**ANNA UNIVERSITY, CHENNAI**

**UNIVERSITY DEPARTMENTS**

**CHOICE BASED CREDIT SYSTEM**

**REGULATIONS – 2023**

**M.E. ENGINEERING DESIGN**

**(FULL – TIME MODE)**

## VISION OF THE DEPARTMENT

Department of Mechanical Engineering strives to be recognized globally for excelling in Engineering education and research leading to innovative, entrepreneurial and competent Graduates in Mechanical Engineering and allied disciplines.

## MISSION OF THE DEPARTMENT

Department of Mechanical Engineering shall contribute to the educational, economic and social development by:

- Providing world class education by fostering effective teaching learning process that is supported through pioneering and cutting-edge research to make impactful contribution to the society.
- Attracting highly motivated students with enthusiasm, aptitude, and interest in the field of Mechanical and allied Engineering disciplines.
- Expanding the frontiers of Engineering and science in technological innovation while ensuring academic excellence and scholarly learning in a collegial environment.
- Exceling in industrial consultancy and research leading to innovative technology development and transfer.
- Serving the society with innovative and entrepreneurially competent graduates for the national and international community towards achieving the sustainable development goals.

## PROGRAM EDUCATIONAL OBJECTIVES (PEOS)

The following are the Program Educational Objectives of Engineering Design:

- **PEO 1**: To develop an aptitude to use engineering principles to conceptualize, create, model, test and evaluate designs within the context of local and global needs.
- **PEO 2**: To become effective and excellent collaborators and innovators, participating in efforts to address and provide solutions to social and technical challenges.
- **PEO 3**: To develop innovative technologies and find solutions to contemporary issues in Engineering Design using fundamental principles in combination with modern engineering tools and methods.
- **PEO 4**: To pursue advanced education, research and development and other creative/ innovative efforts in their professional career.

## PROGRAM OUTCOMES (POS)

The following are the Program Outcomes of Engineering Design:

- **PO 1:** An ability to independently carry out research/investigation and development work to solve practical problems.
- **PO 2:** An ability to write and present a substantial technical report/document.
- **PO 3:** An ability to demonstrate a degree of mastery in Engineering Design. The mastery should be at a level higher than the requirements in the appropriate bachelor programme.
- **PO 4:** Provide optimized solutions during product design using advanced Computer Aided

Engineering tools and mathematical models.

- **PO 5:** Identify the societal needs and industrial problems in different domains of research including inter disciplinary fields and provide innovative solutions using design paradigms.
- **PO 6:** Become a successful professional with acquired creative design skills and knowledge through which impetus would be provided to develop solutions that would lead to next generation technologies.

**Mapping of PEO with PO & PSO:**

| PEO | PO | | | | | |
|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** |
| **1** | 3 | 2 | 3 | 3 | 3 | 3 |
| **2** | 3 | 2 | 3 | 2 | 3 | 3 |
| **3** | 3 | 2 | 3 | 3 | 2 | 3 |
| **4** | 3 | 3 | 3 | 3 | 3 | 3 |

**Program Articulation Matrix (Full Time):**

| Year | Sem. | Courses | PO | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 5 | 6 |
| I | I | Advanced Numerical Methods | 2 | | 1 | 1 | 2 | 2 |
| | | Research Methodology and IPR | 3 | 3 | 2 | - | - | - |
| | | Advanced Mechanics of Deformable bodies | 3 | | 3 | 2 | 2 | 1 |
| | | Design with Advanced Materials | 3 | | 3 | 1 | 2 | 2 |
| | | Design and Analysis of Advanced Mechanisms | 2 | | 3 | 2.4 | 1 | 1.6 |
| | | Integrated Product Design and Development | 3 | 3 | 3 | 3 | 2 | 3 |
| | | Design Practice with CAD Tools Laboratory | 3 | 2.7 | 3 | 3 | 0.3 | 2 |
| | | Multi Body Dynamics Laboratory | 3 | 2 | 3 | 3 | 2 | 1 |
| | II | Finite Element Methods in Mechanical Design | 3 | | 3 | 2.6 | 1 | 1 |
| | | Vibration Analysis and Control | 3 | | 3 | 2 | 2 | 1 |
| | | Engineering Fracture Mechanics | 3 | | 3 | 2 | 1 | 1 |
| | | Professional Elective-I | | | | | | |
| | | Professional Elective-II | | | | | | |
| | | Professional Elective-III | | | | | | |
| | | Finite Element Modelling and Simulation Laboratory | 3 | 2 | 3 | 3 | 2 | 1 |
| II | III | Professional Elective-IV | | | | | | |
| | | Professional Elective-V | | | | | | |
| | | Professional Elective-VI | | | | | | |
| | | Technical Seminar | 3 | 2 | 3 | | 2 | |
| | | Project Work-I | 3 | 3 | 3 | 3 | 2 | 3 |
| | IV | Project Work-II | 3 | 3 | 3 | 3 | 2 | 3 |
| PEC | | Design for Sustainability | 3 | | 3 | 2 | 2 | 3 |
| | | Composite Materials and Mechanics | 3 | | 3 | | 2 | 2 |
| | | Quality Concepts in Design | 3 | 0.8 | 3 | 2 | 2 | 1 |
| | | Bearing Design and Rotor Dynamics | 3 | | 3 | 3 | 2 | 2 |
| | | Solid Freeform Manufacturing | 2.6 | 2.4 | 2.4 | 2.2 | 2.6 | 2.4 |
| | | Product Lifecycle Management | 2 | 1 | 2 | 2 | 3 | 3 |
| | | Optimization Techniques in Design | 3 | | 3 | 3 | 2 | 3 |
| | | Design of Hydraulic and Pneumatic Systems | 3 | | 3 | 2 | 2 | 1.4 |
| | | Mechanical Measurements and Analysis | 3 | | 3 | 1 | 2 | 2 |
| | | Surface Engineering | 3 | | 3 | 2 | 2 | 2 |
| | | Computer Graphics | 3 | | 3 | 3 | 2 | 1 |
| | | Vehicle Dynamics | 3 | | 3 | 1.8 | 2 | 1 |
| | | Advanced Finite Element Analysis | 3 | | 3 | 2.6 | 1 | 1 |
| | | Design of Hybrid and Electric Vehicles | 2 | | 3 | 1 | 3 | 2 |
| | | Advanced Machine Tool Design | 3 | | 3 | 1 | 2 | 2 |
| | | Material Handling Systems and Design | 2 | | 3 | 2 | 2 | 3 |
| | | Creativity and Innovation Management | 3 | 1 | 2 | 2 | 1 | 2 |
| | | Computational Fluid Dynamics for Mobility Systems | 3 | 2 | 2 | 2 | 3 | 2 |

**ANNA UNIVERSITY, CHENNAI**
**UNIVERSITY DEPARTMENTS**
**REGULATIONS - 2023**
**CHOICE BASED CREDIT SYSTEM**
**M.E. ENGINEERING DESIGN**

**I TO IV SEMESTER CURRICULUM AND SYLLABI**

**SEMESTER – I**

| SL. NO. | COURSE CODE | COURSE TITLE | CATEGORY | PERIODS PER WEEK | | | TOTAL CONTACT PERIODS | CREDITS |
|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | | |
| **THEORY** | | | | | | | | |
| 1. | MA3155 | Advanced Numerical Methods | FC | 4 | 0 | 0 | 4 | 4 |
| 2. | ED3101 | Advanced Mechanics of Deformable Bodies | PCC | 3 | 0 | 0 | 3 | 3 |
| 3. | ED3151 | Design with Advanced Materials | PCC | 3 | 0 | 0 | 3 | 3 |
| 4. | ED3152 | Design and Analysis of Advanced Mechanisms | PCC | 3 | 0 | 0 | 3 | 3 |
| 5. | PD3151 | Integrated Product Design and Development | PCC | 3 | 0 | 0 | 3 | 3 |
| 6. | RM3151 | Research Methodology and IPR | RMC | 2 | 1 | 0 | 3 | 3 |
| **PRACTICAL** | | | | | | | | |
| 7. | ED3161 | Design Practice with CAD Tools Laboratory | PCC | 0 | 0 | 4 | 4 | 2 |
| 8. | ED3162 | Multi Body Dynamics Laboratory | PCC | 0 | 0 | 4 | 4 | 2 |
| | | | **TOTAL** | **18** | **1** | **8** | **27** | **23** |

**SEMESTER – II**

| SL. NO. | COURSE CODE | COURSE TITLE | CATEGORY | PERIODS PER WEEK | | | TOTAL CONTACT PERIODS | CREDITS |
|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | | |
| **Theory** | | | | | | | | |
| 1. | ED3251 | Finite Element Methods in Mechanical Design | PCC | 3 | 0 | 0 | 3 | 3 |
| 2. | ED3252 | Vibration Analysis and Control | PCC | 2 | 0 | 2 | 4 | 3 |
| 3. | ED3253 | Engineering Fracture Mechanics | PCC | 3 | 0 | 0 | 3 | 3 |
| 4. | | Professional Elective – I | PEC | 3 | 0 | 0 | 3 | 3 |
| 5. | | Professional Elective – II | PEC | 3 | 0 | 0 | 3 | 3 |
| 6. | | Professional Elective – III | PEC | 3 | 0 | 0 | 3 | 3 |
| **Practical** | | | | | | | | |
| 7. | ED3261 | Finite Element Modelling and Simulation Laboratory | PCC | 0 | 0 | 4 | 4 | 2 |
| | | | **TOTAL** | **17** | **0** | **6** | **23** | **20** |

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

## SEMESTER – III

| SL. NO. | COURSE CODE | COURSE TITLE | CATEGORY | PERIODS PER WEEK | | | TOTAL CONTACT PERIODS | CREDITS |
|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | | |
| **Theory** | | | | | | | | |
| 1. | | Professional Elective – IV | PEC | 3 | 0 | 0 | 3 | 3 |
| 2. | | Professional Elective – V | PEC | 3 | 0 | 0 | 3 | 3 |
| 3. | | Professional Elective – VI | PEC | 3 | 0 | 0 | 3 | 3 |
| **Practical** | | | | | | | | |
| 4. | ED3311 | Technical Seminar | EEC | 0 | 0 | 2 | 2 | 1 |
| 5. | ED3312 | Project Work – I | EEC | 0 | 0 | 12 | 12 | 6 |
| | | | **TOTAL** | **9** | **0** | **14** | **23** | **16** |

## SEMESTER – IV

| SL. NO. | COURSE CODE | COURSE TITLE | CATEGORY | PERIODS PER WEEK | | | TOTAL CONTACT PERIODS | CREDITS |
|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | | |
| **Practical** | | | | | | | | |
| 1. | ED3411 | Project Work – II | EEC | 0 | 0 | 24 | 24 | 12 |
| | | | **TOTAL** | **0** | **0** | **24** | **24** | **12** |

**Total No. of Credits: 71**



Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

## FOUNDATION COURSE (FC)

| SL. NO. | COURSE CODE | COURSE TITLE | CATEGORY | PERIODS PER WEEK | | | TOTAL CONTACT PERIODS | CREDITS |
|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | | |
| 1. | MA3155 | Advanced Numerical Methods | FC | 4 | 0 | 0 | 4 | 4 |

## RESEARCH METHODOLOGY AND IPR COURSES (RMC)

| SL. NO. | COURSE CODE | COURSE TITLE | CATEGORY | PERIODS PER WEEK | | | TOTAL CONTACT PERIODS | CREDITS |
|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | | |
| 1. | RM3151 | Research Methodology and IPR | MC | 2 | 1 | 0 | 3 | 3 |

## PROGRAM CORE COURSES (PCC)

| SL. NO. | COURSE CODE | COURSE TITLE | CATEGORY | PERIODS PER WEEK | | | TOTAL CONTACT PERIODS | CREDITS |
|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | | |
| 1. | ED3101 | Advanced Mechanics of Deformable Bodies | PCC | 3 | 0 | 0 | 3 | 3 |
| 2. | ED3151 | Design with Advanced Materials | PCC | 3 | 0 | 0 | 3 | 3 |
| 3. | ED3152 | Design and Analysis of Advanced Mechanisms | PCC | 3 | 0 | 0 | 3 | 3 |
| 4. | PD3151 | Integrated Product Design and Development | PCC | 3 | 0 | 0 | 3 | 3 |
| 5. | ED3251 | Finite Element Methods in Mechanical Design | PCC | 3 | 0 | 0 | 3 | 3 |
| 6. | ED3252 | Vibration Analysis and Control | PCC | 2 | 0 | 2 | 4 | 3 |
| 7. | ED3253 | Engineering Fracture Mechanics | PCC | 3 | 0 | 0 | 3 | 3 |
| 8. | ED3161 | Design Practice with CAD Tools Laboratory | PCC | 0 | 0 | 4 | 4 | 2 |
| 9. | ED3162 | Multibody Dynamics Laboratory | PCC | 0 | 0 | 4 | 4 | 2 |
| 10. | ED3261 | Finite Element Modelling and Simulation Laboratory | PCC | 0 | 0 | 4 | 4 | 2 |

## PROFESSIONAL ELECTIVE COURSES (PEC)

| SL. NO. | COURSE CODE | COURSE TITLE | CATEGORY | PERIODS PER WEEK | | | TOTAL CONTACT PERIODS | CREDITS |
|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | | |
| 1. | ED3053 | Design for Sustainability | PEC | 3 | 0 | 0 | 3 | 3 |
| 2. | ED3001 | Composite Materials and Mechanics | PEC | 3 | 0 | 0 | 3 | 3 |
| 3. | ED3002 | Quality Concepts in Design | PEC | 3 | 0 | 0 | 3 | 3 |
| 4. | ED3003 | Bearing Design and Rotor Dynamics | PEC | 3 | 0 | 0 | 3 | 3 |
| 5. | CI3151 | Solid Freeform Manufacturing | PEC | 3 | 0 | 0 | 3 | 3 |
| 6. | PD3152 | Product Lifecycle Management | PEC | 2 | 0 | 2 | 4 | 3 |
| 7. | ED3054 | Optimization Techniques in Design | PEC | 3 | 0 | 0 | 3 | 3 |
| 8. | ED3055 | Design of Hydraulic and Pneumatic Systems | PEC | 3 | 0 | 0 | 3 | 3 |
| 9. | ED3004 | Mechanical Measurements and Analysis | PEC | 3 | 0 | 0 | 3 | 3 |
| 10. | ED3056 | Surface Engineering | PEC | 3 | 0 | 0 | 3 | 3 |
| 11. | ED3051 | Computer Graphics | PEC | 3 | 0 | 0 | 3 | 3 |
| 12. | ED3058 | Vehicle Dynamics | PEC | 3 | 0 | 0 | 3 | 3 |
| 13. | ED3005 | Advanced Finite Element Analysis | PEC | 3 | 0 | 0 | 3 | 3 |
| 14. | ED3057 | Design of Hybrid and Electric Vehicles | PEC | 3 | 0 | 0 | 3 | 3 |
| 15. | ED3006 | Advanced Machine Tool Design | PEC | 3 | 0 | 3 | 3 | 3 |
| 16. | ED3052 | Material Handling Systems and Design | PEC | 3 | 0 | 0 | 3 | 3 |
| 17. | PD3251 | Creativity and Innovation Management | PEC | 3 | 0 | 0 | 3 | 3 |
| 18. | IC3253 | Computational Fluid Dynamics for Mobility Systems | PEC | 2 | 0 | 2 | 4 | 3 |

## EMPLOYABILITY ENHANCEMENT COURSES (EEC)

| SL. NO. | COURSE CODE | COURSE TITLE | CATEGORY | PERIODS PER WEEK | | | TOTAL CONTACT PERIODS | CREDITS |
|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | | |
| 1. | ED3311 | Technical Seminar | EEC | 0 | 0 | 2 | 2 | 1 |
| 2. | ED3312 | Project Work – I | EEC | 0 | 0 | 12 | 12 | 6 |
| 3. | ED3411 | Project Work – II | EEC | 0 | 0 | 24 | 24 | 12 |

| MA3155 | ADVANCED NUMERICAL METHODS | L T P C |
|---|---|---|
| | | 4 0 0 4 |

**OBJECTIVES:**

- To impart knowledge in understanding the advantages of various solution procedures of solving the system of linear and nonlinear equations.
- To give a clear picture about the solution methods for solving the BVPs and the system of IVPs.
- To acquire knowledge in solving time dependent one and two dimensional parabolic PDEs by using various methodologies.
- To strengthen the knowledge of finite difference methods for solving elliptic equations.
- To get exposed to the ideas of solving PDEs by finite element method.

