# Department of Mechanical Engineering

## National Institute of Technology Raipur

(Institute of National Importance)

G. E. Road, Raipur-492010 (CG)

## B.Tech. in Mechanical Engineering

## Sixth Semester Scheme

| Sl. No. | Course Title | Course Name | L | T | P | Credits |
|---|---|---|---|---|---|---|
| 1. | Program Core (CXX61) ME106101ME | Machine Design II : Mechanical Drives | 3 | 1 | 0 | 4 |
| 2. | Program Core (CXX62) ME106102ME | Dynamics of Machines | 3 | 1 | 0 | 4 |
| 3. | Program Core (CXX63) ME106103ME | Turbo Machinery | 3 | 1 | 0 | 4 |
| 4. | Program Elective (EXX3) ME10620XME | | 3 | 0 | 0 | 3 |
| 5. | Open Elective (OXX2) ME10630XME | | 3 | 0 | 0 | 3 |
| 6. | Laboratory | Mechanical Lab - 7 | 0 | 0 | 2 | 1 |
| 7. | Laboratory | Mechanical Lab - 8 | 0 | 0 | 2 | 1 |
| | | | **15** | **3** | **4** | **20** |

| List of Program Electives (EXX3) | | |
|---|---|---|
| **Sl. No.** | **Code** | **Course Name** |
| 1. | ME106201ME | **Air Conditioning Techniques and System Design** |
| 2. | ME106202ME | **Fatigue Creep and Fracture** |
| 3. | ME106203ME | **Operations Research** |

| List of Open Electives (OXX2) | | |
|---|---|---|
| **Sl. No.** | **Code** | **Course Name** |
| 1. | ME106301ME | **Design Thinking and Product Innovation** |
| 2. | ME106302ME | **Experimental Stress Analysis** |
| 3. | ME106303ME | **Robotics** |
| 4. | ME106304ME | **Smart Materials and Systems** |

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## Semester-VI

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|---|---|---|
| 1. | Department proposing the course | **Mechanical Engineering** |
| 2. | Course Title | **Air Conditioning Techniques and System Design** |
| 3. | L-T-P Structure | **3-0-0** |
| 4. | Credits / # of period | 3 |
| 5. | Course Number (Code) | |
| 6. | Status (Core/Elective) | **Program Elective** |
| 7. | Pre-requisites (course no./title) | Refrigeration and Air Conditioning, Thermodynamics, Heat and Mass Transfer |
| 8. | Frequency of offer | Once per Academic Year |
| 9. | **Course Objectives (CO):**<br>At the end of this course, the students will be able to<br>1. Estimate cooling and heating load due to solar radiation, ventilation, and infiltration.<br>2. Estimate heat gain or loss through opaque or transparent surface of any building.<br>3. Design, choose, and suggest suitable type of air conditioning system for heating and cooling to any building located at any place on the earth for year around.<br>4. Become Heating Ventilation Air Conditioning installers, energy conserving architectural consultant, and building code inspectors to suggest best energy conservation techniques for heating and cooling of the building with minimum expenses of conventional energy source. This makes the course ideal for mechanical engineers. | |
| 10. | **Course Syllabus**<br>**UNIT I**<br>**Cooling and Heating Load Calculations: Estimation of Solar Radiation**<br>Solar radiation, Constant and irradiation, geometry, Latitude, all basic and derived angles, vertical and tilted surfaces, Calculation of direct, diffuse, and reflected radiation using ASHRAE solar radiation model.<br>**Solar radiation through fenestration Ventilation and Infiltration**<br>Need, effects of fenestration, Estimation of heat transfer rate, Solar heat Gain Factor (SHGF) and Shading Coefficient, external shading, shaded area of fenestration, heat transfer rate through windows with overhangs, ventilation, Infiltration, heat transfer rate due to infiltration and ventilation.<br>**UNIT II**<br>**Heat Transfer through Buildings – Fabric Heat Gain/Loss**<br>One-dimensional, steady state heat transfer through homogeneous, non-homogeneous walls, air spaces, composite walls of the buildings, unsteady heat transfer through opaque walls and roofs, analytical method to solve the 1-D, transient heat transfer problem, numerical methods used to solve the transient heat transfer problem, semi-empirical method based on Effective temperature, Difference or Cooling Load Temperature difference CLTD. | |

