**Department of Mechanical Engineering**
**National Institute of Technology Raipur**
(Institute of National Importance)
G. E. Road, Raipur-492010 (CG)

# B. Tech. in Mechanical Engineering
# VI Semester CBCS Scheme

| Sl. No | Course Title | Course Code | Course Name | Type | L | T | P | TA | | MSE | | ESE | | Total Marks | Credits |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Max | Min | Max | Min | Max | Min | | |
| 1. | Program Elective-III | ME106201ME | Air Conditioning Techniques and System Design | T | 3 | 0 | 0 | 20 | 0 | 30 | 0 | 50 | 0 | 100 | 3 |
| 2. | Program Elective-III | ME106202ME | Fatigue Creep and Fracture | | | | | | | | | | | | |
| 3. | Program Elective-III | ME106203ME | Operations Research | | | | | | | | | | | | |
| 4. | Open Elective-II | ME106301ME | Design Thinking and Product Innovation | T | 3 | 0 | 0 | 20 | 0 | 30 | 0 | 50 | 0 | 100 | 3 |
| 5. | Open Elective-II | ME106302ME | Experimental Stress Analysis | | | | | | | | | | | | |
| 6. | Open Elective-II | ME106303ME | Robotics | | | | | | | | | | | | |
| 7. | Open Elective-II | ME106304ME | Smart Materials and Systems | | | | | | | | | | | | |
| 8. | Program Core | ME106101ME | Machine Design II-Mechanical Drives | T | 3 | 1 | 0 | 20 | 0 | 30 | 0 | 50 | 0 | 100 | 4 |
| 9. | Program Core | ME106102ME | Dynamics of Machines | T | 3 | 1 | 0 | 20 | 0 | 30 | 0 | 50 | 0 | 100 | 4 |
| 10. | Program Core | ME106103ME | Turbo Machinery | T | 3 | 1 | 0 | 20 | 0 | 30 | 0 | 50 | 0 | 100 | 4 |
| 11. | Laboratory | ME106401ME | Mechanical Lab – 7 | P | 0 | 0 | 2 | 40 | 0 | 20 | 0 | 40 | 0 | 100 | 1 |
| 12. | Laboratory | ME106402ME | Mechanical Lab - 8 | P | 0 | 0 | 2 | 40 | 0 | 20 | 0 | 40 | 0 | 100 | 1 |
| Total | | | | | 15 | 3 | 4 | | | | | | | 700 | 20 |

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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) | **ME106201ME** |
| 6. | Status (Core/Elective) | **Program Elective-III** |
| 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:**<br>1. To teach how to estimate cooling and heating load due to solar radiation, ventilation, and infiltration.<br>2. To teach how to estimate heat gain or loss through opaque or transparent surface of any building.<br>3. To make students to learn the designing, choosing, and suggesting 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. To make students to be capable to be heating ventilation air conditioning installers, energy conserving architectural consultant, 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.<br>**Course Outcomes (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. | |

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| | **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.<br>**UNIT III**<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>**UNIT IV**<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>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>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

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|---|---|---|
| 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) | **ME106202ME** |
| 6. | Status (Core/Elective) | **Program Elective-III** |
| 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:**<br>1. The objective f the course is to make the students familiarize with the concepts of cyclic loading, sustained loading and fatigue fracture of various engineering materials.<br>2. The course is offered as a program elective and is intended towards application of mathematical concepts in design of mechanical components subjected to cyclic and sustained loadings.<br>3. The overall course is framed such that it covers both the simulation and experimental concepts for assessing the real time problems and provide suitable solutions.<br>**Course Outcomes (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. Improvement of fatigue strength by chemical/metallurgical processes such as Nitriding, | |