**UNIT I ALGEBRAIC EQUATIONS 12**

Systems of linear equations: Gauss Elimination method, pivoting techniques, Thomas algorithm for tridiagonal system – Jacobi, Gauss Seidel, SOR iteration methods - Systems of nonlinear equations: Fixed point iterations, Newton Method, Eigenvalue problems: power method, Faddeev – Leverrier Method.

**UNIT II ORDINARY DIFFERENTIAL EQUATIONS 12**

Runge Kutta Methods for system of IVPs, numerical stability, Adams-Bashforth multistep method, solution of stiff ODEs, shooting method, BVP: Finite difference method, collocation method, orthogonal collocation method, Galerkin finite element method.

**UNIT III FINITE DIFFERENCE METHOD FOR TIME DEPENDENT PARTIAL DIFFERENTIAL EQUATION 12**

Parabolic equations: explicit and implicit finite difference methods, weighted average approximation - Dirichlet and Neumann conditions – Two dimensional parabolic equations – ADI method; First order hyperbolic equations – method of characteristics, Lax - Wendroff explicit and implicit methods; numerical stability analysis, method of lines – Wave equation: Explicit scheme-Stability of above schemes.

**UNIT IV FINITE DIFFERENCE METHODS FOR ELLIPTIC EQUATIONS 12**

Laplace and Poisson's equations in a rectangular region: Five point finite difference schemes, Leibmann's iterative methods, Dirichlet and Neumann conditions – Laplace equation in polar coordinates: finite difference schemes – approximation of derivatives near a curved boundary while using a square mesh.

**UNIT V FINITE ELEMENT METHOD 12**

Partial differential equations – Finite element method - collocation method, orthogonal collocation method, Galerkin finite element method.



**TOTAL: 60 PERIODS**

**OUTCOMES:**

**At the end of the course, students will be able to**

**CO1** Get familiarized with the methods which are required for solving system of linear, nonlinear equations and eigenvalue problems.
**CO2** Solve the BVPs and the system of IVPs by appropriate methods discussed.
**CO3** Solve time dependent parabolic PDEs by using various methodologies up to dimension two.
**CO4** Solve elliptic equations by finite difference methods.
**CO5** Use the ideas of solving PDEs by finite element method.

**REFERENCES:**


1. Burden, R.L., and Faires, J.D., "Numerical Analysis – Theory and Applications", Cengage Learning, India Edition, New Delhi, 2010.
2. Gupta S.K., "Numerical Methods for Engineers", New Age Publishers, 3rd Edition, New Delhi, 2015.
3. Jain M. K., Iyengar S. R. K., Jain R.K., "Computational Methods for Partial Differential Equations", New Age Publishers, 2nd Edition, New Delhi, 2016.
4. Morton K.W. and Mayers D.F., "Numerical solution of partial differential equations", Cambridge University press, Cambridge, 2005.
5. Sastry S.S., "Introductory Methods of Numerical Analysis", Prentice - Hall of India Pvt. Limited, 5th Edition, New Delhi, 2012.
6. Saumyen Guha and Rajesh Srivastava, "Numerical methods for Engineering and Science", Oxford Higher Education, New Delhi, 2010.

**CO-PO Mapping:**

| CO | PO | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| 1 | 3 | 3 | 3 | 3 | 2 | 2 |
| 2 | 3 | 3 | 3 | 3 | 2 | 2 |
| 3 | 3 | 3 | 3 | 3 | 2 | 2 |
| 4 | 3 | 3 | 3 | 3 | 2 | 2 |
| 5 | 3 | 3 | 3 | 3 | 2 | 2 |
| Avg. | 3 | 3 | 3 | 3 | 2 | 2 |

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

**ED3101 ADVANCED MECHANICS OF DEFORMABLE BODIES**

| L | T | P | C |
|---|---|---|---|
| 3 | 0 | 0 | 3 |

**COURSE OBJECTIVES:**

The main learning objective of this course is to prepare the students for acquiring the knowledge on the mechanics of materials under various loading conditions.

**UNIT I Elasticity 9**

Stress-Strain relations and general equations of elasticity in Cartesian, Polar and curvilinear coordinates, theories of failure, differential equations of equilibrium-compatibility-boundary conditions-representation of three-dimensional stress of a tension generalized hook's law - St. Venant's principle - plane stress - Airy's stress function. Energy methods

**UNIT II SHEAR CENTRE AND UNSYMMETRICAL BENDING 9**

Location of shear centre for various thin sections - shear flows. Stresses and Deflections in beams subjected to unsymmetrical loading-kern of a section

**UNIT III STRESSES IN FLAT PLATES AND CURVED MEMBERS 9**

Circumference and radial stresses – deflections - curved beam with restrained ends - closed ring subjected to concentrated load and uniform load - chain links and crane hooks. Solution of rectangular plates – pure bending of plates – deflection – uniformly distributed load – various end conditions

**UNIT IV TORSION OF NON-CIRCULAR SECTIONS 9**

General Torsional equation - Torsion of rectangular cross section - St.Venants theory - elastic membrane analogy - Prandtl's stress function - torsional stress in hollow thin walled tubes and multi-walled sections

**UNIT V STRESSES IN ROTATING MEMBERS AND CONTACT STRESSES 9**

Radial and tangential stresses in solid disc and ring of uniform thickness and varying thickness allowable speeds. Methods of computing contact stress-deflection of bodies in point and line contact applications

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:** Upon completion of this course, the students will be able to:

**CO1** apply the concepts of theory of elasticity in three-dimensional stress system.
**CO2** determine the shear centre of various cross-sections and deflections in beams subjected to unsymmetrical bending.
**CO3** evaluate the stresses in flat plates and curved members
**CO4** calculate torsional stress of non-circular sections.
**CO5** determine the stresses in rotating members, contact stresses in point and line contact applications.

**REFERENCES:**


1. Arthur P Boresi, Richard J. Schmidt, “Advanced Mechanics of Materials”, Wiley India Pvt.Ltd., 2009.
2. Hibbeler. R.C., “Mechanics of Materials”, Prentice Hall, 2011.
3. Robert D. Cook, Warren C. Young, "Advanced Mechanics of Materials", Prentice Hall, 1999.
4. P.N. Chandramouli, “Theory of Elasticity”, Yes Dee Publishing, 2017.
5. Srinath. L.S., “Advanced Mechanics of Solids”, Tata McGraw Hill, 2010.
6. Timoshenko and Goodier, "Theory of Elasticity", Tata McGraw Hill, 2010.


| CO | PO | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| 1 | 3 | | 3 | 2 | 2 | 1 |
| 2 | 3 | | 3 | 2 | 2 | 1 |
| 3 | 3 | | 3 | 2 | 2 | 1 |
| 4 | 3 | | 3 | 2 | 2 | 1 |
| 5 | 3 | | 3 | 2 | 2 | 1 |
| Avg. | 3 | | 3 | 2 | 2 | 1 |

| ED3151 | DESIGN WITH ADVANCED MATERIALS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**COURSE OBJECTIVES:**

The main learning objective of this course is to prepare the students for acquiring the knowledge on the mechanical behaviour of both metallic and non-metallic materials under different loading and temperature conditions.

**UNIT I BASIC CONCEPTS OF MATERIAL BEHAVIOR 9**

Engineering Design process and the role of materials; materials classification and their properties, Strengthening mechanisms-grain size reduction, solid solution strengthening, strain hardening, grain boundary strengthening, precipitation, particle, fibre and dispersion strengthening, Effect of temperature, strain and strain rate on plastic behavior – Super plasticity –Failure of metals.

**UNIT II BEHAVIOUR UNDER CYCLIC LOADS AND DESIGN APPROACHES 9**

Stress intensity factor and fracture toughness – Fatigue-low and high cycle fatigue test, fracture mechanisms and Paris law.- Effect of surface and metallurgical parameters on fatigue – Safe life, Stress-life, strain-life and fail - safe design approaches- Fracture of nonmetallic Materials – Failure analysis, sources of failure, procedure of failure analysis.

**UNIT III SELECTION OF MATERIALS 9**

Selection of materials based on function, Objective, Constraints, free variables and service requirements – Relationship between materials selection and processing – Case studies in advanced materials selection with relevance to aero, auto, marine, machinery and nuclear applications.

**UNIT IV MODERN METALLIC MATERIALS 9**

Steels-Advanced high strength steel, Dual phase (DP) steel, Transformation induced plasticity (TRIP) Steel, Maraging steel, Nitrogen steel, Austenitic steel and Q&P steels – Intermetallics, Ni and Ti aluminides-Alloys–Al, Mg, Cu,Super alloys-Iron base, Cobalt base, Nickel base. Metal matrix composites (MMC).

**UNIT V NON METALLIC MATERIALS 9**

Polymeric materials – Formation of polymer structure, properties and applications of engineering polymers, Environmental aspects of polymers – Ceramic- Advanced ceramics, WC, TIC, TaC, Al2O3, SiC, Si3N4 CBN and diamond – Fracture of ceramics-Stress strain behavior-Deformation behavior. Glasses-Clay products-refractory ceramics, Composite Materials-GFRP and CFRP laminated composite.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:** Upon completion of this course, the students will be able to:

**CO1** Analyze the different strengthening and failure mechanism of the metals
**CO2** Apply the effects of metallurgical parameters in the materials design
**CO3** Analyze the relationship between the selection of materials and processing
**CO4** Develop the novel material through understanding the properties of the existing metallic materials
**CO5** Analyze the different materials used in the engineering applications

**REFERENCES:**


1. George E.Dieter, Mechanical Metallurgy, McGraw Hill, 1988.
2. Thomas H. Courtney, Mechanical Behavior of Materials, (2nd Edition), McGraw Hill, 2000.
3. Willam D. CallisterJr.and David G. Rethwisch, Callister's Materials Science and Engineering,(2nd Edition) Wiley Editorial, 2018.
4. Charles, J.A., Crane, F.A.A. and Fumess, J.A.G., Selection and use of engineering materials,(34d edition), Butterworth-Heiremann, 1997.
5. Flinn, R.A., and Trojan, P.K., Engineering Materials and their Applications, (4th Edition) Jaico, 1999.
6. Metals Hand book, Vol.10, Failure Analysis and Prevention, (10th Edition), Jaico, 1999.
7. Ashby M.F., Materials Selection in Mechanical Design, 2nd Edition, Butter worth.
8. www.astm.org/labs/pages/131350.htm.

| CO | PO | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| 1 | 3 | | 3 | 1 | 2 | 2 |
| 2 | 3 | | 3 | 1 | 2 | 2 |
| 3 | 3 | | 3 | 1 | 2 | 2 |
| 4 | 3 | | 3 | 1 | 2 | 2 |
| 5 | 3 | | 3 | 1 | 2 | 2 |
| Avg. | 3 | | 3 | 1 | 2 | 2 |

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

| ED3152 | DESIGN AND ANALYSIS OF ADVANCED MECHANISMS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**COURSE OBJECTIVES:**

The main learning objective of this course is to prepare the students for acquiring the knowledge on various mechanisms and its design and simulation.

**UNIT I INTRODUCTION 9**

Review of fundamentals of kinematics-classifications of mechanisms-components of mechanisms – mobility analysis – formation of one D.O.F. multi loop kinematic chains, Network formula – Gross motion concepts-Basic kinematic structures of serial and parallel robot manipulators-Compliant mechanisms-Equivalent mechanisms.

**UNIT II KINEMATIC ANALYSIS 9**

Position Analysis – Vector loop equations for four bar, slider crank, inverted slider crank, geared five bar and six bar linkages. Analytical methods for velocity and acceleration Analysis– four bar linkage jerk analysis. Plane complex mechanisms-auxiliary point method. Spatial RSSR mechanism- Denavit-Hartenberg Parameters – Forward and inverse kinematics of robot manipulators.

**UNIT III PATH CURVATURE THEORY, COUPLER CURVE 9**

Fixed and moving centrodes, inflection points and inflection circle. Euler Savary equation, graphical constructions – cubic of stationary curvature. Four bar coupler curve-cusp -crunode - coupler driven six-bar mechanisms-straight line mechanisms.

**UNIT IV SYNTHESIS OF FOUR BAR MECHANISMS 9**

Type synthesis – Number synthesis – Associated Linkage Concept. Dimensional synthesis – function generation, path generation, motion generation. Graphical methods-Pole technique inversion technique-point position reduction-two, three and four position synthesis of four- bar mechanisms. Analytical methods- Freudenstein's Equation-Bloch's Synthesis.

**UNIT V SYNTHESIS OF COUPLER CURVE BASED MECHANISMS AND CAM MECHANISMS 9**

Cognate Linkages-parallel motion Linkages. Design of six bar mechanisms-single dwell-double dwell-double stroke. Geared five bar mechanism-multi-dwell. Cam Mechanisms- determination of optimum size of cams. Mechanism defects.

**TOTAL:45 PERIODS**

**COURSE OUTCOMES:** Upon completion of this course, the students will be able to:

**CO1** Apply concepts of gross motion capability and develop multi loop kinematic chains and equivalent mechanisms
**CO2** Determine velocity and acceleration of complex mechanisms
**CO3** Evaluate inflection points and draw the inflection circle
**CO4** Synthesize planar mechanisms
**CO5** Design of six bar coupler driven mechanisms and cam mechanisms

**REFERNCES:**


1. Amitabha Ghosh and Asok Kumar Mallik, "Theory of Mechanism and Machines", EWLP, Delhi,1999.
2. Kenneth J, Waldron, Gary L. Kinzel, "Kinematics, Dynamics and Design of Machinery", John Wiley-sons, 2016.
3. Robert L.Norton., "Design of Machinery",Tata McGraw Hill, 2012
4. Sandor G.N., and Erdman A.G., "Advanced Mechanism Design Analysis and Synthesis", Prentice Hall, 1984.
5. Uicker, J.J., Pennock, G. R. and Shigley, J.E., "Theory of Machines and Mechanisms", Oxford University Press, 2017.


| CO | PO | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **1** | 2 | | 3 | 2 | 1 | 2 |
| **2** | 2 | | 3 | 3 | 1 | 2 |
| **3** | 2 | | 3 | 2 | 1 | 1 |
| **4** | 2 | | 3 | 3 | 1 | 2 |
| **5** | 2 | | 3 | 2 | 1 | 1 |
| **Avg.** | 2 | | 3 | 2.4 | 1 | 1.6 |




Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

| PD3151 | INTEGRATED PRODUCT DESIGN AND DEVELOPMENT | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**COURSE OBJECTIVES:**
To understand and apply the principles and concepts in Integrated Product Design and Development.