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| | **UNIT III**<br><br>**Passive Solar Technologies for Heating: concept and design**<br>Basics of Passive heating: Definition, various strategies for passive heating Various heat gains, reducing heat losses, importance of orientation, Radiation and Surfaces, Heat Transfer, Heat Storage, Design for heating, direct, indirect, and isolated gain, design consideration: site selection, building shape and orientation, design based on direct gain, heat storing techniques, design based on indirect heat gain, green houses, roof ponds. Trombe wall and Earth Air Heat Exchanger for heating of a residential building, mathematical modelling.<br><br>**UNIT IV**<br><br>**Passive Solar Technologies for Cooling: concept and design**<br>Definition, types of passive cooling, preventive techniques: - solar control (shading, overhang), thermal insulation, internal heat gain control, light colour painted on roof and walls, roof space (false ceiling), heat dissipation techniques: - ventilation, types of ventilation: - mechanical, mixed model, natural ventilation, types of natural ventilation: - wind driven ventilation and buoyancy driven ventilation, Natural cooling, ventilation, Heat gain control, convective cooling, radiative cooling, Evaporative cooling, combination of different systems: metallic, Trombe, evaporative walls, solar chimney for cooling and heating, mathematical modelling, air change per hour, calculation of minimum outdoor air required, Cooling Load Estimation, Night flushing, radiative cooling, evaporative cooling, types of evaporative cooling, earth coupling. |
| 11. | **Text Books-**<br><br>1. **Refrigeration and Air Conditioning** by C. P. Arora, TMH Publication.<br>2. **Refrigeration and Air Conditioning** by R.K. Rajput Katson Publication.<br>3. **Refrigeration and Air Conditioning** by Arora & Domkundwar, Dhanpat Rai and Sons.<br>4. **Solar Energy Fundamentals** by G N Tiwari |
| 12. | **Reference Books-**<br><br>1. **Alternatives in Refrigeration and Air Conditioning** by S.C. Kaushik, A. Arora, P.S. Bilga.<br>2. **Refrigeration and Air Conditioning** by Stooker W.F.<br>3. **Refrigeration and Air Conditioning** by Ahmadul Ameen, PHI Publication<br>4. **Handbook of Air Conditioning and Refrigeration** by Shan K. Wang, Tata McGraw Hill Publications.<br>5. **Solar Engineering of Thermal Processes** by Duffie and Beckman |

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## Semester-VI

| | | |
|---|---|---|
| 1. | Department proposing the course | **Mechanical Engineering** |
| 2. | Course Title | **Fatigue Creep and Fracture** |
| 3. | L-T-P Structure | **3-0-0** |
| 4. | Credits / # of period | 3 |
| 5. | Course Number (Code) | |
| 6. | Status (Core/Elective) | **Program Elective** |
| 7. | Pre-requisites (course no./title) | MOS-I, MOS-II and Machine Design-I |
| 8. | Frequency of offer | Once per Academic Year |
| 9. | **Course Objectives (CO):**<br>At the end of this course, the students will be able to<br>1. Apply the concept of fatigue in the analysis and design of structural components subjected to cyclic loading.<br>2. Design effectively the structural components effected by several environmental factors which enhance the creep effect.<br>3. Understand the concept of modes of fracture and apply them to effectively model various structural components.<br>4. Get a preliminary understanding of determining the fracture parameters and their role in designing the structures. | |
| 10. | **Course Syllabus**<br>**UNIT I – Design Philosophy**<br>Concepts of Infinite life design, Finite Safe life design, Fail safe design and Damage tolerant design.<br>**Introduction to Fatigue**: Cyclic stress and stress reversals, Fatigue and progressive fracture, Endurance limit. Influence of mean stress on fatigue, Gerber, Goodman and Soderberg's criteria. Effect of compressive cyclic stress on fatigue. Fatigue design formula for axial, bending, torsional and combined loading.<br>**Fatigue Tests:** Cantilever and Beam type of Fatigue Tests, Axial Fatigue Tests.<br>**Fatigue controlling factors**: Effect of frequency, Temperature, size, form, stress concentration factors, Notch, sensitivity & surface conditions, residual stresses.<br>Improvement of fatigue strength by chemical/metallurgical processes such as Nitriding, flame hardening, case carburizing. Fatigue strength enhancement by mechanical work such as cold rolling, peening, shot peening.<br>**Effect of environment:** Corrosion Fatigue, Concept of cumulative fatigue damage.<br>**UNIT II – Creep Mechanism**<br>Mechanics of creep, inter-granular, trans-granular creep, Creep test, Creep strain rate-time curves, Deformation mechanism map, High temperature properties of materials, | |