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| | 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><br>**UNIT II – Creep Mechanism**<br><br>Mechanics of creep, inter-granular, trans-granular creep, Creep test, Creep strain rate-time curves, Deformation mechanism map, High temperature properties of materials, Long time creep-stress-time relations, Creep contribution to the fracture mechanism, DVM, DVL German-standard, Hatifield time yield test.<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>**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>**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>**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>**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>1. **Elements of Fracture Mechanics**, Prasanth Kumar, Tata McGraw Hill Ltd.<br>2. **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) | **ME106203ME** |
| 6. | Status (Core/Elective) | **Program Elective-III** |
| 7. | Pre-requisites (course no./title) | Mathematics |
| 8. | Frequency of offer | Once per Academic Year |
| 9. | **Course Objectives:**<br>1. Identify and develop operational research models from the description of the real system.<br>2. Apply the concepts of transportation problems, assignment problems, decision theory, game theory and simulation to solve the real-life problems.<br>3. Assess the optimal decision in queuing theory, project Management Problems (CPM, PERT etc.)<br>**Course Outcomes (CO):** The students will be able to:<br>1. Develop the mathematical model of real-life problems and able to solve the LPP.<br>2. Optimize the cost of transportation problems, assignment problems.<br>3. Determine the waiting time in queue and analyze the project through CPM & PERT methods.<br>4. Simulate the various system like inventory, queuing 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 | |

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| | 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.<br>**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>**UNIT IV**<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>**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>1. **Operation Research** – N. D. Vohra – TMH<br>2. **Operation Research** – Hira & Gupta – S. Chand & Co.<br>3. **Operation Research** – H. Gillette – TMH, New Delhi<br>4. **Operation Research** – M. Taha – TMH, New Delhi |
| 12. | **Reference Books-**<br>1. **Operation Research,** Sasien Yaspan<br>2. **Fundamentals of Operation Research** – Ackof Sasieni – Dhanpat Rai & Sons<br>3. **Quantitative Approach to Management –** Lovin and Krit Patrick – TMH<br>4. **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) | **ME106301ME** |
| 6. | Status (Core/Elective) | **Open Elective-II** |
| 7. | Pre-requisites (course no./title) | Nil |
| 8. | Frequency of offer | Once per Academic Year |
| 9. | **Course Objectives:**<br>1. To provide the basic concepts and techniques of engineering, process of design, analytical thinking and ideas.<br>2. To understand design ideas through different techniques and innovative product design.<br>3. To get exposure of exhibiting their creativity in terms of an innovative product development in a structured process through this course.<br>4. Importance of reverse engineering and understanding the new products.<br>**Course Outcomes (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. | |

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| | **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, 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>1. **Engineering Design Process,** Yousef Haik and Tamer M.Shahin, Cengage Learning, Second Edition, 2011.<br>2. **Product Design & Development**, Karl T Ulrich, Steven D Eppinger and Anita Goyal, Tata McGraw Hill. |

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## Semester-VI

| | | |
|---|---|---|
| 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) | **ME106302ME** |
| 6. | Status (Core/Elective) | **Open Elective-II** |
| 7. | Pre-requisites (course no./title) | Physics, Basic Mechanical Engineering |
| 8. | Frequency of offer | Once per Academic Year |
| 9. | **Course Objectives:**<br>1. The objective of the course is to make the students familiarize with the concepts of photoelasticity and electric circuits for stress and strain analysis encountered in engineering problems.<br>2. The course is offered as an open elective and is intended towards application of mathematical, experimental and non-destructive concepts in assessing the mechanical components for their integrity.<br>3. The overall course is framed such that it covers the experimental techniques and correlating them with the mathematical models for better understanding of complex situations.<br>**Course Outcomes (CO):**<br>At the end of this course, the students will be able to<br>1. 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>2. Implement the theoretical concepts of stress and strain in their measurement.<br>3. Understand the photoelastic technique for principal stress measurement on 2-D and 3-D objects<br>4. 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 | |