**UNIT I INTRODUCTION TO PRODUCT DEVELOPMENT 9**
Introduction – Characteristics of Successful Product Development – Product Development Team – Challenges of Product Development – Duration and Cost of Product Development – Product Development Process – Concept Development: The Front-End Process – Adapting the Generic Product Development Process – Product Development Process Flows – Product Development Organizations – Tournament Structure of Opportunity Identification – Opportunity Identification Process.

**UNIT II PRODUCT PLANNING, CUSTOMER NEEDS IDENTIFICATION AND PRODUCT SPECIFICATION 9**
Product Planning Process – Identifying Customer Needs – Importance of Latent Needs – Process of Identifying Customer Needs – Definition of Specifications – Time to Establish Specification – Establishing Target Specifications – Setting the Final Specifications.

**UNIT III PRODUCT CONCEPT GENERATION, SELECTION AND TESTING 9**
Activity of Concept Generation – Concept Selection – Concept Screening – Concept Scoring – Caveats – Concept Testing.

**UNIT IV PRODUCT ARCHITECTURE, INDUSTRIAL DESIGN, DESIGN FOR MANUFACTURING 9**
Product Architecture – Definition – Implications – Establishing the Architecture – Delayed Differentiation – Platform Planning – Related System-Level Design Issues – Industrial Design – Assessing the Need for Industrial Design – Impact of Industrial Design – Industrial Design Process – Management of the Industrial Design Process – Assessing the Quality of Industrial Design – Design for Manufacturing – DFM Process.

**UNIT V PROTOTYPING, PRODUCT DEVELOPMENT ECONOMICS AND MANAGEMENT 9**
Prototyping – Principles, Technologies & Planning – Product Development Economics – Elements of Economic Analysis – Economic Analysis Process – Managing Projects – Understanding and Representing Tasks – Baseline Project Planning - Accelerating Projects – Project Execution – Postmortem Project Evaluation.

**TOTAL:45 PERIODS**

**COURSE OUTCOMES:** Upon completion of this course, the students will be able to:

**CO1** Apply the principles of concept development process and opportunity identification process.
**CO2** Apply the principle of product planning; customer needs analysis and set product specifications for new product design and development.
**CO3** Generate, select, screen, test concepts for new product design and development.
**CO4** Apply the principles of product architecture, industrial design and design for manufacturing in new product development.
**CO5** Apply the principles of prototyping techniques. Apply the concepts of economics principles; project management practices in accelerating the new product development activity.

**REFERENCES:**


1. Karl T.Ulrich, Steven D.Eppinger, Anita Goyal, "Product Design and Development",McGraw – Hill Education (India) Pvt. Ltd, 4th Edition, 2012.
2. Kenneth Crow, "Concurrent Engineering/Integrated Product Development". DRMAssociates, 6/3,Via Olivera, Palos Verdes, CA 90274, (310) 377-569,Workshop Book
3. Kevin N Otto, Kristin L Wood, “Product Design — Techniques in Reverse Engineeringand New Product Development”, Pearson Education, Inc, 2016
4. Stephen Rosenthal, "Effective Product Design and Development", Business One Orwin, Homewood, 1992
5. Stuart Pugh, "Total Design – Integrated Methods for successful Product Engineering", Addison Wesley Publishing, Neyourk, NY,1991.

| CO | PO | | | | | |
|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** |
| **1** | 3 | 3 | 3 | 3 | 2 | 3 |
| **2** | 3 | 3 | 3 | 3 | 2 | 3 |
| **3** | 3 | 3 | 3 | 3 | 2 | 3 |
| **4** | 3 | 3 | 3 | 3 | 2 | 3 |
| **5** | 3 | 3 | 3 | 3 | 2 | 3 |
| **Avg.** | 3 | 3 | 3 | 3 | 2 | 3 |

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

**RM3151** **RESEARCH METHODOLOGY AND IPR** **L T P C**
**2 1 0 3**

**OBJECTIVES:**

To impart knowledge on

- Formulation of research problems, design of experiment, collection of data, interpretation and presentation of result
- Intellectual property rights, patenting and licensing

**UNIT I RESEARCH PROBLEM FORMULATION 9**

Objectives of research, types of research, research process, approaches to research; conducting literature review- information sources, information retrieval, tools for identifying literature, Indexing and abstracting services, Citation indexes, summarizing the review, critical review, identifying research gap, conceptualizing and hypothesizing the research gap

**UNIT II RESEARCH DESIGN AND DATA COLLECTION 9**

Statistical design of experiments- types and principles; data types & classification; data collection - methods and tools

**UNIT III DATA ANALYSIS, INTERPRETATION AND REPORTING 9**

Sampling, sampling error, measures of central tendency and variation,; test of hypothesis- concepts; data presentation- types of tables and illustrations; guidelines for writing the abstract, introduction, methodology, results and discussion, conclusion sections of a manuscript; guidelines for writing thesis, research proposal; References – Styles and methods, Citation and listing system of documents; plagiarism, ethical considerations in research

**UNIT IV INTELLECTUAL PROPERTY RIGHTS 9**

Concept of IPR, types of IPR – Patent, Designs, Trademarks and Trade secrets, Geographical indications, Copy rights, applicability of these IPR; , IPR & biodiversity; IPR development process, role of WIPO and WTO in IPR establishments, common rules of IPR practices, types and features of IPR agreement, functions of UNESCO in IPR maintenance.

**UNIT V PATENTS 9**

Patents – objectives and benefits of patent, concept, features of patent, inventive steps, specifications, types of patent application; patenting process - patent filling, examination of patent, grant of patent, revocation; equitable assignments; Licenses, licensing of patents; patent agents, registration of patent agents.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES**

Upon completion of the course, the student can

CO1: Describe different types of research; identify, review and define the research problem
CO2: Select suitable design of experiment s; describe types of data and the tools for collection of data
CO3: Explain the process of data analysis; interpret and present the result in suitable form
CO4: Explain about Intellectual property rights, types and procedures
CO5: Execute patent filing and licensing

**REFERENCES:**


1. Cooper Donald R, Schindler Pamela S and Sharma JK, “Business Research Methods”, Tata McGraw Hill Education, 11e (2012).
2. Soumitro Banerjee, “Research methodology for natural sciences”, IISc Press, Kolkata, 2022,
3. Catherine J. Holland, “Intellectual property: Patents, Trademarks, Copyrights, Trade Secrets”, Entrepreneur Press, 2007.
4. David Hunt, Long Nguyen, Matthew Rodgers, “Patent searching: tools & techniques”, Wiley, 2007.
5. The Institute of Company Secretaries of India, Statutory body under an Act of parliament, “Professional Programme Intellectual Property Rights, Law and practice”, September 2013.

**ED3161** **DESIGN PRACTICE WITH CAD TOOLS LABORATORY**

| L | T | P | C |
|---|---|---|---|
| 0 | 0 | 4 | 2 |

**COURSE OBJECTIVES:**

The main learning objective of this course is to prepare the students to generate the geometric model using commercial CAD tools.

**List of Experiments**

- CAD Introduction.
- Sketcher
- Solid modeling –Extrude, Revolve, Sweep, etc. and Variational sweep, Loft, etc.
- Surface modeling –Extrude, Sweep, Trim .etc. and Mesh of curves, Free form etc.
- Feature manipulation – Copy, Edit, Pattern, Suppress, History operations etc.
- Assembly-Constraints, Exploded Views, Interference check, Mass and CG.
- Drafting-Layouts, Standard & Sectional Views, Detailing & Plotting

**TOTAL:60 PERIODS**

**COURSE OUTCOMES:**

Upon completion of this course, the students will be able to:

**CO1** Utilize CAD software to create Geometric Constructions and apply principles of technical drawings to create different 3D models

**CO2** construct solid models, assemblies, and detail drawings using a feature-based parametric design CAD program, while capturing design intent in the models

**CO3** solve design problems in parts and assemblies at the intermediate level.

| CO | PO | | | | | |
|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** |
| **1** | 3 | 3 | 3 | 3 | | 2 |
| **2** | 3 | 3 | 3 | 3 | | 2 |
| **3** | 3 | 2 | 3 | 3 | 1 | 2 |
| **Avg.** | 3 | 2.7 | 3 | 3 | 0.3 | 2 |

| ED3162 | MULTI BODY DYNAMICS LABORATORY | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 0 | 4 | 2 |

**COURSE OBJECTIVES:**

The main learning objective of this course is to prepare the students for understanding the forces and torques that come into action in various kinds of mechanical systems.

**List of Experiments:**

1. Free fall of rigid body
2. Projectile motion
3. Simulation of simple Pendulum
4. Simulation of Compound Pendulum
5. Kinematic Analysis four bar and slider crack mechanism and its inversions
6. Dynamic Analysis four bar and slider crack mechanism and its inversions
7. Design of cam Profile for various follower output motion
8. Kinematic & Dynamic Analysis of Gear Tracks
9. Vibration Analysis SDOF and MDOF
10. Project on virtual product design using Commercial Software Package

**TOTAL:60 PERIODS**

**COURSE OUTCOMES:** Upon completion of this course, the students will be able to:

**CO1** Model different systems and import them into the multi body dynamic software
**CO2** Conduct multi body dynamic tests and obtain required dynamic properties by
**CO3** Use the above data in additional stress analysis software

| CO | PO | | | | | |
|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** |
| **1** | 3 | 2 | 3 | 3 | 2 | 1 |
| **2** | 3 | 2 | 3 | 3 | 2 | 1 |
| **3** | 3 | 2 | 3 | 3 | 2 | 1 |
| **Avg.** | 3 | 2 | 3 | 3 | 2 | 1 |

| ED3251 | FINITE ELEMENT METHODS IN MECHANICAL DESIGN | L | T | P | C |
|---|---|---|---|---|---|

**3 0 0 3**

**COURSE OBJECTIVES:**

To develop a thorough understanding of the basic principles of the finite element analysis techniques with an ability to effectively use the tools of the analysis for solving practical problems arising in engineering design.

**UNIT I FINITE ELEMENT ANALYSIS OF ONE DIMENSIONAL PROBLEMS 9**

Historical Background – Weighted Residual Methods - Basic Concept of FEM – Variational Formulation of B.V.P. – Ritz Method – Finite Element Modelling – Element Equations – Linear and Higher order Shape functions – Bar, Beam Elements –Applications to Heat Transfer problems

**UNIT II FINITE ELEMENT ANALYSIS OF TWO DIMENSIONAL PROBLEMS 9**

Basic Boundary Value Problems in two-dimensions – Linear and higher order Triangular, quadrilateral elements – Poisson's and Laplace's Equation – Weak Formulation – Element Matrices and Vectors – Application to scalar variable problems - Introduction to Theory of Elasticity – Plane Stress – Plane Strain and Axisymmetric Formulation – Principle of virtual work – Element matrices using energy approach

**UNIT III ISO-PARAMETRIC FORMULATION 9**

Natural Co-ordinate Systems – Lagrangian Interpolation Polynomials – Isoparametric Elements – Formulation – Shape functions -one dimensional , two dimensional triangular and quadrilateral elements -Serendipity elements- Jacobian transformation - Numerical Integration – Gauss quadrature – one, two and three point integration

**UNIT IV EIGEN VALUE PROBLEMS 9**

Dynamic Analysis – Equations of Motion – Consistent and lumped mass matrices – Free Vibration analysis – Natural frequencies of Longitudinal, Transverse and torsional vibration – Solution of Eigenvalue problems - Introduction to transient field problems.

**UNIT V NON-LINEAR ANALYSIS 9**

Introduction to Non-linear problems - some solution techniques- computational procedure material non-linearity-Plasticity and viscoplasticity, stress stiffening, contact interfaces- problems of gaps and contact - geometric non-linearity - modeling considerations - Free and Mapped meshing -Mesh quality- Error estimate.

**TOTAL:45 PERIODS**

**COURSE OUTCOMES:**

Upon completion of this course, the students will be able to:

**CO1** Develop mathematical models for one dimensional problems and their numerical solutions.
**CO2** Determine field variables for two dimensional scalar and vector variable problems.
**CO3** Apply Isoparametric transformation and numerical integration for evaluation of element matrices.
**CO4** Apply various solution techniques to solve Eigen value problems.
**CO5** Formulate solution techniques to solve non-linear problems.

**REFERENCES:**


1. Bathe K.J., "Finite Element Procedures in Engineering Analysis", Prentice Hall, 1990.
2. David Hutton, "Fundamentals of Finite Element Analysis", Tata Mc Graw Hill, 2005.
3. Rao, S.S., "The Finite Element Method in Engineering", 6th Edition, Butterworth Heinemann,2018.
4. Reddy,J.N. "Introduction to the Finite Element Method", 4th Edition, Tata Mc Graw Hill,2018.
5. Seshu.P, "Text Book of Finite Element Analysis", PHI Learning Pvt. Ltd., New Delhi, 2012.
6. Tirupathi R.Chandrupatla and Ashok D.Belegundu, "Introduction to Finite Elements in Engineering", International Edition, Pearson Education Limited, 2014.


| CO | PO |
|---|---|

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| **1** | 3 | | 3 | 3 | 1 | 1 |
| **2** | 3 | | 3 | 2 | 1 | 1 |
| **3** | 3 | | 3 | 3 | 1 | 1 |
| **4** | 3 | | 3 | 3 | 1 | 1 |
| **5** | 3 | | 3 | 2 | 1 | 1 |
| **Avg.** | 3 | | 3 | 2.6 | 1 | 1 |




Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

| ED3252 | VIBRATION ANALYSIS AND CONTROL | L | T | P | C |
|---|---|---|---|---|---|
| | | 2 | 0 | 2 | 3 |

**COURSE OBJECTIVES:**
The main learning objective of this course is to prepare the students to acquire knowledge on Vibration, and its control strategies for practical applications.

**UNIT I FUNDAMENTALS OF VIBRATION 6**
Introduction – Sources of Vibration – Mathematical Models – Displacement, Velocity and Acceleration – Review of Single Degree Freedom Systems – Vibration Isolation – Vibrometers and Accelerometers – Response to Arbitrary and Non-harmonic Excitations – Transient Vibration – Impulse loads Critical Speed of Shaft-Rotor systems.

**UNIT II TWO-DEGREE FREEDOM SYSTEM 6**
Introduction – Free Vibration of Un-damped and Damped System – Forced Vibration with Harmonic Excitation System – Coordinate Couplings and Principal Coordinates.