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| | Long time creep-stress-time relations, Creep contribution to the fracture mechanism, DVM, DVL German-standard, Hatifield time yield test.<br><br>**Creep Analysis:** Definition, Constant stress and constant, strain creep tests. Uniaxial creep tests, Baily's Power Law, Creep relaxation, strain hardening and time hardening creep relaxation. Introduction to Creep bending and deflection of simple problems.<br><br>**UNIT III – Introduction to Fracture Mechanics**<br><br>**Modes of Fracture:** Mode-I, Mode-II and Mode-III fracture, Ductile and Brittle fracture, Griffith theory of brittle fracture, Modified Griffith theory, Energy release rate (ERR), conditions for stable and unstable crack growth, crack arrest.<br><br>**Linear elastic fracture mechanics:** William's analysis of stress field at the tip of a crack, Solution of stress and displacement field for plane cracks using complex methods in plane elasticity (Westergaards or Kolosov-Muskhelishvili approach), Stress intensity factor (SIF) for plane and penny shaped cracks, Equivalence of SIF and ERR, fracture toughness.<br><br>**Elasto-plastic fracture mechanics:** First order estimate of crack tip plastic zone using Irwin's and Dugdle's approach, Plastic zone for plane stress and plane strain situation and effect on fracture toughness, Review of small strain plasticity, Crack tip fields in an elasto-plastic material (Discussion on HRR fields), J-integral as a fracture parameter and crack tip opening displacement.<br><br>**Mixed mode fracture:** Prediction of crack path and critical condition for crack extension under mixed mode loading using Maximum tensile stress, Minimum strain energy density and Maximum energy release rate (ERR) criteria.<br><br>**UNIT IV – Experimental Determination of SIF and Fracture Toughness**<br><br>SIF measurement using strain gauges and optical techniques, Evaluation of fracture Toughness using Linear-elastic toughness testing comprising of slow and rapid loading, crack initiation, and crack arrest method. Nonlinear testing comprises $J_{IC}$ testing, J-R curve evaluation, and crack tip opening displacement (CTOD) method. combined J standard method, the common fracture toughness test, transition fracture toughness testing, and the weldment fracture testing method.<br><br>**Fatigue crack growth:** Mechanism of crack nucleation and growth under cyclic loading, Determination of life of a cracked solid using Paris-Erdogan law and its variants. Introduction to Dynamic Fracture. |
| 11. | **Text Books-**<br>5. **Elements of Fracture Mechanics**, Prasanth Kumar, Tata McGraw Hill Ltd.<br>6. **Mechanical Metallurgy,** George E. Dieter, Tata McGraw Hill Ltd. |
| 12. | **Reference Books-**<br>1. **Advanced Mechanics of Materials**, L. S. Srinath, Tata McGraw Hill Ltd.<br>2. **Fracture Mechanics**, S. A. Meguid, John Wiley & Sons.<br>3. **Stress Concentration Design Factors,** Peterson, R. E., John Wiley & Sons |