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| | sensors, Linear voltage differential transducer and capacitance-based displacement sensors.<br><br>**UNIT II – Introduction to Optics and Photoelasticity**<br><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><br>**Photoelasticity:** Light and Optics as Related to Photoelasticity Behavior of Light, Polarized Light, Plane Polarizers, Wave Plates, Arrangement of Optical Elements in a 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>1. **Experimental Stress Analysis**, J. W. Dally and W. H. Riley, Tata McGraw Hill Ltd.<br>2. **Experimental Stress Analysis**, Jindal, Pearson Publishers. |
| 12. | **Reference Books-**<br>1. **Experimental Stress Analysis**, L. S. Srinath, M. R. Raghavan, K. Lingaiah, G. Gargesa, B. Pant, and K. Ramachandra, Tata McGraw Hill Ltd.<br>2. **Digital Photoelasticity – Advanced Techniques and Applications**, K. Ramesh, Springer, 2000.<br>3. **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) | **ME106303ME** |
| 6. | Status (Core/Elective) | **Open Elective-II** |
| 7. | Pre-requisites (course no./title) | Nil |
| 8. | Frequency of offer | Once per Academic Year |
| 9. | **Course Objectives:**<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>1. To be familiar with Robotics and Robotic manipulators.<br>2. To apply various transformations for kinematic modeling of serial robotic manipulators.<br>3. To develop forward and inverse kinematic models of serial robotic manipulators.<br>4. To understand use of sensors in robots.<br>5. To understand trajectory planning and basics of robotic control.<br>**Course Outcomes (CO):**<br>1. Carryout the various transformations for kinematic modelling of Serial Robotic Manipulators.<br>2. Develop forward and inverse kinematic model of Serial Robotic Manipulator.<br>3. Use suitable sensors for Serial Robotic Manipulators.<br>4. Develop trajectories of various Serial Robotic Manipulators.<br>5. Understand the control issues of Serial Robotic Manipulators. | |
| 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 | |

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| | Models of Robotic Manipulators, various examples.<br><br>**UNIT III**<br><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><br>Robotic Vision, Process of Imaging, Architecture of Robotic Vision Systems, Image Acquisition, Image Representation, Image Processing.<br><br>**UNIT IV**<br><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><br>1. **Robotics & Control** – R.K. Mittal & I.J. Nagrath – TMH Publications<br>2. **Introduction to Robotics Analysis, Systems Applications** - Saeed B. NiKu - Pearson Education |
| 12. | **Reference Books-**<br><br>1. **Introduction to Robotics** – S.K.Saha – McGraw Hill Education.<br>2. **Robotics Control Sensing, Vision and Intelligence** - K.S.Fu, R.C.Gonzalex, C.S.G.Lee- McGrew hill Book co.<br>3. **Robotic Engineering- An Integrated Approach** by R.D. Klafter-PHI Learning Pvt. Ltd. Delhi. |

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## Semester-VI

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|---|---|---|
| 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) | **ME106304ME** |
| 6. | Status (Core/Elective) | **Open Elective-II** |
| 7. | Pre-requisites (course no./title) | Nil |
| 8. | Frequency of offer | Once per Academic Year |
| 9. | **Course Objectives:**<br>The course objective is<br>1. To acquire the basic concept of smartness, and data analysis.<br>2. To classify the smart materials according to its modes of activation along with their potential applications.<br>3. To learn the constitutive equations for the modelling of smart materials and systems.<br>4. To understand the application of smart materials in fabrication of actuator, sensor, and generator.<br>5. To identify the proper material for design and fabrication of transducers (mechanical, health sector, etc)<br>**Course Outcomes (CO):**<br>At the end of the course students should be able to<br>1. Recognize basic concept of data acquisition, calibration of measuring instruments and statistical analysis of data.<br>2. Apply concept of modes of activation in smart material to identify the appropriate material for various transducers application.<br>3. Establish constitutive relation to predict the performance of smart material and systems.<br>4. Recognize the suitable material to harvest energy for non-conventional sources.<br>5. Describe electro rheological fluid and its applications<br>6. Discuss 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- | |