**UNIT III MULTI-DEGREE FREEDOM SYSTEM AND CONTINUOUS SYSTEM 6**
Multi Degree Freedom System – Influence Coefficients and Stiffness Coefficients – Flexibility Matrix and Stiffness Matrix – Eigen Values and Eigen Vectors – Matrix Iteration Method – Approximate Methods: Dunkerley, Rayleigh's, and Holzer Method – Geared Systems – Eigen Values & Eigenvectors for Large System of Equations Using Sub Space, Lanczos Method – Continuous System: Vibration of String, Shafts and Beams – Longitudinal Vibration of Rods.

**UNIT IV VIBRATION AND NOISE CONTROL 6**
Specification of Vibration Limits – Vibration Severity Standards – Vibration as Condition Monitoring Tool – Vibration Isolation Methods – Dynamic Vibration Absorber – Static and Dynamic Balancing Machines – Field Balancing – Major Sources of Noise – Noise Survey Techniques – Measurement Technique for Vehicular Noise – Road Vehicle Noise Standards – Industrial Noise Sources – Control Strategies – Noise control at the Source and along the Path – Use of Acoustic Barriers – Noise Control at the Receiver.

**UNIT V EXPERIMENTAL METHODS IN VIBRATION ANALYSIS 6**
Vibration Analysis Overview – Experimental Methods in Vibration Analysis. – Vibration Measuring Instruments – Selection of Sensors – Accelerometer Mountings. – Vibration Exciters – Mechanical, Hydraulic, Electromagnetic and Electrodynamics – Frequency Measuring Instruments – System Identification from Frequency Response – Testing for Resonance and Mode Shapes.

**Laboratory Experiments 30**

**List of Experiments:**

1. Verification of law of springs in an undamped spring-mass system arranged in series, parallel and series-parallel fashions
2. Determination of stiffness and natural frequency of undamped spring-mass systems arranged in series, parallel and series-parallel fashions
3. Determination of natural frequency a single rotor shaft system
4. Determination of critical speed of shaft
5. Dynamic balancing of a rotor
6. Determination of natural frequency, damping coefficient and mode shapes of specimens supported at its ends
7. Forced vibration of a component vibrated through sine and random profiles – Determination of natural frequency and durability

**TOTAL 60 PERIODS**

**COURSE OUTCOMES:** Upon completion of this course, the students will be able to:

**CO1** Apply the basic concepts of vibration in damped and undamped systems and the concepts of dynamic balancing technique to balance various components
**CO2** Determine the natural frequencies and mode shapes of the two-degree freedom systems.
**CO3** Calculate the natural frequencies and mode shapes of the multi-degree freedom and continuous systems
**CO4** Control the vibration and noise levels in a body
**CO5** Measure and analyze the vibration levels in a body

**REFERENCES:**


1. Singiresu S. Rao,"Mechanical Vibrations', Pearson Education Inc., 2017.
2. Graham Kelly. S and Shashidhar K. Kudari, "Mechanical Vibrations", Tata McGraw –Hill Publishing Com. Ltd., 2007.
3. William T. Thomson, "Theory of Vibration with Applications", Taylor & Francis, 2003.
4. Ramamurti. V, "Mechanical Vibration Practice with Basic Theory", Narosa Publishing House, 2000.
5. Rao V Dukkipati, "Vibration Analysis", Narosa Publishing House, 2004.


| CO | PO | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| 1 | 3 | | 3 | 2 | 2 | 1 |
| 2 | 3 | | 3 | 2 | 2 | 1 |
| 3 | 3 | | 3 | 2 | 2 | 1 |
| 4 | 3 | | 3 | 2 | 2 | 1 |
| 5 | 3 | | 3 | 2 | 2 | 1 |
| Avg. | 3 | | 3 | 2 | 2 | 1 |

**ED3253 ENGINEERING FRACTURE MECHANICS**

| L | T | P | C |
|---|---|---|---|
| 3 | 0 | 0 | 3 |

**COURSE OBJECTIVES:**

The main learning objective of this course is to prepare the students to acquire knowledge on mechanics of cracked components of different modes by which these components fail under static and fatigue load conditions.

**UNIT I ELEMENTS OF SOLID MECHANICS 9**

Introduction to Failure and Fracture – Spectacular Failures-Basics Principles – Governing equations for the deformable body – Stress-Strain relations and general equations of elasticity in Cartesian and Polar Coordinates – Vectors and tensors – Differential equations of equilibrium – Compatibility – Boundary conditions – Representation of three-dimensional stress system – Generalized hook's law – Plane stress and stain problems – Airy's stress function – Methods of formulation of Governing Differential equations for plane elasticity – Naviers Equation – Biharmonic equation in Cartesian and Polar coordinates.

**UNIT II STRESS AND DISPLACEMENT AROUND THE CRACK TIP FOR DIFFERENT MODES OF FRACTURE 9**

Brittle and Ductile Fracture – Modes of Fracture – Weakness of the components due to Flaws – Need for Linear Elastic Fracture Mechanics (LEFM) – Evaluation of Structural Design – Stress and displacement around the crack tip in K – Annulus for Mode-I and Mode-II plane crack problems – Stress and displacement around the crack tip in K – Annulus for Mode III crack problems.

**UNIT III STATIONARY CRACK UNDER STATIC LOADING 9**

Griffith analysis – Irwin's approximation – CTOD and stress ahead of the crack tip – Westergaard solutions: Analytical Calculations for SIF for different crack geometries – Critical crack length and fracture stress calculations – Two dimensional elastic fields – Analytical solutions for small scale yielding near a crack front – Plastic zone size – Specimen size calculations: $K_{1c}$ Testing for Fracture toughness of the Material

**UNIT IV FATIGUE FAILURE AND ENVIRONMENTAL-ASSISTED FRACTURE 9**

Introduction to fatigue failure – S-N Curve – Crack Initiation – Crack propagation – Effect of an Overload – Variable amplitude Fatigue load – Crack closure – Characteristics of fatigue crack – Paris Law – Fatigue Crack Growth Test to evaluate Paris constants – Life calculations for a given load amplitude – Effects of changing the load spectrum Environmental-assisted Fracture – Micro mechanisms – Factors influencing Environmental-assisted fracture – Environment-assisted Fatigue Failure affecting fatigue performance, fatigue loading, constant and variable amplitude loading.

**UNIT V APPLICATIONS OF FRACTURE MECHANICS 9**

J-integral, Mixed-mode fracture, Crack arrest methodologies – Case studies: Analysis on failed components and design for the extension of its life.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:**

Upon completion of this course, the students will be able to:

**CO1** Formulate the governing equations for elastic problems.
**CO2** Evaluate the stresses/displacements around the crack tip for different modes of fracture.
**CO3** Estimate the $k_{1c}$/SIF/critical flaws/failure stresses for different crack geometries.
**CO4** Assess the life of the cracked components under different types of repeated/variable fatigue loads and for designing for its life extension
**CO5** Analyze the failed engineering components under different modes of fracture.

**REFERENCES:**


1. Broek, David, "Elementary Engineering Fracture Mechanics ", Springer Netherlands, 1982.
2. John M.Barson and Stanely T.Rolfe, "Fatigue and fracture control in structures", Butterworth-Heinemann; 3rd edition. 1999.
3. Kare Hellan, "Introduction of Fracture Mechanics", McGraw-Hill Book Company, 1985.
4. Prashant Kumar, "Elements of Fracture Mechanics", Tata McGraw-Hill Publishing Company Ltd, 2009.

5. Ted L. Anderson, “Fracture Mechanics: Fundamentals and Applications”, CRC Taylor and Francis, 4th Edition, 2017 .
6. Tribikram Kundu, “Fundamentals of Fracture Mechanics”, Ane Books Pvt. Ltd. New Delhi/ CRC Press, 1st Indian Reprint, 2012

| CO | PO | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| 1 | 3 | | 3 | 2 | 1 | 1 |
| 2 | 3 | | 3 | 2 | 1 | 1 |
| 3 | 3 | | 3 | 2 | 1 | 1 |
| 4 | 3 | | 3 | 2 | 1 | 1 |
| 5 | 3 | | 3 | 2 | 1 | 1 |
| Avg. | 3 | | 3 | 2 | 1 | 1 |



Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

| ED3261 | FINITE ELEMENT MODELLING AND SIMULATION LABORATORY | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 0 | 4 | 2 |

**COURSE OBJECTIVES:**

The main learning objective of this course is to prepare the students for effectively using analysis tools for solving practical problems.

**List of Experiments:**

1. Force and Stress analysis using link elements in Trusses.
2. Stress and deflection analysis in beams with different support conditions.
3. Stress analysis of flat plates.
4. Stress analysis of axi–symmetric components.
5. Thermal stress and heat transfer analysis of plates.
6. Thermal stress analysis of cylindrical shells.
7. Vibration analysis of spring-mass systems.
8. Modal analysis of Beams.
9. Harmonic, transient and spectrum analysis of simple systems.
10. Analysis of machine elements under dynamic loads
11. Analysis of non-linear systems

**TOTAL:60 PERIODS**

**COURSE OUTCOMES:**

Upon completion of this course, the students will be able to:

**CO1** Solve the engineering problems numerically with Computer Aided Finite Element Analysis packages
**CO2** Create Finite Element Model to accurately simulate the physical behaviour.
**CO3** Demonstrate problem-solving skills by Result and Post-Processing the solution

| CO | PO | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| 1 | 3 | | 3 | 2 | 1 | 1 |
| 2 | 3 | | 3 | 2 | 1 | 1 |
| 3 | 3 | 3 | 3 | 2 | 1 | 1 |
| Avg. | 3 | 1 | 3 | 2 | 1 | 1 |

**ED3311** **Technical Seminar**

| L | T | P | C |
|---|---|---|---|
| 0 | 0 | 2 | 1 |

**COURSE OBJECTIVES:**

The main learning objective of this course is to prepare the students for acquiring skills of oral presentation in seminars and conferences and technical writing abilities for journal publications.

The students will work for two hours per week guided by a group of staff members. They will be asked to talk on any topic of their choice related to Engineering design topics and to engage in dialogue with the audience. A brief copy of their talk also should be submitted. Similarly, the students will have to present a seminar of not less than fifteen minutes and not more than thirty minutes on the technical topic. They will also answer the queries on the topic. The students as audience also should interact. Evaluation will be based on the technical presentation and the report and also on the interaction during the seminar.

**TOTAL:30 PERIODS**

**COURSE OUTCOMES:** Upon completion of this course, the students will be able to:

**CO1** Comprehend concepts and methods for inductive and deductive reasoning of technical contents.
**CO2** Develop report writing skills.
**CO3** Develop oral presentation skills.

| CO | PO | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| 1 | 3 | | 3 | | 2 | |
| 2 | 3 | 3 | 3 | | 2 | |
| 3 | 3 | 3 | 3 | | 2 | |
| Avg. | 3 | 2 | 3 | | 2 | |

**ED3312** **PROJECT WORK – I**

| L | T | P | C |
|---|---|---|---|
| 0 | 0 | 12 | 6 |

**COURSE OBJECTIVES:**

The main learning objective of this course is to prepare the students for identifying a specific problem for the current need of the society and or industry, through detailed review of relevant literature, developing an efficient methodology to solve the identified specific problem.

Each PG student shall work individually on a selected specific topic in the area of Product Design & Development which shall be approved by the Head of the Division under the supervision of a Faculty Member (Guide / Supervisor) who is familiar in the selected specific topic. The selected specific topic maybe theoretical and or experimental and or simulation and or case study. The students' Project Work – I shall be evaluated through Internal Examination and End Semester Examination.

The Internal Examination must be conducted periodically (Zeroth, First, Second and Third) through Project Work Review Presentation Meetings followed by questions from the panel of Review Committee Members comprising of two expert faculty members and a project coordinator.

At the end of the semester, a detailed report on the work done by the PG student must be submitted with the approval from the Guide/Supervisor and the Review Committee Members. The Project Work – I Report must contain the Introduction with clear definition along with detailed review of relevant literature on the selected specific problem; an efficient methodology to solve the selected specific problem along with necessary hypothesis and or experimental setup and or simulation and or case study for carrying out the research project work along with preliminary results; discussions, relevant conclusions and future direction along with specified references.

The End Semester Examination must be conducted through Project Work Presentation followed by questions from the panel of Examiners comprising an External Examiner and Project Coordinator as Internal Examiner.

**TOTAL: 180 PERIODS**

**COURSE OUTCOMES:** Upon completion of this course, the students will be able to:

**CO1** Demonstrate a sound technical knowledge in their selected project topic.

**CO2** Select and identify the problem statement along with scope and boundary; assimilate detailed review of relevant literature; formulate an efficient methodology to solve the selected specific problem.

**CO3** Propose engineering design solutions to complex problems using a systematic approach.

| CO | PO | | | | | |
|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** |
| **1** | 3 | 3 | 3 | 3 | 2 | 3 |
| **2** | 3 | 3 | 3 | 3 | 2 | 3 |
| **3** | 3 | 3 | 3 | 3 | 2 | 3 |
| **Avg.** | 3 | 3 | 3 | 3 | 2 | 3 |

**ED3411** **PROJECT WORK – II**

| **L** | **T** | **P** | **C** |
|---|---|---|---|
| **0** | **0** | **24** | **12** |

**COURSE OBJECTIVES:**

The main learning objective of this course is to prepare the students for solving the specific problem for the current need of the society and or industry, through the formulated efficient methodology, and to develop necessary skills to critically analyse and discuss in detail regarding the project results and making relevant conclusions.

The student may continue to work on the Project Work – I's selected topic as per the formulated efficient methodology under the same Faculty Member (Guide/Supervisor). The students' Project Work – II shall be evaluated through Internal Examination and End Semester Examination.

The Internal Examination must be conducted periodically (First, Second and Third) through Project Work Review Presentation Meetings followed by questions from the panel of Review Committee Members comprising of two expert faculty members and a project coordinator.

At the end of the semester, a detailed report on the work done by the PG student must be submitted with the approval from the Guide/Supervisor and the Review Committee Members. The Thesis (Project Work – II Report) must contain the Introduction with clear definition along with detailed review of relevant literature on the selected specific problem; an efficient methodology to solve the selected specific problem along with necessary theoretical hypothesis and or experimentation and or simulation and or case study for carrying out the research project work along with complete results with critical analysis and detail discussions, followed by relevant conclusions, along with specified references.

The End Semester Examination must be conducted through Project Work Presentation followed by questions from the panel of Examiners comprising an External Examiner and Project Coordinator as Internal Examiner.

**TOTAL: 360 PERIODS**

**COURSE OUTCOMES:** Upon completion of this course, the students will be able to:

**CO1** Demonstrate a sound technical knowledge of their selected project topic.

**CO2** Propose product design & development solutions to complex problems using a systematic approach.

**CO3** Demonstrate the knowledge, skills and attitudes of a professional engineer to take up any challenging practical problem in the field of engineering design and find optimum solutions to it.

| CO | PO | | | | | |
|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** |
| **1** | 3 | 3 | 3 | 3 | 2 | 3 |
| **2** | 3 | 3 | 3 | 3 | 2 | 3 |
| **3** | 3 | 3 | 3 | 3 | 2 | 3 |
| **Avg.** | 3 | 3 | 3 | 3 | 2 | 3 |

| ED3053 | DESIGN FOR SUSTAINABILITY | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**COURSE OBJECTIVES:**

The main learning objective of this course is to prepare the students for understanding the design for sustainable behaviour and design practices.