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## Semester-VI

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|---|---|---|
| 1. | Department proposing the course | **Mechanical Engineering** |
| 2. | Course Title | **Operations Research** |
| 3. | L-T-P Structure | **3-0-0** |
| 4. | Credits / # of period | 3 |
| 5. | Course Number (Code) | |
| 6. | Status (Core/Elective) | **Program Elective** |
| 7. | Pre-requisites (course no./title) | Mathematics |
| 8. | Frequency of offer | Once per Academic Year |
| 9. | **Course Objectives (CO):**<br>At the end of this course, the students will be able to<br>5. Identify and develop operational research models from the description of the real system.<br>6. Apply the concepts of transportation problems, assignment problems, decision theory, game theory and simulation to solve the real-life problems.<br>7. Assess the optimal decision in queuing theory, project Management Problems (CPM, PERT etc.) | |
| 10. | **Course Syllabus**<br>**UNIT I**<br>**Basic Concepts:** Introduction, Objective function, max-min conversion, decision variable, constraints, types of constraints, solution space, types of solution space, Feasible space, optimum solution, constraint vs unconstraint problem and unimodal vs multimodal.<br>**General Linear Programming Problems**: Introduction, Formulation of a linear programming problem, Graphical method, canonical form and Simplex method, Big M method, Degeneracy, Application of Linear Programming (LPP) in Mechanical Engineering.<br>**UNIT II**<br>**The Transportation Problems:** Mathematical formulation, stepping stone method, Modified Distribution Method, Vogel's Approximation Method, Solution of balanced and unbalanced transportation problems and case of Degeneracy.<br>**The Assignment Problems:** Mathematical formulation of assignment problems, Solution of assignment problems, Traveling salesman problems, Air crew Assignment problems.<br>**UNIT III**<br>**Waiting Line Theory:** Basic queuing process, Basic structure of queuing models, Some commonly known queuing situations, Kendall's notation, Solution to M/M/1: ∞ /FCFS models. | |

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| | **Network Analysis:** CPM/PERT, Network Representation, Techniques for drawing network, Resource smoothing and levelling, Project cost, Optimum project duration, Project crashing, Updating, Time estimation in PERT<br><br>**UNIT IV**<br><br>**Decision Theory and Game Theory:** Decision making, Steps in decision theory approach, Decision making under certainty, Uncertainty and under condition of risk, Decision Tree, Theory of Games, two-person zero sum game, Methods for solving two person zero sum game.<br><br>**Simulation:** Basic concept of simulation, applications of simulation, Merits and demerits of simulation, Monte Carlo simulation, Simulation of Inventory system, Simulation of Queuing system. |
| 11. | **Text Books-**<br><br>7. **Operation Research** – N. D. Vohra – TMH<br>8. **Operation Research** – Hira & Gupta – S. Chand & Co.<br>9. **Operation Research** – H. Gillette – TMH, New Delhi<br>10. **Operation Research** – M. Taha – TMH, New Delhi |
| 12. | **Reference Books-**<br><br>6. **Operation Research,** Sasien Yaspan<br>7. **Fundamentals of Operation Research** – Ackof Sasieni – Dhanpat Rai & Sons<br>8. **Quantitative Approach to Management –** Lovin and Krit Patrick – TMH<br>9. **Operation Research–** S.D. Sharma – S. Chand & Com. New Delhi. |

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## Semester-VI

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|---|---|---|
| 1. | Department proposing the course | **Mechanical Engineering** |
| 2. | Course Title | **Design Thinking and Product Innovation** |
| 3. | L-T-P Structure | **3-0-0** |
| 4. | Credits / # of period | 3 |
| 5. | Course Number (Code) | |
| 6. | Status (Core/Elective) | **Open Elective** |
| 7. | Pre-requisites (course no./title) | Nil |
| 8. | Frequency of offer | Once per Academic Year |
| 9. | **Course Objectives (CO):**<br>Upon the successful completion of the course, students will be able to<br>1. Gather deep insights of design thinking and appreciate various design process procedure.<br>2. Develop design ideas through different technique and Analyse innovative product design.<br>3. Identify the significance of reverse Engineering to understand products. | |
| 10. | **Course Syllabus**<br>**UNIT I - DESIGN THINKING**<br>Introduction to Design Thinking, What is Design Thinking? What is Innovation, Best-Suited for Design Thinking, Visualization Tool? Preparing Your Mind for Innovation, The Physics of Innovation, How Prepared is Your Mind?<br>**UNIT II - IDEA GENERATION AND DEVELOPMENT**<br>The Idea Generation Process, Create Thinking - Generating Design Ideas - Lateral Thinking – Anologies – Brainstorming - Mind Mapping Tool- National Group Technique – Development of work - Analytical Thinking - Group Activities Recommended<br>**UNIT III - PRODUCT DEVELOPMENT**<br>Creativity, Innovation and Invention - differences; Creativity types; Innovation types - Jugaad Innovation, Social Innovation, Sustaining Innovation, Disruptive Innovation, Open Innovation. **Product Design,** Usability and User experience design; Product Architecture; Industrial Design; Design for Manufacturing.<br>**UNIT IV - REVERSE ENGINEERING**<br>Introduction - Reverse Engineering Leads to New Understanding about Products - Reasons for Reverse Engineering - Reverse Engineering Process - Step by Step - Case Study. | |
| 11. | **Text Books-**<br>1. **Engineering Design,** John. R. Karsnitz, Stephen O'Brien and John P. Hutchinson, | |