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| | magnetism, Pyro-magnetism, Piezo-resistivity, Thermoelectricity, shape memory alloy, Hyperelastic, Viscoelastic, Electro-active Polymers, Elastorestrictive, Electrorheological, Thermochromic materials, Functionally Graded Materials.<br><br>**UNIT III**<br><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><br>**UNIT IV**<br><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, Photonics, Structural Health Monitoring. |
| 11. | **Text Books-**<br><br>1. **Ferroelectric devices-** Kenji Uchino, Marcell Decker Inc., 2000.<br>2. **Adaptronics and Smart Structures- Basics, Design and Applications-** Janocha Harmut (Ed.), Springer-Verlag Berlin Heidelberg, 1999.<br>3. **Smart Materials and Structures-** M.V. Gandhi, B.S. Thompson, Chapman and Hall, London1992. |
| 12. | **Reference Books-**<br><br>1. **Electromechanical Sensors and Actuators**, Ilene J. Busch-Vishniac, Springer-Verlag NY, 1999.<br>2. **Fundamentals of Piezoelectricity**- Takuro Ikeda, Oxford University Press, 1990.<br>3. **Piezoelectric Senorics**, G. Gautschi, Springer-Verlag Berlin Heidelberg, 2002.<br>4. **Actauators: Basics and Applications** H.armut Janocha (Ed), Springer-Verlag Berlin Heidelberg, 2004.<br>5. **Multifunctional Cement based Materials,** Deobrah D. L. Chung, Marcel Dekker, NY, 2003.<br>6. **Smart materials, structures and mathematical issues,** Rogers A Craig, Technomic Publishing Company, Inc, 1991.<br>7. **Computational methods for smart structures and materials,** P. Santini, M. Marchetti, C.A. Brebbia, W.I.T. Press, Computational Mechanics Publications, Boston, 1999.<br>8. **Smart Material Systems: Model Developments,** Ralph C. Smith, Cambridge University Press, Series: Frontiers in Applied Mathematics (No. 32), 2005.<br>9. **Smart Material Structures: modeling, estimation and control**, H.T. Banks, R.C. Smith and Y. Wang, John Wiley & Sons Inc. NY, 1996 |

# Department of Mechanical Engineering

## National Institute of Technology Raipur

(Institute of National Importance)

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

## Semester-VI

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| 1. | Department proposing the course | **Mechanical Engineering** |
| 2. | Course Title | **Dynamics of Machine** |
| 3. | L-T-P Structure | **3+1+0** |
| 4. | Credits / # of period | 4 |
| 5. | Course Number (Code) | **ME106102ME** |
| 6. | Status (Core/Elective) | **Program Core** |
| 7. | Pre-requisites (course no./title) | Engineering Mechanics, Kinematics of Machines |
| 8. | Frequency of offer | Once in a Year |
| 9. | **Course Objectives (CO):**<br>At the end of the course, the students will be able to:<br>1. Apply and identify the concept of relative motion of cam and follower mechanism for various applications.<br>2. Visualize and identify the gear technology and the mechanical application of different gear trains.<br>3. Analyze and perform the static and dynamic balancing of single and multi-cylinders combustion engines.<br>4. Expand the knowledge and application of gyroscopic couple in aircraft, marie and automobiles.<br>5. Analyze the importance of mechanical vibration through solving problems of one and two degree of freedom engineering system. | |
| 10. | **Course Syllabus**<br>**UNIT I – Cams:**<br>Classification of cams and followers, Nomenclature of a radial cam, Description of follower movement, Displacement diagrams, Uniform and modified uniform motion, Simple harmonic motion, Uniform acceleration motion and its modifications, Cycloidal motion, Synthesis of cam profile by graphical approach, Considerations of pressure angle. Cams with specified contours: Circular arc cam & tangent cam.<br>**UNIT II – Gear and Gear trains:**<br>Introduction to Gears, Gear Tooth Profile, Simple, Compound, Reverted, and Epicyclical gear trains, Computation of velocity ratio in gear trains by different methods.<br>**Gyroscope:** Gyroscopic forces and couple, Gyroscopic effect in Airplanes, Ship motion and Vehicles moving on curved path.<br>**UNIT III –Balancing:**<br>Balancing of rotating masses, Static and dynamic balancing, Determination of balancing | |

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| | masses in two plane balancing, Balancing of reciprocating masses, Primary and Secondary unbalanced forces, Partial balancing, Hammer Blow, Balancing of internal combustion engines, Balancing of in-line engines, Balancing of secondary forces of Multi Cylinder engines.<br><br>**UNIT IV – Mechanical Vibrations:**<br><br>Introduction to Longitudinal, Transverse and Torsional vibrations, Natural Frequency, Shaft with different boundary condition and subjected to different types of loading, Effect of damping on vibrations, Different types of damping, Vibration Isolation, Whirling of shafts, Free Torsional Vibrations of a single, two and three rotor system. |
| 11. | **Text Books-**<br><br>1. Theory of Machine- S. S. Rattan – Tata McGraw Hill<br>2. The Theory of Machines – Thomas Bevan – CBS/Cengage Publishers<br>3. Theory of Machines – J. E. Shigley – McGraw Hill |
| 12. | **Reference Books-**<br><br>1. Theory of Mechanisms and Machines- A. Ghosh, A. K. Mallik – EWP Press.<br>2. Theory of Machine – P.L. Ballaney – Khanna Publishers. |