**UNIT I INTRODUCTION 9**

Addressing sustainability by design – Challenges-evolution for sustainability – Need and impact – Responses from design – Product lifecycle design – Design for eco-efficient product service systems –Eco design principles and strategies – Green design – Principles and strategies.

**UNIT II DESIGN FOR SUSTAINABLE BEHAVIOUR 9**

Triggering and supporting changes in human behaviour – Comprehensive action determination model (CADM) – Design practices – Decision support framework for promoting sustainable behaviour – Benefits – DfSB Methods and tools – Middle ground – Individual cognitive methods – Context driven methods – Future research direction.

**UNIT III DESIGN FOR ENVIRONMENT 9**

Environmental objectives – Global issues – Regional and local issues – Basic DFE methods – Design guide lines – Example application – Lifecycle assessment – Basic method – AT&T's environmentally responsible product assessment – Weighted sum assessment method – Lifecycle assessment method – Techniques to reduce environmental impact – Design to minimize material usage – Design for disassembly – Design for recyclability – Design for manufacture – Design for energy efficiency.

**UNIT IV PRODUCT SERVICE DESIGN FOR SUSTAINABILITY 9**

Design of individual products to integrated set of products and services – Categories – Need to implement – Design practice – PSS design for sustainability examples – Methods and tools – Benefits and limitations – Future research direction – Case studies.

**UNIT V SYSTEMIC DESIGN AND FUTURE OF DESIGN FOR SUSTAINABILITY 9**

Sustainable productive systems at a territorial scale – Design practice – Design for sustainability transitions – Framework to capture DfS – Approach – Innovation levels – Evolution of DfS – Design to regulations and standards.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:** Upon completion of this course, the students will be able to:

**CO1** Address the need, challenges and impact the need for sustainable design
**CO2** Understand the design for sustainable behaviour and design practices
**CO3** Evaluate design considerations for environmental issues
**CO4** Know the design categories in the product service design and future research directions
**CO5** Understand the evolution of Design for sustainability and its framework

**REFERENCES:**


1. Fabrizio Ceschin and Idil Gaziuluosy, "Design for sustainability: A Multi-level Framework from Products to Socio-technical System", Routledge focus on environment and sustainability,2020.
2. Boothroyd,G, "Design for Assembly Automation and Product Design", NewYork, Marcel Dekker, 1980.
3. J. G. Bralla, "Design for Manufacture Handbook", McGrawhill,1999.
4. Boothroyd, G, Heartz and Nike, "Product Design for Manufacture", Marcel Dekker,1994.
5. Dickson, John.R, and Corroda Poly, "Engineering Design and Design for Manufacture and Structural Approach", Field Stone Publisher, USA,1995.
6. Fixel, J., "Design for the Environment", McGraw Hill., 1996
7. Graedel T.E. and B. R. Allenby, "Design for the Environment", Pearson, 1996.
8. Kevin Otto and Kristin Wood, "Product Design", Pearson Publication, (Fourth Impression), 2009.

| CO | PO | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| 1 | 3 | | 3 | 2 | 2 | 3 |
| 2 | 3 | | 3 | 2 | 2 | 3 |
| 3 | 3 | | 3 | 2 | 2 | 3 |
| 4 | 3 | | 3 | 2 | 2 | 3 |
| 5 | 3 | | 3 | 2 | 2 | 3 |
| Avg. | 3 | | 3 | 2 | 2 | 3 |



Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

| ED3001 | COMPOSITE MATERIALS AND MECHANICS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**COURSE OBJECTIVES:**
The main learning objective of this course is to prepare the students for understanding the design for sustainable behaviour and design practices.

**UNIT I INTRODUCTION TO COMPOSITE MATERIALS 9**

Definition - Matrix materials – polymers - metals-ceramics - Reinforcements: Particles, whiskers, inorganic fibers, metal filaments - Advanced Fibers - Carbon and Graphite Fibers, ceramic fibers - fiber fabrication-natural composite wood, Jute - Advantages and drawbacks of composites over monolithic materials. Mechanical properties and applications of composites, Particulate-Reinforced composite Materials, Dispersion-Strengthened composite, Fiber-reinforced composites Rule of mixtures-Characteristics of fiber-Reinforced composites, Manufacturing fiber and composites.

**UNIT II MANUFACTURING OF COMPOSITES 9**

Manufacturing process of Epoxy resins and Fibers - Manufacturing of Polymer Matrix Composites (PMCs) - hand lay-up, spray technique, filament winding, Pultrusion, Resin Transfer Moulding (RTM), bag moulding, injection moulding, Sandwich Mould Composites (SMC) - Manufacturing of Metal Matrix Composites (MMCs) - Solid state, liquid state, vapour state processing, Manufacturing of Ceramic Matrix Composites (CMCs) – Hot pressing reaction bonding process - infiltration technique, direct oxidation - interfaces.

**UNIT III LAMINA CONSTITUTIVE EQUATIONS 9**

Lamina Constitutive Equations: Lamina Assumptions – Macroscopic Viewpoint, Generalized Hooke's Law, Reduction to Homogeneous Orthotropic Lamina – Isotropic limit case, Orthotropic Stiffness matrix (Qij), Definition of stress and Moment Resultants. Strain Displacement relations. Basic Assumptions of Laminated anisotropic plates. Laminate Constitutive Equations – Coupling Interactions, Balanced Laminates, Symmetric Laminates, Angle Ply Laminates, Cross Ply Laminates. Laminate Structural Moduli. Evaluation of Lamina Properties from Laminate Tests. Quasi-Isotropic Laminates. Determination of Lamina stresses within Laminates - Laminate Analysis Through Computers.

**UNIT IV LAMINA STRENGTH ANALYSIS AND ANALYSIS OF LAMINATED FLAT PLATES 9**

Introduction - Maximum Stress and Strain Criteria. Von-Misses Yield criterion for Isotropic Materials. Generalized Hill's Criterion for Anisotropic materials. Tsai-Hill's Failure Criterion for Composites. Tensor Polynomial (Tsai-Wu) Failure criterion. Prediction of laminate Failure Equilibrium Equations of Motion. Energy Formulations. Governing Equations for Plates -Static Bending Analysis. Buckling Analysis. Free Vibrations – Natural Frequencies.

**UNIT V THERMO-STRUCTURAL ANALYSIS 9**

Fabrication stresses/Residual stresses in FRP laminated composites- Co-efficient of Thermal Expansion (C.T.E.) - Modification of Hooke's Law. Modification of Laminate Constitutive Equations. Orthotropic Lamina C.T.E's -Stress and Moment Resultants due cooling of the laminates during fabrication-Calculations for thermo-mechanical stresses in FRP laminates - Thermally Quasi-Isotropic Laminates.
Case studies: Implementation of CLT for evaluating residual stresses in the components made with different isotropic layers such as electronic packages etc.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:** Upon completion of this course, the students will be able to:

**CO1** calculate for mechanical strength of the composite material
**CO2** fabricate the FRP and other composites by different manufacturing methods
**CO3** analyze fiber reinforced Laminates for different combinations of plies with different orientations of the fiber

**CO4** evaluate the stresses in the lamina of the laminate using different failure theories
**CO5** analyze thermo-mechanical behaviour and evaluate residual stresses in different types of laminates using the Classical Laminate Theory

**REFERENCES:**


1. Agarwal BD and Broutman LJ, “Analysis and Performance of Fiber Composites”, John Wiley and Sons, New York, 1990.
2. Gibson R F, Principles of Composite Material Mechanics, McGraw-Hill, 1994,CRC press, 4th Edition, 2015.
3. Hyer MW and Scott R White, “Stress Analysis of Fiber – Reinforced Composite Materials”, McGraw-Hill, 1998
4. Issac M Daniel and Orilshai, “Engineering Mechanics of Composite Materials”, Oxford University Press-2006, First Indian Edition - 2007 Madhujit Mukhopadhyay, “Mechanics of Composite Materials and Structures”, University Press (India) Pvt. Ltd., Hyderabad, 2004 (Reprinted 2008)
5. Mallick PK, Fiber – Reinforced Composites: Materials, Manufacturing and Design, CRC Press, 3rd Edition,2007.


| CO | PO | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| 1 | 3 | | 3 | | 2 | 2 |
| 2 | 3 | | 3 | | 2 | 2 |
| 3 | 3 | | 3 | | 2 | 2 |
| 4 | 3 | | 3 | | 2 | 2 |
| 5 | 3 | | 3 | | 2 | 2 |
| Avg. | 3 | | 3 | | 2 | 2 |

| ED3002 | QUALITY CONCEPTS IN DESIGN | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**COURSE OBJECTIVES:**

The main learning objective of this course is to prepare the students for imparting knowledge on various concepts in engineering design and principles of implementing quality in a product or service.

**UNIT I DESIGN FUNDAMENTALS, METHODS AND MATERIAL SELECTION 9**

Morphology of Design – The Design Process – Computer Aided Engineering – Concurrent Engineering – Competition Bench Marking – Creativity – Theory of Problem solving (TRIZ) – Value Analysis - Design for Manufacture, Design for Assembly – Design for casting, Forging, Metal Forming, Machining and Welding

**UNIT II DESIGN FOR QUALITY 9**

Quality Function Deployment **-**House of Quality-Objectives and functions-Targets-Stakeholders- Measures and Matrices-Design of Experiments –design process-Identification of control factors, noise factors, and performance metrics - developing the experimental plan- experimental design – testing noise factors-Running the experiments –Conducting the analysis-Selecting and conforming factor-Set points-reflecting and repeating

**UNIT III FAILURE MODE EFFECTS ANALYSIS, DESIGN FOR SIX SIGMA AND DESIGN FOR SAFETY 9**

Basic methods: Refining geometry and layout, general process of product embodiment - Embodiment checklist- Advanced methods: systems modeling, mechanical embodiment principles-FMEA method-linking fault states to systems modeling - Basis of SIX SIGMA –Serviceability – Preventive Maintenance – Breakdown Maintenance – Testability – Role of reliability in maintenance and repair

**UNIT IV DESIGN OF EXPERIMENTS 9**

Importance of Experiments, Experimental Strategies, Basic principles of Design, Terminology, ANOVA, Steps in Experimentation, Sample size, Single Factor experiments – Completely Randomized design, Randomized Block design, Statistical Analysis, Multifactor experiments - Two and three factor full Factorial experiments, 2K factorial Experiments, Confounding and Blocking designs, Fractional factorial design, Taguchi's approach - Steps in experimentation, Design using Orthogonal Arrays, Data Analysis, Robust Design- Control and Noise factors, S/N ratios

**UNIT V STATISTICAL CONSIDERATION AND RELIABILITY 9**

Frequency distributions and Histograms- Run charts –stem and leaf plots- Pareto diagrams- Cause and Effect diagrams-Box plots- Probability distribution-Statistical Process control–Scatter diagrams – Multivariable charts –Matrix plots and 3-D plots.-Reliability-Survival and Failure- Series and parallel systems-Mean time between failure-Weibull distribution

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:** Upon completion of this course, the students will be able to:

**CO1** apply fundamentals of design process and material selection for developing a quality product
**CO2** apply the quality concepts to develop a robust product
**CO3** perform Failure Mode Effect Analysis on a product and use six sigma principles to enhance its quality
**CO4** apply different experimental design methods in product development
**CO5** implement various statistical tools to improve its quality and reliability

**REFERENCES:**


1. Amitava Mitra, "Fundamentals of Quality control and improvement", John Wiley & Sons, 2016
2. George E. Dieter, Linda C. Schmidt, "Engineering Design", McGraw Hill Education Pvt. Ltd., 2013
3. Karl T. Ulrich, Steven D. Eppinger, "Product Design And Development, ,TataMcgraw-Hill Education, 2015

4. Kevin N. Otto and Kristin L. Wood, “Product Design: Techniques in Reverse Engineering and New Product Development”, Prentice Hall, 2001
5. Montgomery, D.C., “Design and Analysis of experiments”, John Wiley and Sons, 2019.
6. Phillip J. Ross, “Taguchi techniques for quality engineering”, Tata McGraw Hill, 2005.

| CO | PO | | | | | |
|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** |
| **1** | 3 | | 3 | 2 | 2 | 1 |
| **2** | 3 | | 3 | 2 | 2 | 1 |
| **3** | 3 | 2 | 3 | 2 | 2 | 1 |
| **4** | 3 | 2 | 3 | 2 | 2 | 1 |
| **5** | 3 | | 3 | 2 | 2 | 1 |
| **Avg.** | 3 | 0.8 | 3 | 2 | 2 | 1 |



Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

| ED3003 | BEARING DESIGN AND ROTOR DYNAMICS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**COURSE OBJECTIVES:**

The main learning objective of this course is to prepare the students for knowing about different types of bearings available for machine design and their operating principles and acquiring research knowledge in the developing area of the rotor dynamics such as identification of rotor bearing system parameters and its use in futuristic model-based condition monitoring and fault diagnostic.

**UNIT I CLASSIFICATION AND SELECTION OF BEARINGS 9**

Selection criteria-Dry and Boundary Lubrication Bearings-Hydrodynamic and Hydrostatic bearings- Electro Magnetic bearings-Dry bearings-Rolling Element bearings- Bearings for Precision Applications-Foil Bearings-Special bearings- Selection of plain Bearing materials –Metallic and Non metallic bearings

**UNIT II SELECTION AND DESIGN OF ROLLING BEARINGS 9**

Design and performance analysis of Thrust and Journal bearings – Full, partial, fixed and pivoted journal bearings design procedure-Design and performance analysis of Rolling bearings- Contact Stresses and Centrifugal stresses-Elasto hydrodynamic lubrication- Fatigue life calculations- dynamics of hydro dynamic bearings -Squeeze film effects in journal bearings and thrust bearings -Rotating loads, alternating and impulse loads in journal bearings

**UNIT III TORSIONAL VIBRATION OF ROTATING MEMBERS AND THEIR INSTABILITY 9**

Flexural and torsional vibrations, critical speeds of shafts using Rayleigh's method, matrix iteration methods, Prohal and Myklested method, equivalent discrete systems, geared and branched systems. - Instability of rotors mounted on fluid film bearings, rigid rotor instability, instability of a flexible rotor, instability threshold by transfer matrix methods, internal hysteresis of shafts, instability in torsional vibrations

**UNIT IV BALANCING OF ROTORS 9**

Balancing of rotors, Concepts and principles of Single-plane balancing, Two-plane balancing, balancing criteria for flexible rotors, bearing dynamic parameters estimation, measurement & digital processing techniques

**UNIT V CONDITIONING MONITORING 9**

Introduction to rotary machinery maintenance, fundamentals of data acquisition, principles of condition monitoring, transducers for condition monitoring, fault diagnosis in rotating machines, NDT methods in condition monitoring, wear and debris analysis, case studies in condition monitoring

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:** Upon completion of this course, the students will be able to:

**CO1** acquisition of knowledge in the analysis of all types of bearings.
**CO2** ability to make specifications of all types of bearings
**CO3** ability to develop the vibration models of rotor bearing systems with changing complexities for real engineering systems.
**CO4** ability to formulate the response due to unbalance and instability in practical rotor systems.
**CO5** ability to identify rotor bearing system parameters and capability to carry out research in condition monitoring and fault identification in rotors

**REFERENCES:**


1. J. S. Rao, "Rotor Dynamics", New Age International Publishers, New Delhi.
2. T. Yamamoto and Y. Ishida, "Linear and Nonlinear Rotor Dynamics: A Modern Treatment with Applications", John Wiley.
3. J. S. Rao, "Vibratory Condition Monitoring of Machines", Narosa Publishing House.
4. Neale, M.J. "Tribology Hand Book", Butterworth Heinemann, United Kingdom 2001.
5. Cameron, A. "Basic Lubrication Theory", Ellis Herward Ltd., UK, 1981.