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| | Cengage learning (International edition) second Edition, 2013.<br>2. **New Products Management,** Anthony Di Benedetto and Merle Crawford, TataMcGraw Hill.<br>3. **Innovators Dilemma,** Clayton Christensen, Harper Collins Publishers |
| 12. | **Reference Books-**<br>4. **Engineering Design Process,** Yousef Haik and Tamer M.Shahin, Cengage Learning, Second Edition, 2011.<br>5. **Product Design & Development**, Karl T Ulrich, Steven D Eppinger and Anita Goyal, Tata McGraw Hill. |

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## Semester-VI

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|---|---|---|
| 1. | Department proposing the course | **Mechanical Engineering** |
| 2. | Course Title | **Experimental Stress Analysis** |
| 3. | L-T-P Structure | **3-0-0** |
| 4. | Credits / # of period | 3 |
| 5. | Course Number (Code) | |
| 6. | Status (Core/Elective) | **Open Elective** |
| 7. | Pre-requisites (course no./title) | Physics, Basic Mechanical Engineering |
| 8. | Frequency of offer | Once per Academic Year |
| 9. | **Course Objectives (CO):**<br>At the end of this course, the students will be able to<br>5. Understand the concept of application of Strain gauges for the measurement of strain and also be able to use and mount them for the same.<br>6. Implement the theoretical concepts of stress and strain in their measurement.<br>7. Understand the photoelastic technique for principal stress measurement on 2-D and 3-D objects<br>8. Develop an insight into the geometric and displacement Moire fringe techniques, and the interferometry concepts. | |
| 10. | **Course Syllabus**<br>**UNIT I – Introduction**<br>Concepts of Stress and Strain, principal stresses, stress-strain relations, equilibrium equations, stress and strain measurements. Need for experimental stress analysis.<br>**Strain Measurement Techniques:** Basic Characteristics of a Strain Gauge, Types of Strain Gauge, Electrical Resistance Strain Gauge: Factors Influencing Strain sensitivity in Metallic Alloys, Gauge Construction Temperature Compensation, Factors-Influencing Gauge Section Gauge Sensitivity and Gauge Factor, Correction for transverse Strain Effects, Semiconductor Strain gauge. Rosette Analysis – three element rectangular Rosette. the Delta Rosettee, the Four Element. The Delta Rosette, The Strain Gauge, Strain Circuits, Potensiometer Circuits, The Wheatstone Bridge. Optical displacement and strain sensors, Linear voltage differential transducer and capacitance-based displacement sensors.<br>**UNIT II – Introduction to Optics and Photoelasticity**<br>Representing light using electric field (plane and spherical wave fronts), Coherence, Coherence length and Interference, Diffraction of light, Optical elements like lenses, prisms, beam splitters, front surface mirrors etc.<br>**Photoelasticity:** Light and Optics as Related to Photoelasticity Behavior of Light, Polarized Light, Plane Polarizers, Wave Plates, Arrangement of Optical Elements in a | |