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## Semester-VI

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| 1. | Department proposing the course | **Mechanical Engineering** |
| 2. | Course Title | **Machine Design II-Mechanical Drives** |
| 3. | L-T-P Structure | **3+1+0** |
| 4. | Credits / # of period | 4 |
| 5. | Course Number (Code) | **ME106101ME** |
| 6. | Status (Core/Elective) | **Program Core** |
| 7. | Pre-requisites (course no./title) | Machine Design-I |
| 8. | Frequency of offer | Once in a Year |
| 9. | **Course Objectives (CO):**<br>The course objective of Machine Design-II is to provide an overview of machine parts used for power and rotary motion transmission, such as gears, bearings, clutches, brakes, ropes and chain drives. Attention is paid particularly to impart understanding of the functions of the power transmission components and learn the methods used in their design process. The course teaches students how to apply the concepts of stress analysis, theories of failure and material science to analyze, design and/or select commonly used machine components. The lab work attached to the course integrates the knowledge of Mechanical drafting, CAD and design validation using Finite Element application software. Students will work on problem solving and their projects during the laboratory classes. This course will develop the technical competence capability and at the conclusion of this course, students should be able to demonstrate:<br>1. The ability to apply the fundamentals of stress analysis, theories of failure and material science in the design of machine components.<br>2. Knowledge of the principles of design, selection, operation and application of the mechanical drive components.<br>3. The ability to invoke appropriate assumptions and select elements and subsequently develop and validate the same.<br>4. Be able to communicate effectively in reporting (both textually and graphically) the design and its validation.<br><br>**Lab Objectives** are as follows:<br>1. To impart ability to apply gained knowledge to the design process of new machinery and equipment.<br>2. To impart knowledge of the FEM as applied to design and validation of the drive components.<br>3. To impart the ability to use existing as well as develop new computer-based techniques and algorithms for the analysis, selection, and synthesis of mechanical components. | |

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| 10. | **Course Syllabus**<br><br>**UNIT I – Clutches:**<br><br>Introduction, Friction materials, Torque transmitting capacity, Single and Multiple plate clutch, Centrifugal clutches, Cone clutch.<br><br>Brakes: Introduction, Block Brake, design procedure, Internal Expanding Shoe Brake, design procedure, Band brakes, design procedure, Disc brake, design procedure.<br><br>**Pulley and Flywheel:** Flywheel Inertia, Stresses in Flywheel and pulleys, failure criterion.<br><br>**UNIT II – Chain Drives:**<br><br>Chain drives, Roller chains, Geometric relationships, Dimensions of chain components, Polygonal effect, Power rating of roller chains, Selection of Chain drives. Belt & Rope Drive: Design of Flat and Round belt drives, V-Belt, Timing belt, Wire Rope.<br><br>**UNIT III – Sliding contact bearing:**<br><br>Types, Selection of bearing, Plain journal bearing, Hydrodynamic lubrication, Lubricants and lubrication, Heat generation, Design of journal bearing, Thrust bearing, pivot and collar bearing.<br><br>Rolling contact bearing: Hertz contact stress theory, advantages and disadvantages, Types, selection of rolling contact bearing, Bearing life, Dynamic equivalent load for bearing under constant and variable loading, Reliability of Bearing, Lubrication of ball and roller bearing, Mounting of bearing.<br><br>**UNIT IV – Gears and Gear System Design**<br><br>Tooth forms, System of gear teeth, Selection of gear materials, Gear manufacturing methods, Design considerations, Forces in gears. Virtual number of teeth, Effective load of gear tooth. Beam strength of gear tooth, Dynamic tooth load, wear strength of gear tooth, Failure of gear tooth, Design of spur, helical, bevel and worm gears, AGMA and Indian standards. |
| 11. | **Text Books-**<br><br>1. V B Bhandari, Design of Machine Elements, Tata McGraw-Hill Publishing Company Ltd., 2017.<br>2. A Hall and A Holowenko, Machine Design – Schaum's Series, Tata McGraw-Hill Publishing Company Ltd., 2017.<br>**Other materials:** Pre-installed open-source libraries and software discussed in the class from time to time. PSG Design Data book and/or Design Data book by V B Bhandari. |
| 12. | **Reference Books-**<br><br>1. R L Norton, Machine Design, Pearson, 2018.<br>2. R G Budynas, JK Nisbett, Shingley's Mechanical Engineering Design – SIE, McGraw Hill Education, 2017. |