6. Halling, J. (Editor) – “Principles of Tribology “, Macmillian – 1984. 4. Williams J.A. “ Engineering Tribology”, Oxford Univ. Press, 1994.
7. S.K.Basu, S.N.Segupta & B.B.Ahuja ,”Fundamentals of Tribology”, Prentice –Hall of India Pvt Ltd , New Delhi, 2005.
8. G.W.Stachowiak& A.W .Batchelor , Engineering Tribology, Butterworth-Heinemann, UK, 2005.

| CO | PO | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| 1 | 3 | | 3 | 3 | 2 | 2 |
| 2 | 3 | | 3 | 3 | 2 | 2 |
| 3 | 3 | | 3 | 3 | 2 | 2 |
| 4 | 3 | | 3 | 3 | 2 | 2 |
| 5 | 3 | | 3 | 3 | 2 | 2 |
| Avg. | 3 | | 3 | 3 | 2 | 2 |

| CI3151 | SOLID FREEFORM MANUFACTURING | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**OBJECTIVES:**

- To gain knowledge on evolution of Solid Freeform Manufacturing (SFM) and the importance of DfAM in improving the quality.
- To acquaint with various SFM Technologies and hybrid processes, along with their material science and applications in different fields.

**UNIT I INTRODUCTION** **9**

Introduction to solid freeform manufacturing (SFM) - Need- SFM evolution, Distinction between SFM & CNC machining- Development of SFM systems — Hierarchical structure of SFM - SFM process chain — Classification. SFM Supply chain - Economics aspect: Strategic aspect- Operative aspect

**UNIT II DESIGN FOR ADDITIVE MANUFACTURING (DfAM)** **9**

Concepts and Objectives- General Guidelines for DfAM - DfAM tools, Requirements of DfAM methods, - Additive Manufacturing (AM) Unique Capabilities –Design Consideration in AM- Part Consolidation – Computational tools for design analysis- Topology Optimization - Lightweight Structures – Generative design- DfAM for Part Quality Improvement - CAD Modeling - Model Reconstruction - Data Processing for AM - Data Formats: STL, AMF,PLY, VRML- Data Interfacing - Part Orientation - Support Structure Design and Support Structure Generation - Model Slicing - Tool Path Generation.

**UNIT III VAT POLYMERIZATION, MATERIAL EXTRUSION & SHEET LAMINATION TECHNOLOGIES** **9**

Vat polymerization: Stereolithography Apparatus (SLA): Principles — Photo Polymerization of SL Resins - Pre Build Process — Part-Building and Post-Build Processes - Part Quality and Process Planning, Recoating Issues - Materials - Capabilities - Limitations and Applications. Digital Light Processing (DLP) - Materials - Process – Capabilities and Applications. Continuous Liquid Interface Production (CLIP)- Materials - Process - Capabilities and Applications. Material extrusion: Fused deposition Modeling (FDM): Working Principles - Process - Materials – Capabilities and Applications. Design Rules for FDM. Sheet lamination processes: Laminated Object Manufacturing (LOM): Working Principles - Process – Materials- Capabilities- Limitations and Applications. Ultrasonic Additive Manufacturing (UAM) - Process - Parameters –Capabilities- Applications. Case Studies.

**UNIT IV POWDER BED FUSION, BINDER JETTING, MATERIAL JETTING & DIRECT ENERGY DEPOSITION TECHNOLOGIES** **9**

Powder Bed Fusion: Selective Laser Sintering (SLS): Principles - Process - Indirect and Direct SLS - Powder Structure -Materials - Surface Deviation and Accuracy – Capabilities- Applications. Multi-jet Fusion Principles – Processes - Materials — Capabilities and Applications. Selective Laser Melting (SLM) and Electron Beam Melting (EBM): Principles — Processes — Materials — Capabilities - Limitations and Applications. Binder Jetting: Three dimensional Printing (3DP): Principles - Process - Physics of 3DP - Process — Materials - Capabilities - Limitations - Applications. Material Jetting: Multi Jet Modelling (MJM) - Principles - Process - Materials - Capabilities and Application. Direct Energy Deposition: Laser Engineered Net Shaping (LENS): Processes- Materials- Capabilities - Limitations and Applications. Hybrid Additive Manufacturing – Need - Principles - Part Quality and Process Efficiency. Wire Arc Additive Manufacturing (WAAM) Processes- Materials- Capabilities - Limitations and Applications. Case Studies.

**UNIT V MATERIALS AND APPLICATIONS OF SFM** **9**

Materials science for SFM - Multifunctional and graded materials in AM, Role of solidification rate, Evolution of non-equilibrium structure, microstructural studies, Structure property relationship. Application of SFM in Automotive-Aerospace-Bio Medical-Bio printing- Food Printing- Electronics printing — Rapid Tooling - Building printing.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:**

**At the end of the course, students will be able to**

CO 1: Explore the importance in the evolution of SFM/AM, proliferation into the various fields and its effects on supply chain

CO 2: Recognize the importance of DfAM in improving the quality of fabricated parts and understand the guidelines of DfAM

CO 3: Acquire knowledge on principles and applications of vat polymerization, material extrusion and sheet lamination processes with case studies.

CO 4: Acquire knowledge on principles of powder bed fusion, jetting, direct energy deposition and hybrid processes

CO 5: Understand the properties and characteristics of materials used in SFM/AM and explore the applications in various fields.

**REFERENCES:**


1. Ian Gibson, David W. Rosen and Brent Stucker, “Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing” Springer - New York, USA, 3rd Edition, 2021. ISBN-978- 3-030-56126-0.
2. Andreas Gebhardt and Jan-Steffen Hotter, “Additive Manufacturing: 3D Printing for Prototyping and Manufacturing”, Hanser publications Munchen, Germany, 2016. ISBN: 978-1-56990-582-1.
3. A Practical Guide to Design for Additive Manufacturing, Diegel, Olaf, Axel Nordin, and Damien Motte, Springer, 2020.
4. Liou, L.W. and Liou, F.W., “Rapid Prototyping and Engineering applications: A tool box for prototype development", CRC Press, 1°t Edition, 2019 FL, USA. ISBN- 9780429029721
5. Ben Redwood, Brian Garret, Filemon Schoffer, and Tony Fadel, “The 3D Printing Handbook: Technologies, Design and Applications”, 3D Hubs B.V., Netherland, 2017. ISBN-13: 978-9082748505.
6. Milan Brandt., “Laser Additive Manufacturing 1st Edition Materials, Design, Technologies, and Applications”, Woodhead Publishing, UK, 2016. ISBN- 9780081004333.


| CO | PO | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| 1 | 1 | 2 | 2 | 1 | 2 | 2 |
| 2 | 3 | 3 | 2 | 2 | 2 | 3 |
| 3 | 3 | 2 | 3 | 3 | 3 | 2 |
| 4 | 3 | 3 | 2 | 3 | 3 | 2 |
| 5 | 3 | 2 | 3 | 2 | 3 | 3 |
| Avg | 2.6 | 2.4 | 2.4 | 2.2 | 2.6 | 2.4 |

**PD3152** **PRODUCT LIFECYCLE MANAGEMENT**

| L | T | P | C |
|---|---|---|---|
| 2 | 0 | 2 | 4 |

**COURSE OBJECTIVES:**

To understand and apply the principles and concepts in Product Life-Cycle Management for Product Design and Development.

**UNIT I INTRODUCTION TO PLM** **6**

Definition of PLM; PLM Initiative; PLM Paradigm – P, L and M of PLM – Scope of PLM – PLM Paradigm – Benefits of PLM – Spread of PLM – Overcoming Problems & Enabling Opportunities – PLM Environment – Issues in the Traditional Environment – Product Data Issues – A Complex, Changing Environment – Example from "Before PLM" – Product Pains: Aerospace Products; Power Plants; Automotive Products – Product Opportunities.

**UNIT II PLM ENVIRONMENT: BUSINESS PROCESS** **6**

Business Processes in the PLM Environment – Relevance of Business Processes in PLM – Definitions & Introductions for Business Process – Business Process Reality in a Typical Company – Business Process Activities in the PLM Initiative – Learning from Experience with Business Process.

**UNIT III PLM ENVIRONMENT: PRODUCT DATA** **6**

Product Data in the PLM Environment – Relevance of Product Data in PLM – Product Data Reality in a Typical Company – Product Data Activities in the PLM Initiative – Learning from Experience with Product Data.

**UNIT IV PLM ENVIRONMENT: INFORMATION SYSTEMS** **6**

Information Systems in the PLM Environment – Relevance of Information Systems Applications in PLM – PLM Applications in the Product Lifecycle – Generic and Specific PLM Applications – PDM System: A Special Application – Importance of the PDM System in PLM – Reality in a Typical Company – Application Activities in the PLM Initiative – Best Practice PDM System Selection – Learning from Experience with Information Systems.

**UNIT V PLM ENVIRONMENT: PROJECT MANAGEMENT** **6**

Project/Program Management in the PLM Environment – Skills and Relevance – Definitions and Introduction with Project Management – Project Management Reality in a Typical Company – Project Management Activities in the PLM Initiative – Learning from Experience with Project Management.

**Laboratory Experiments** **30 PERIODS**

**List of Experiments:**

1. Getting Started with PLM software's Engineering BOM
2. Working with CAD Parts
3. Creating and Attaching Specifications
4. Creating Engineering Bill of Materials
5. Releasing Parts Using the ECM Process
6. Use Matrix Query Language (MQL) to fetch the info from Database (DB) and test queries on PLM.

**TOTAL: 60 PERIODS**

**COURSE OUTCOMES:** Upon completion of this course, the students will be able to:

**CO1** Apply the fundamental concepts and principles behind PLM in Product Design & Development.
**CO2** Apply the business process concept of PLM in Product Design & Development.
**CO3** Apply the product data concept of PLM in Product Design & Development.
**CO4** Apply the information systems concept of PLM in Product Design & Development.
**CO5** Apply the project management concept of PLM in Product Design & Development.

**REFERENCES:**


1. John Stark, "Product Lifecycle Management: 21st Century Paradigm for Product Realisation", Springer Publisher, 2011 (2nd Edition).
2. John Stark, "Global Product: Strategy, Product Lifecycle Management and the Billion Customer Question", Springer Publisher, 2007.
3. Antti Saaksvuori and AnselmiImmonen, "Product Lifecycle Management, Springer Publisher, 3rd Ed., 2008.

4. Michael Grieves, “Product Life Cycle Management”, Tata McGraw Hill, 2006.
5. IvicaCrnkovic, Ulf Asklund and Annita Persson Dahlqvist, “Implementing and Integrating Product Data Management and Software Configuration Management”, Artech House Publishers, 2003.

| CO | PO | | | | | |
|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** |
| **1** | 2 | 1 | 2 | 2 | 3 | 3 |
| **2** | 2 | 1 | 2 | 2 | 3 | 3 |
| **3** | 2 | 1 | 2 | 2 | 3 | 3 |
| **4** | 2 | 1 | 2 | 2 | 3 | 3 |
| **5** | 2 | 1 | 2 | 2 | 3 | 3 |
| **Avg.** | 2 | 1 | 2 | 2 | 3 | 3 |




Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

| ED3054 | OPTIMIZATION TECHNIQUES IN DESIGN | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**COURSE OBJECTIVES:**

The main learning objective of this course is to prepare the students for imparting knowledge on various categories of existing engineering problems and solutions to such problems through different optimization techniques and approaches.

**UNIT I UNCONSTRAINED OPTIMIZATION TECHNIQUES 9**

Introduction to optimum design - General principles of optimization – Statement of an Optimization Problem & their classifications – Single variable and multi variable optimization, Techniques of unconstrained minimization – Exhaustive Search, Dichotomous Search, Interval Halving Method, Fibonacci Method and Golden section, Random, Steepest Descent Method.

**UNIT II CONSTRAINED OPTIMIZATION TECHNIQUES 9**

Optimization with equality and inequality constraints – Direct methods – Indirect methods using penalty functions, Lagrange multipliers – Geometric programming.

**UNIT III ARTIFICIAL NEURAL NETWORKS AND SWARM INTELLIGENCE 9**

Introduction – Activation functions, types of activation functions, neural network architectures, Single layer feed forward network, multilayer feed forward network, Neural network applications. Swarm intelligence- Various animal behaviors, Ant Colony optimization, Particle Swarm optimization.

**UNIT IV ADVANCED OPTIMIZATION TECHNIQUES 9**

Multistage optimization – Dynamic programming; Stochastic programming; Multi objective optimization – Genetic algorithms and Simulated annealing technique.

**UNIT V STATIC AND DYNAMIC APPLICATIONS 9**

Structural applications – Design of simple truss members – Design of simple axial, transverse loaded members for minimum cost, weight – Design of shafts and torsionally loaded members – Design of springs. Design of brakes, gears and gear boxes.

Dynamic Applications – Optimum design of single, two degree of freedom systems, vibration absorbers. Application in Mechanisms – Optimum design of simple linkage mechanisms.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:** Upon completion of this course, the students will be able to:

**CO1** Formulate unconstrained optimization techniques in engineering design application.
**CO2** Formulate constrained optimization techniques for various application.
**CO3** Implement neural network technique to real world design problems.
**CO4** Apply genetic algorithms to combinatorial optimization problems.
**CO5** Evaluate solutions by various optimization approaches for a design problem.