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| | Polariscopic, Constructional Details of Diffused Light and Lens type.<br><br>**Theory of Photoelasticity:** The Stress Optic Law in Two Dimensions at Normal Incidence, Effects of a Stressed Model in a Plane Polariscope, Effects of a Plane Model in a Circular Polariscope with Dark and Light Field Arrangements. Analysis Techniques: Isochromatic Fringe Patterns, Isoclinic Fringe Patterns, Compensation Techniques, separation Techniques, Sealing Model to Prototype Stresses.<br><br>**Three-Dimensional Photoelasticity:** Locking in Model Deformation Slicing the Model and Interpretation of the Resulting Fringe Pattern, Effective Stresses. the Shear Difference Method in Three Dimensions.<br><br>**UNIT III – Full Field Displacement Measurement Techniques**<br><br>Geometric Moiré, Moiré Interferometry, Electronic Speckle Pattern Interferometry, Digital Image Correlation. Moire Method of Strain Analysis, Grid Method of Strain Analysis. Holographic interferometry.<br><br>**UNIT IV – Photoelastic Coating and Brittle Coatings**<br><br>Brittle coating Method: Coating Stresses, Failure theories, Brittle Coating Crack Patterns produced by Direct Loading Brittle-Coating Crack Patterns produced by refrigeration techniques, Brittle coating crack, Pattern produced by releasing the load, Double Crack Pattern, Crack Detection, Load-Time relation and Its influence on the threshold Strain Effects of a Biaxial stress Field. |
| 11. | **Text Books-**<br><br>11. **Experimental Stress Analysis**, J. W. Dally and W. H. Riley, Tata McGraw Hill Ltd.<br>12. **Experimental Stress Analysis**, Jindal, Pearson Publishers. |
| 12. | **Reference Books-**<br><br>6. **Experimental Stress Analysis**, L. S. Srinath, M. R. Raghavan, K. Lingaiah, G. Gargesa, B. Pant, and K. Ramachandra, Tata McGraw Hill Ltd.<br>7. **Digital Photoelasticity – Advanced Techniques and Applications**, K. Ramesh, Springer, 2000.<br>8. **Springer Handbook of Experimental Solid Mechanics,** W. N. Sharpe, Springer, 2008. |

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## Semester-VI

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|---|---|---|
| 1. | Department proposing the course | **Mechanical Engineering** |
| 2. | Course Title | **Robotics** |
| 3. | L-T-P Structure | **3-0-0** |
| 4. | Credits / # of period | 3 |
| 5. | Course Number (Code) | |
| 6. | Status (Core/Elective) | **Open Elective** |
| 7. | Pre-requisites (course no./title) | Nil |
| 8. | Frequency of offer | Once per Academic Year |
| 9. | **Course Objectives (CO):**<br>The course is designed to give an overview to Robotics and Serial Robotic Manipulator. Subject being interdisciplinary, an attempt has been made to discuss all aspects. At the end of this course, the students will be able<br>4. To be familiar with Robotics and Robotic manipulators.<br>5. To apply various transformations for kinematic modeling of serial robotic manipulators.<br>6. To develop forward and inverse kinematic models of serial robotic manipulators.<br>7. To understand use of sensors in robots.<br>8. To understand trajectory planning and basics of robotic control. | |
| 10. | **Course Syllabus**<br>**UNIT I**<br>**Introduction to Robotics, Coordinate Frames, Mapping and Transforms**<br>Evolution of Robots and Robotics, Laws of Robotics, Progressive Advancement in Robots, Robot Applications, Robot Anatomy, Arm Configuration & work space, Human Arm Characteristics, Coordinate Frames, Description of Objects in Space, Transformation of Vectors, Homogeneous Transformation, Rotation Matrices.<br>**UNIT II**<br>**Kinematic Modeling of Serial Robotic Manipulators**<br>Mechanical Structure and Notations, Description of Links and Joints, Kinematic Modeling of the Manipulator, Denavit–Hartenberg Notation, Kinematic Relationship between Adjacent Links, Manipulator Transformation Matrix, Direct and Inverse Kinematic Models of Robotic Manipulators, various examples.<br>**UNIT III**<br>**Robotic Sensors and Vision**<br>Sensors in Robots, Kinds of Sensors used in Robotics, Classification, Characteristics, Internal Sensors – position, velocity, acceleration sensors, Force sensors, External sensors – proximity, touch and slip sensors.<br>Robotic Vision, Process of Imaging, Architecture of Robotic Vision Systems, Image | |

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| | Acquisition, Image Representation, Image Processing.<br>**UNIT IV**<br>**Motion Planning and Motion Control**<br>Trajectory Planning of Robotic Manipulator: Joint Space and Cartesian Space techniques. Open Loop and Close Loop Control, Block Diagram representation, Transfer Function, Characteristics of 1st and 2nd Order Transfer Functions, Characteristic Equation, Steady State Error, State Space Representation, Various Controllers & Applications. |
| 11. | **Text Books-**<br>4. **Robotics & Control** – R.K. Mittal & I.J. Nagrath – TMH Publications<br>5. **Introduction to Robotics Analysis, Systems Applications** - Saeed B. NiKu - Pearson Education |
| 12. | **Reference Books-**<br>9. **Introduction to Robotics** – S.K.Saha – McGraw Hill Education.<br>10. **Robotics Control Sensing, Vision and Intelligence** - K.S.Fu, R.C.Gonzalex, C.S.G.Lee- McGrew hill Book co.<br>11. **Robotic Engineering- An Integrated Approach** by R.D. Klafter-PHI Learning Pvt. Ltd. Delhi. |

