301)**

**[To be decided by the Department]: Dissertation (Phase-I)**

**Semester-4**

**Project 2: (PPRME401)**

**[To be decided by the Department]: Dissertation (Phase-II)**