**REFERENCES:**


1. Goldberg, David.E, “Genetic Algorithms in Search, Optimization and Machine Learning”, Pearson,2009.
2. Jang, J.S.R,Sun,C.TandMizutaniE.,"Neuro-FuzzyandSoftComputing",PearsonEducation.2015,
3. Johnson Ray,C.,“Optimumdesignofmechanicalelements”,Wiley,2ndEdition1980.
4. KalyanmoyDeb,“OptimizationforEngineeringDesign:AlgorithmsandExamples”,PHILearningPrivateLimited,2nd Edition,2012.
5. Rao Singiresu S.,“Engineering Optimization – Theory and Practice”, New Age InternationalLimited,NewDelhi,3rdEdition,2013.
6. RajasekaranS and Vijayalakshmi Pai,G .A, "Neural Networks, Fuzzy Logic and Genetic Algorithms" ,PHI,2011.

| CO | PO | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| 1 | 3 | | 3 | 3 | 2 | 3 |
| 2 | 3 | | 3 | 3 | 2 | 3 |
| 3 | 3 | | 3 | 3 | 2 | 3 |
| 4 | 3 | | 3 | 3 | 2 | 3 |
| 5 | 3 | | 3 | 3 | 2 | 3 |
| Avg. | 3 | | 3 | 3 | 2 | 3 |



Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

**ED3055 DESIGN OF HYDRAULIC AND PNEUMATIC SYSTEMS**

| L | T | P | C |
|---|---|---|---|
| 3 | 0 | 0 | 3 |

**COURSE OBJECTIVES:**

The main learning objective of this course is to prepare the students for imparting knowledge on fluid power principles and inculcating the skills to design and develop hydraulic and Pneumatic circuits.

**UNIT I FLUID POWER PRINCIPLES AND HYDRAULIC PUMPS 9**

Introduction to Fluid power – Advantages and Applications – Fluid power systems – Types of fluids - Properties of fluids and selection – Basics of Hydraulics – Pascal's Law – Principles of flow - Friction loss – Work, Power and Torque- Problems, Sources of Hydraulic power : Pumping Theory-– Pump Classification – Construction, Working, Design, Advantages, Disadvantages, Performance, Selection criteria of pumps – Fixed and Variable displacement pumps – Problems.

**UNIT II HYDRAULIC ACTUATORS AND CONTROL COMPONENTS 9**

Hydraulic Actuators: Cylinders – Types and construction, Application, Hydraulic cushioning – Rotary Actuators – Hydraulic motors - Control components: Direction Control, Flow control and pressure control valves – Types, Construction and Operation – Accessories: Reservoirs, Accumulators, Pressure Intensifiers, Heat Exchangers, Pressure Gages - Pressure Switches– Filters –types and selection- Applications – Fluid Power ANSI Symbols – Problems.

**UNIT III HYDRAULIC CIRCUITS AND SYSTEMS 9**

Accumulators, Intensifiers, Industrial hydraulic circuits – Regenerative, Pump Unloading, Double Pump, Pressure Intensifier, Air-over oil, Sequence, Reciprocation, Synchronization, Fail-Safe, Speed Control, Deceleration circuits, Sizing of hydraulic systems, Hydrostatic transmission, Electro hydraulic circuits – Servo and Proportional valves – Applications- Mechanical, hydraulic servosystems – Maintenance of Hydraulic Systems.

**UNIT IV PNEUMATIC AND ELECTRO PNEUMATIC SYSTEMS 9**

Properties of air –Air preparation and distribution – Filters, Regulator, Lubricator, Muffler, Air control Valves, Quick Exhaust Valves, Pneumatic actuators, Design of Pneumatic circuit –classification single cylinder and multi cylinder circuits – Cascade method –Integration of fringe circuits, Electro Pneumatic System – Elements – Relay ladder diagram – timer circuits –Problems, PLC – Logic ladder diagram – Controlling Fluid power actuators.

**UNIT V TROUBLE SHOOTING AND APPLICATIONS 9**

Installation, Selection, Maintenance, Trouble Shooting and Remedies in Hydraulic and Pneumatic systems, Conditioning of hydraulic fluids Design of hydraulic circuits for Drilling, Planning, Shaping, Surface grinding, Press and Forklift applications. Design of Pneumatic circuits for metal working, handling, clamping counter and timer circuits. – Low cost Automation – Hydraulic and Pneumatic power packs.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:** Upon completion of this course, the students will be able to:

**CO1** Apply the principles of fluid power systems, and select relevant hydraulic pumps for the fluid power applications.
**CO2** Select necessary control components and hydraulic actuators for the fluid power applications.
**CO3** Design and develop hydraulic circuits and systems.
**CO4** Design and develop pneumatic circuits and systems.
**CO5** Solve problems and troubles in fluid power systems.

**REFERENCES:**


1. Anthony Esposito, “Fluid Power with Applications”, Prentice Hall, 2009.
2. James A. Sullivan, “Fluid Power Theory and Applications”, Prentice Hall, 1997.
3. Shanmuga Sundaram. K., “Hydraulic and Pneumatic Controls”. Chand & Co, 2006.
4. Jagadeesha. T., “Pneumatics Concepts, Design and Applications “, Universities Press, 2015.
5. Joshi.P., Pneumatic Control”, Wiley India, 2008.
6. Srinivasan.R., “Hydraulic and Pneumatic Controls”, Vijay Nicole Imprints, 2008.
7. Majumdar, S.R., “Oil Hydraulics Systems – Principles and Maintenance”,Tata McGraw Hill, 2001.


| CO | PO | | | | | |
|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** |
| **1** | 3 | | 3 | 2 | 2 | 1 |
| **2** | 3 | | 3 | 2 | 2 | 1 |
| **3** | 3 | | 3 | 2 | 2 | 1 |
| **4** | 3 | | 3 | 2 | 2 | 1 |
| **5** | 3 | | 3 | 2 | 2 | 3 |
| **Avg.** | 3 | | 3 | 2 | 2 | 1.4 |



Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

| ED3004 | MECHANICAL MEASUREMENT AND ANALYSIS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**COURSE OBJECTIVES:**

The main learning objective of this course is to prepare the students for understanding the working principle of force/strain, vibration, acoustic, wind flow, structural health monitoring devices.

**UNIT I FORCES AND STRAIN MEASUREMENT 9**

Strain gauge, principle, types, performance and uses. Photo elasticity – Principle and applications -- Moire Fringe - Hydraulic jacks and pressure gauges – Electronic load cells – Proving Rings –Calibration of Testing Machines. Digital Image correlation

**UNIT II VIBRATION MEASUREMENTS 9**

Characteristics of Structural Vibrations – Linear Variable Differential Transformer (LVDT) – Transducers for velocity and acceleration measurements. Vibration meter – Seismographs – Vibration Analyzer – Display, recording and processing of signals – Cathode Ray Oscilloscope – XY Plotter – Chart Plotters – Digital data Acquisition systems

**UNIT III ACOUSTICS AND WIND FLOW MEASUREMENTS 9**

Principles of Pressure and flow measurements – pressure transducers – sound level meter – venturimeter and flow meters – wind tunnel and its use in structural analysis – structural modeling – direct and indirect model analysis

**UNIT IV DISTRESS MEASUREMENTS 9**

Diagnosis of distress in structures – crack observation and measurements – corrosion of reinforcement in concrete – Half-cell, construction and use – damage assessment – controlled blasting for demolition

**UNIT V STRUCTURAL HEALTH MONITORING 9**

Load testing on structures, buildings, bridges and towers – Rebound Hammer – acoustic emission – ultrasonic testing principles and application – Holography – use of laser for structural testing –Brittle coating - Wireless fatigue nodes – No Power and Low power devices

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:** Upon completion of this course, the students will be able to:

**CO1** measure physical quantities such as forces and strains.
**CO2** apply different vibration measurements techniques.
**CO3** measure physical quantities such as pressure and flow.
**CO4** apply techniques involved in crack measurement.
**CO5** select the appropriate non-destructive testing methods for various engineering applications

**REFERENCE BOOKS:**


1. Bray Don E and Stanley, R. K., "Non-destructive Evaluation", McGraw Hill Publishing Company,N.Y.1989
2. Garas, F.K., Clarke, J.L and Armer GST, "Structural assessment", Butterworths, London,1987
3. James W. Dally and William Franklin Riley, "Experimental Stress Analysis", McGraw Hill , 3rd Edition, 1991
4. Sadhu Singh, Experimental Stress Analysis, Khanna Publishers, New Delhi, 2009.
5. Sirohi, R.S.and Radha krishna, H.C, "Mechanical Measurements ", New Age International (P) Ltd, 3rd Edition 1997
6. Thomas G B and Buck N L "Mechanical Measurements" Oxford publishing 1969.


| CO | PO | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| 1 | 3 | | 3 | 1 | 2 | 2 |
| 2 | 3 | | 3 | 1 | 2 | 2 |
| 3 | 3 | | 3 | 1 | 2 | 2 |
| 4 | 3 | | 3 | 1 | 2 | 2 |
| 5 | 3 | | 3 | 1 | 2 | 2 |
| Avg. | 3 | | 3 | 1 | 2 | 2 |

| ED3056 | SURFACE ENGINEERING | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**COURSE OBJECTIVES:**

The main learning objective of this course is to prepare the students for imparting knowledge on surface engineering and surface modification methods to solve the industrial problems.

**UNIT I FRICTION, WEAR AND LUBRICATION 9**

Topography of Surfaces – Surface features – Surface interaction – Adhesive Theory of Sliding Friction – Rolling Friction – Friction properties of metallic and non-metallic materials – Friction in extreme conditions – Thermal considerations in sliding contact – Introduction to wear – Abrasive wear, Erosive, Cavitation, Adhesion, Fatigue wear and Fretting Wear – Laws of wear – Wear of metals and non-metals – Lubrication – Introduction, types of lubricants and their industrial uses, lubricant additives.

**UNIT II CORROSION 9**

Introduction – Principle of corrosion – Classification of corrosion – Types of corrosion – Factors influencing corrosion – Testing of corrosion – In-service monitoring, Simulated service, Laboratory testing – Evaluation of corrosion – Prevention of Corrosion – Material selection, Alteration of environment, Design, Cathodic and Anodic Protection, Corrosion inhibitors.

**UNIT III SURFACE TREATMENTS 9**

Introduction – Surface properties, Superficial layer – Changing surface metallurgy – Wear resistant coatings and Surface treatments – Techniques – PVD – CVD – Physical CVD – Ion implantation – Surface welding – Thermal spraying – Laser surface hardening and alloying, laser re-melting, and laser cladding – Friction Stir Processing (FSP).

**UNIT IV ENGINEERING MATERIALS 9**

Introduction – Advanced alloys – Super alloys, Titanium alloys, Magnesium alloys, Aluminium alloys, and Nickel based alloys – Ceramics – Polymers – Biomaterials – Applications – Bio Tribology – Nano Tribology.

**UNIT V SURFACE MEASURING INSTRUMENTS 9**

Need for surface properties and measurement – International standards in friction and wear measurement –Construction and working principle of tribometer – Scratch tester – Construction and working principle of Optical Microscope (OM), Scanning Electron Microscope (SEM) and Transmission Electron Microscope (TEM) instruments – Sample preparation techniques for OM, SEM and TEM analysis – Construction and working principle of Atomic Force Microscope (AFM) and Scanning Tunneling Microscope (STM) instruments – Sample preparation techniques for AFM and STM analysis.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:** Upon completion of this course, the students will be able to:

**CO1** Understand the basics of surface features, laws of friction, and different types of friction
**CO2** Understand the types of corrosion and its preventive measures
**CO3** Understand the types of surface properties and various surface modification techniques
**CO4** Understand the different types of materials used in friction and wear applications
**CO5** Develop knowledge of the need for surface-measuring instruments

**REFERENCES:**


1. G.W.Stachowiak& A.W .Batchelor, “Engineering Tribology”, Butterworth-Heinemann, UK,2005
2. Rabinowicz.E, “Friction and Wear of materials”, John Willey &Sons,UK,1995
3. Halling, J. (Editor), “Principles of Tribology “, Macmillian – 1984.
4. Williams J.A. “Engineering Tribology”, Oxford Univ. Press, 1994.
5. S.K.Basu, S.N.Sengupta&B.B.Ahuja ,”Fundamentals of Tribology”, Prentice –Hall of India Pvt. Ltd , New Delhi, 2005.
6. Fontana G., “Corrosion Engineering”, McGraw Hill, 1985.


| CO | PO | | | | | |
|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** |
| **1** | 3 | | 3 | 3 | 2 | 2 |
| **2** | 3 | | 3 | 2 | 2 | 2 |
| **3** | 3 | | 3 | 1 | 2 | 2 |
| **4** | 3 | | 3 | 1 | 2 | 2 |
| **5** | 3 | | 3 | 3 | 2 | 2 |
| **Avg.** | 3 | | 3 | 2 | 2 | 2 |



Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

| ED3051 | COMPUTER GRAPHICS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**COURSE OBJECTIVES:**
To impart knowledge on computer graphics which are used routinely in diverse areas as science, engineering, medicine, etc.

**UNIT I INTRODUCTION TO COMPUTER GRAPHICS FUNDAMENTALS 9**
Scan-Conversion of a Lines (Digital Differential Analyzer Algorithm, Bresenham's Line Drawing Algorithm – Scan-Conversion of Circle and Ellipse (Bresenham's Method of Circle Drawing, Midpoint Circle Algorithm) – Drawing Ellipses and Other Conics – Introduction to 2D and 3D transformations – Transformation Matrix – Types of Transformations in Two-Dimensional Graphics: Identity Transformation, Scaling, Reflection, Shear Transformations, Rotation, Translation, Rotation about an Arbitrary Point, Combined Transformation – Introduction to Clipping – Two-Dimensional Clipping, Point Clipping, Line Clipping – Introduction to a Polygon Clipping – Viewing and Clipping in Three Dimensions – Three-Dimensional Viewing Transformations – Text Clipping.

**UNIT II CURVES AND SURFACES MODELLING 9**
Introduction to curves – Analytical curves: line, circle and conics – Synthetic curves: Hermite cubic spline – Bezier curve and B-Spline curve – Curve manipulations – Introduction to surfaces – Analytical surfaces: Plane surface, Ruled surface, Surface of revolution and Tabulated cylinder – Synthetic surfaces: Hermite bicubic surface – Bezier surface and B-Spline surface manipulations.

**UNIT III NURBS AND SOLID MODELING 9**
NURBS – Basics – Curves, lines, arcs, circle and bi-linear surface – Regularized Boolean set operations – Primitive instancing – Sweep representations – Boundary representations – Constructive Solid Geometry – Comparison of representations – User interface for solid modeling.

**UNIT IV VISIBLE SURFACE AND OBJECT RENDERING 9**
Introduction to visible and hidden surfaces – Coherence for visibility – Extents and Bounding Volumes – Back Face Culling – Painter's Algorithm, Z-Buffer Algorithm, Floating Horizon Algorithm, Roberts Algorithm – Introduction to Object-Rendering, Light Modeling Techniques, illumination Model, Shading, Flat Shading, Polygon Mesh Shading, Gaurand Shading Model, Phong Shading, Transparency Effect, Shadows, Texture and Object Representation, Ray Tracing, Ray Casting, Radiosity, Color Models.