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## Semester-VI

| | | |
|---|---|---|
| 1. | Department proposing the course | **Mechanical Engineering** |
| 2. | Course Title | **Smart Materials and Systems** |
| 3. | L-T-P Structure | **3-0-0** |
| 4. | Credits / # of period | 3 |
| 5. | Course Number (Code) | |
| 6. | Status (Core/Elective) | **Open Elective** |
| 7. | Pre-requisites (course no./title) | Nil |
| 8. | Frequency of offer | Once per Academic Year |
| 9. | **Course Objectives (CO):**<br>At the end of the course students should be able to<br>9. Understand basics of data acquisition and analysis.<br>10. Overview to smart materials and its characteristics<br>11. Smart structures and modeling Design of sensors and actuators using smart materials.<br>12. Energy harvesting using piezoelectric materials.<br>13. Electro rheological fluid and its applications<br>14. Magneto rheological fluid and its applications | |
| 10. | **Course Syllabus**<br>**UNIT I**<br>**Introduction:** Basic concepts of smartness, Introduction to measurement and measuring instruments, generalized measuring system and functional elements, Design of Instruments, Calibration, Analysis of experimental data (Concept of error, Sources of error, Statistical analysis of errors).<br>**UNIT II**<br>**Smart Behaviors and Materials:** Piezoelectric, electrostrictive, magnetostrictive, Piezo-magnetism, Pyro-magnetism, Piezo-resistivity, Thermoelectricity, shape memory alloy, Hyperelastic, Viscoelastic, Electro-active Polymers, Elastorestrictive, Electrorheological, Thermochromic materials, Functionally Graded Materials.<br>**UNIT III**<br>**Material properties and performance parameters:** Phenomenology and constitutive relations, Modeling of a smart system (Beam, Plate, and shell), Modeling of viscoelastic damping (active and passive), Finite Element modeling of Smart System.<br>**UNIT IV**<br>**Applications**: Design and fabrication of devices and structures and their integration with system: Biomorphs/Moonies, Shape Memory devices (SMA), Sensor, actuator and transducers, Accelerometer, Gyroscopes, Ultrasonic Motor, Liquid Crystal display, | |

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| | Photonics, Structural Health Monitoring. |
| 11. | **Text Books-**<br>6. **Ferroelectric devices-** Kenji Uchino, Marcell Decker Inc., 2000.<br>7. **Adaptronics and Smart Structures- Basics, Design and Applications-** Janocha Harmut (Ed.), Springer-Verlag Berlin Heidelberg, 1999.<br>8. **Smart Materials and Structures-** M.V. Gandhi, B.S. Thompson, Chapman and Hall, London1992. |
| 12. | **Reference Books-**<br>12. **Electromechanical Sensors and Actuators**, Ilene J. Busch-Vishniac, Springer-Verlag NY, 1999.<br>13. **Fundamentals of Piezoelectricity**- Takuro Ikeda, Oxford University Press, 1990.<br>14. **Piezoelectric Senorics**, G. Gautschi, Springer-Verlag Berlin Heidelberg, 2002.<br>15. **Actauators: Basics and Applications** H.armut Janocha (Ed), Springer-Verlag Berlin Heidelberg, 2004.<br>16. **Multifunctional Cement based Materials,** Deobrah D. L. Chung, Marcel Dekker, NY, 2003.<br>17. **Smart materials, structures and mathematical issues,** Rogers A Craig, Technomic Publishing Company, Inc, 1991.<br>18. **Computational methods for smart structures and materials,** P. Santini, M. Marchetti, C.A. Brebbia, W.I.T. Press, Computational Mechanics Publications, Boston, 1999.<br>19. **Smart Material Systems: Model Developments,** Ralph C. Smith, Cambridge University Press, Series: Frontiers in Applied Mathematics (No. 32), 2005.<br>20. **Smart Material Structures: modeling, estimation and control**, H.T. Banks, R.C. Smith and Y. Wang, John Wiley & Sons Inc. NY, 1996 |