# Department of Mechanical Engineering

## National Institute of Technology Raipur

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## Semester-VI

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| 1. | Department proposing the course | **Mechanical Engineering** |
| 2. | Course Title | **Turbo Machinery** |
| 3. | L-T-P Structure | **3+1+0** |
| 4. | Credits / # of period | 4 |
| 5. | Course Number (Code) | **ME106103ME** |
| 6. | Status (Core/Elective) | **Program Core** |
| 7. | Pre-requisites (course no./title) | Thermodynamics, Fluid Mechanics |
| 8. | Frequency of offer | Once per Academic Year |
| 9. | **Course Objectives:**<br>1. To understand the concepts of Impulse and Reaction Turbine.<br>2. To able to differentiate between types of rotary equipment like compressors, turbines.<br>3. To analyze the performance of different types of compressors and turbines.<br>**Course Outcomes (CO):**<br>1. Detailed analytical analysis of Impulse turbine.<br>2. Detailed analytical analysis of Reaction turbine.<br>3. State point locus and governing of steam turbine.<br>4. Idea and performance analysis of Gas turbine and compressors. | |
| 10. | **Course Syllabus**<br>**UNIT I – Impulse Turbine**<br>Steam turbine – Principal of operation of steam turbine, Simple impulse turbine, Velocity diagrams for impulse turbine, blade work done, Diagram efficiency, Gross stage efficiency, Optimum velocity ratio. Compounding of Impulse turbine, Pressure compounded, Velocity compounded. Efficiency of multi stage turbine.<br>Impulse blade sections, choice of blade angle. Blade height in velocity compounded impulse turbine.<br>**UNIT II – Impulse Reaction Turbine.**<br>Velocity diagram, degree of reaction, impulse-reaction turbine with similar blade section and half degree of reaction (Parson's turbine) Height of reaction turbine blading section, internal losses in steam turbine Nozzle Losses, blade friction losses, disc friction losses, blade windage losses or partial admission losses, gland leakage or clearance losses, leaving velocity or residual loss, carryover losses.<br>**UNIT III – State Point Locus and Reheat Factor**<br>Stage efficiency, stage point locus of an impulse turbine. State point locus for multistage turbine, reheat factor. Internal efficiency, overall efficiency, relative efficiency. | |

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| | Governing of steam turbine: Throttle governing, nozzle governing, bypass governing, combination of throttle and nozzle governing and combination of bypass and throttle governing. Effect of governing on the performance of steam turbine.<br><br>**UNIT IV – Turbines and Compressors**<br><br>Classification of gas turbine, Simple open cycle gas turbine, ideal and actual cycle (Brayton Cycle) for gas turbine, Optimum pressure ratio for maximum specific output, Regeneration, reheat and inter cooling and effect of these modification on efficiency and output, closed cycle gas turbine.<br><br>**Turbo Compressors**<br><br>Introduction, classification of Centrifugal compressor – components, working, velocity diagrams, calculations of power and efficiencies. Slip factor surging and choking power and efficiencies.<br><br>**Axial Flow Compressor**-<br><br>Construction and working, velocity diagram, calculation of power and efficiencies, Degree of reaction, work done factor, stalling comparison of centrifugal and axial flow compressor. |
| 11. | **Text Books-**<br><br>1. Gas turbine theory: Cohen, Rogers & Saravanmuttoo – Pearson.<br>2. Turbo machines – A Valan Arasu – Vikas publishing.<br>3. Steam and Gas turbine – By R. Yadav – Central Publishing House, Allahabad. |
| 12. | **Reference Books-**<br><br>1. Turbine compressors and Fans – S. M. Yahya – TMH<br>2. Gas Turbine – V. Ganeshan – TMH<br>3. Power Plant Engineering: P K Nag- TMH |