**UNIT V ASSEMBLY OF PARTS AND PRODUCT LIFE CYCLE 9**
Assembly modeling – Design for manufacture – Design for assembly – Computer aided DFMA – Inferences of positions and orientation – Tolerances analysis – Center of Gravity and mass property calculations – Mechanism simulation – Graphics and computing standards – Data Exchange standards – Product development and management – New product development – Models utilized in various phases of new product development – Product life cycle.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:** Upon completion of this course, the students will be able to:
**CO1** Solve 2D and 3D transformations for the basic entities like line and circle.
**CO2** Formulate the basic mathematics fundamental to CAD system.
**CO3** Use the different geometric modeling techniques like feature-based modeling, surface modeling and solid modeling.
**CO4** Create geometric models through animation and transform them into real world systems
**CO5** Simulate assembly of parts using Computer-Aided Design software

**REFERENCES:**


1. Boothroyd, G, “Assembly Automation and Product Design”, Marcel Dekker, New York, 1991.
2. Chitale A.K and Gupta R.C., “Product Design and Manufacturing“, PHI Learning Private Limited, 6th Edition, 2015.
3. David Rogers, James Alan Adams, “Mathematical Elements for Computer Graphics”, 2nd Edition, Tata McGraw-Hill, 2002.
4. Donald D Hearn and M. Pauline Baker, “Computer Graphics C Version”, Prentice Hall, Inc., 2nd Edition, 1996.
5. Ibrahim Zeid, "Mastering CAD/CAM", McGraw Hill, 2nd Edition, 2006.
6. William M Newman and Robert F.Sproull “Principles of Interactive Computer Graphics”, Mc Graw Hill Book Co., 1st Edition, 2001.


| CO | PO | | | | | |
|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** |
| **1** | 3 | | 3 | 3 | 2 | 1 |
| **2** | 3 | | 3 | 3 | 2 | 1 |
| **3** | 3 | | 3 | 3 | 2 | 1 |
| **4** | 3 | | 3 | 3 | 2 | 1 |
| **5** | 3 | | 3 | 3 | 2 | 1 |
| **Avg.** | 3 | | 3 | 3 | 2 | 1 |



Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

| ED3058 | VEHICLE DYNAMICS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**COURSE OBJECTIVES:**

The main learning objective of this course is to prepare the students for applying the principles of tire mechanics, steering, vertical, longitudinal and lateral dynamics in vehicle design.

**UNIT I TYRE MECHANICS** **9**

Tyre Classification, Tyre specification, Tyre forces and moments, Tyre structure, Rolling resistance and effect of various parameters on rolling resistance, Longitudinal forces , Lateral forces, Mechanism of force generation, Tractive and cornering property of tyre, Camber Thrust, Aligning Moment, Conicity and Plysteer, Performance of tyre on wet surface, Magic formulae tyre model, Tyre vibration.

**UNIT II STEERING DYNAMICS** **9**

Steering Linkages, Steering Geometry Error, Front Wheel Geometry, Steering system forces and moments, Steering system models, Effect of steering ratio, understeer and braking stability on steering system, Influence of front wheel drive, Four wheel steer, Steering of Vehicle with trailer.

**UNIT III VERTICAL DYNAMICS** **9**

Human response to vibration, Sources of Vibration. Passive, Semi-active and Active suspension . Suspension Models-Quarter car, half car and full car model. Suspension isolation, Influence of suspension stiffness, suspension damping, and tyre stiffness. Active control, Control law for LQR, H-Infinite, Skyhook damping.

**UNIT IV LONGITUDINAL DYNAMICS AND CONTROL** **9**

Aerodynamic forces and moments. Equation of motion. Load distribution for three wheeler and four wheeler. Calculation of Maximum acceleration, Reaction forces for Different drives. Brake force distribution, braking efficiency and braking distance. Prediction of Vehicle performance, ABS, stability control, Traction control.

**UNIT V LATERAL DYNAMICS** **9**

Steady state handling characteristics. Steady state response to steering input. Testing of handling characteristics. Transient response characteristics, Direction control of vehicles. Roll center, Rollaxis, Vehicle under side forces. Stability of vehicle on banked road and during turn. Effect of suspension on cornering.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:** Upon completion of this course, the students will be able to:

**CO1** Create a tire model based on required performance
**CO2** Apply various vehicle performance and control methodologies to ensure stability and enhance ride properties
**CO3** Formulate and develop mathematical model of a system
**CO4** Predict vehicle performance, control methodologies to ensure stability and ride comfort.
**CO5** Apply vertical, longitudinal and lateral dynamics vehicle design.

**REFERENCES:**


1. Singiresu S. Rao, “Mechanical Vibrations”, 5th Edition, Prentice Hall, 2010.
2. J. Y. Wong, “Theory of Ground Vehicles”, 3rd Edition, Wiley-Interscience, 2001.
3. Rajesh Rajamani, “Vehicle Dynamics and Control”, 1st edition, Springer, 2005.
4. Thomas D. Gillespie, “Fundamentals of Vehicle Dynamics”, Society of Automotive Engineers Inc, 1992.
5. G. Nakhaie Jazar, “Vehicle Dynamics: Theory and Application”, 1st Edition, Springer, 2008.


| CO | PO | | | | | |
|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** |
| **1** | 3 | | 3 | 1 | 2 | 1 |
| **2** | 3 | | 3 | 2 | 2 | 1 |
| **3** | 3 | | 3 | 2 | 2 | 1 |
| **4** | 3 | | 3 | 2 | 2 | 1 |
| **5** | 3 | | 3 | 2 | 2 | 1 |
| **Avg.** | 3 | | 3 | 1.8 | 2 | 1 |



Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

| ED3005 | ADVANCED FINITE ELEMENT ANALYSIS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**COURSE OBJECTIVES:**

The main learning objective of this course is to prepare the students for solving non-linear problems.

**UNIT I BENDING OF PLATES AND SHELLS 9**

Review of Elasticity Equations – Bending of Plates and Shells – Finite Element Formulation of Plate and Shell Elements - Conforming and Non-Conforming Elements – C0 and C1 Continuity Elements – Degenerated shell elements- Application and Examples

**UNIT II NON-LINEAR PROBLEMS 9**

Introduction – Iterative Techniques – Material non-linearity – Elasto Plasticity – Plasticity – Visco Plasticity – Geometric Non linearity – large displacement Formulation –Solution procedure - Application in Metal Forming Process and Contact Problems

**UNIT III DYNAMIC PROBLEM 9**

Direct Formulation – Free, Transient and Forced Response – Solution Procedures – Eigen solution-Subspace Iterative Technique – Response analysis-Houbolt, Wilson, Newmark – Methods – Explicit &Implict Methods- Lanchzos, Reduced method for large size system equations

**UNIT IV FLUID MECHANICS AND HEAT TRANSFER 9**

Governing Equations of Fluid Mechanics – Solid structure interaction - Inviscid and Incompressible Flow – Potential Formulations – Slow Non-Newtonian Flow – Metal and Polymer Forming – Navier Stokes Equation – Steady and Transient Solution

**UNIT V ERROR ESTIMATES AND ADAPTIVE REFINEMENT 9**

Error norms and Convergence rates – h-refinement with adaptivity – Adaptive refinement.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:** Upon completion of this course, the students will be able to:

**CO1** Apply concept of Finite Element Analysis to solve problems involving plate and shell elements.
**CO2** Apply concept of Finite Element Analysis to solve problems involving geometric and material non linearity.
**CO3** Formulate solution techniques to solve dynamic problems.
**CO4** Apply concepts of Finite Element Analysis to solve fluid mechanics and heat transfer problems.
**CO5** Investigate error norms, convergence rates and refinement.

**REFERENCES:**


1. Bathe K.J., “Finite Element Procedures in Engineering Analysis”, Prentice Hall, 1990.
2. Logan.D.L., “A first course in Finite Element Method”, Cengage Learning, 2012.
3. Reddy,J.N. “An Introduction to Nonlinear Finite Element Analysis ”, 2ndEdition, Oxford, 2015.
4. Robert D. Cook, David S. Malkus, Michael E. Plesha, Robert J. Witt, “Concepts and Applications of Finite Element Analysis”, 4th Edition, Wiley Student Edition, 2004.
5. Tirupathi.R.Chandrupatla and Ashok D.Belegundu, “Introduction to Finite Elements in Engineering”, International Edition, Pearson Education Limited, 2014.
6. Zienkiewicz, O.C., Taylor, R.L. and Zhu.J.Z.,“The Finite Element Method : Its Basis and Fundamentals”, 7th Edition, Butterworth-Heinemann,2013. .


| CO | PO | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| 1 | 3 | | 3 | 3 | 1 | 1 |
| 2 | 3 | | 3 | 2 | 1 | 1 |
| 3 | 3 | | 3 | 3 | 1 | 1 |
| 4 | 3 | | 3 | 3 | 1 | 1 |
| 5 | 3 | | 3 | 2 | 1 | 1 |
| Avg. | 3 | | 3 | 2.6 | 1 | 1 |

**ED3057 DESIGN OF HYBRID AND ELECTRIC VEHICLES**

| L | T | P | C |
|---|---|---|---|
| 3 | 0 | 0 | 3 |

**COURSE OBJECTIVES:**

The main learning objective of this course is to prepare the students for designing hybrid and electric vehicles.

**UNIT I INTRODUCTION TO ELECTRIC VEHICLES 9**

Electric Vehicles (EV) system- EV History – EV advantages – EV market – vehicle mechanics: roadway fundamentals- law of motion-vehicle kinetics- dynamics of vehicle motion – propulsion power –velocity and acceleration- propulsion system design- introduction to types of hybrid vehicles.

**UNIT II ENERGY SOURCE 9**

Introduction to engine power train - Battery basics- lead acid battery –lithium ion battery – alternative batteries – battery parameters- technical characteristics – battery power – Battery Thermal Management System - alternative energy sources: Fuel cells - Fuel Cell characteristics - Fuel cell types.

**UNIT III SERIES HYBRID ELECTRIC DRIVE TRAIN DESIGN 9**

Operation Patterns- Control Strategies-Sizing of the Major Components -Design of peaking power source - Traction Motor Size - Design of the Gear Ratio-Verification of Acceleration Performance - Verification of gradability - Design of Engine/Generator Size - Design of the Power Capacity - Design of the Energy Capacity -Fuel Consumption.

**UNIT IV PARALLEL HYBRID ELECTRIC DRIVE TRAIN DESIGN 9**

Control Strategies of Parallel Hybrid Drive Train- Drive Train Parameters- Engine Power Capacity- Electric Motor Drive Power Capacity- Transmission Design- Energy Storage Design.

**UNIT V ELECTRIC VEHICLE DRIVE TRAIN 9**

EV Transmission configurations – Transmission components –Ideal gear box –Gear ratio- torque – speed characteristics - EV motor sizing –initial acceleration-rated vehicle velocity –maximum velocity – maximum gradability.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:**

Upon completion of this course, the students will be able to:

**CO1** Explain the working of hybrid vehicle and describe its main components and their function
**CO2** Choose proper energy storage systems for vehicle applications
**CO3** Design series hybrid electric vehicles.
**CO4** Design parallel hybrid electric vehicles.
**CO5** Describe the transmission components and their configurations for electric vehicles

**REFERENCES:**


1. Ehsani, M, “Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design”, CRC Press, 2005
2. “Hybrid Electric Vehicle Technology Assessment: Methodology, Analytical Issues, and Interim Results,” Center for Transportation Research Argonne National Laboratory, United States Department of Energy.
3. Iqbal Hussain, “Electric & Hybrid Vehicles – Design Fundamentals”, Second Edition, CRC Press, 2011.
4. James Larminie, “Electric Vehicle Technology Explained”, John Wiley & Sons, 2003.
5. Sandeep Dhameja, “Electric Vehicle Battery Systems”, Newnes, 2000 .http://nptel.ac.in/courses/108103009/.


| CO | PO | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| 1 | 2 | | 3 | 1 | 3 | 2 |
| 2 | 2 | | 3 | 1 | 3 | 2 |
| 3 | 2 | | 3 | 1 | 3 | 2 |
| 4 | 2 | | 3 | 1 | 3 | 2 |
| 5 | 2 | | 3 | 1 | 3 | 2 |
| Avg. | 2 | | 3 | 1 | 3 | 2 |

| ED3006 | ADVANCED MACHINE TOOL DESIGN | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**COURSE OBJECTIVES:**

The main objective of this course is to prepare the students for acquiring the knowledge on selection and design of machine tools.

**UNIT I INTRODUCTION TO MACHINE TOOL DESIGN 9**

Introduction to Machine Tool Drives and Mechanisms, Constructional and operational features, Auxiliary Motions in Machine Tools, Kinematics of Machine Tools, Motion Transmission, mechanical, hydraulic and electric drives.

**UNIT II REGULATION OF SPEEDS AND FEEDS 9**

Aim of Speed and Feed Regulation, Layout of Speed Change Gears, Stepped Regulation of Speeds, Multiple Speed Motors, Ray Diagrams and Design Considerations, Design of Speed Gear Boxes, Feed Drives, Feed Box Design.

**UNIT III DESIGN OF MACHINE TOOL STRUCTURES 9**

Functions of Machine Tool Structures and their Requirements, Design for Strength, Design for Rigidity, Materials for Machine Tool Structures, Static and Dynamic Stiffness, Machine Tool Constructional Features, Beds and Housings, Columns and Tables, Saddles and Carriage.

**UNIT IV DESIGN OF GUIDEWAYS AND POWER SCREWS 9**

Functions and Types of Guideways, Design of Guideways, Clearance adjustment in slideways, Design of Aerostatic Slide ways, Design of Anti-Friction Guide ways, Combination Guide ways, Design of Power Screws and Recirculating ball screws.

**UNIT V DESIGN OF SPINDLES AND SPINDLE SUPPORT 9**

Functions of Spindles and Requirements, Effect of Machine Tool Compliance on Machining Accuracy, Design of Spindles, Anti-friction Bearings. Dynamics of Machine Tools: Machine Tool Elastic System, Static and Dynamic Stiffness, Effects of vibration, Stability Analysis.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:** Upon completion of this course, the students will be able to:

**CO1** select the different machine tool mechanisms.
**CO2** design the Multi speed Gear Box and feed drives
**CO3** design the machine tool structures.
**CO4** design the guideways and power screws
**CO5** design the spindles and bearings

**REFERENCES:**


1. N.K. Mehta, Machine Tool Design and Numerical Control, TMH, New Delhi, 2010.
2. G.C. Sen and A. Bhattacharya, Principles of Machine Tools, New Central Book Agency, 2009.
3. D. K Pal, S. K. Basu, “Design of Machine Tools”, 5th Edition. Oxford IBH, 2008.
4. N. S. Acherkhan, “Machine Tool Design”, Vol. I, II, III and IV, MIR publications, 1968.
5. F. Koenigsberger, Design Principles of Metal-Cutting Machine Tools, Pergamon Press, 1964.
6. F. Koenigsberger, Machine Tool Structures, Pergamon Press,1970.


| CO | PO | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| 1 | 3 | | 3 | 1 | 2 | 2 |
| 2 | 3 | | 3 | 1 | 2 | 2 |
| 3 | 3 | | 3 | 1 | 2 | 2 |
| 4 | 3 | | 3 | 1 | 2 | 2 |
| 5 | 3 | | 3 | 1 | 2 | 2 |
| Avg. | 3 | | 3 | 1 | 2 | 2 |

**ED3052** **MATERIAL HANDLING SYSTEMS AND DESIGN** **L T P C**
**3 0 0 3**

**COURSE OBJECTIVES:**
To impart students on the need, use, application and design of different material handling techniques, equipment and machines used in common use and in industrial sector.

**UNIT I INTRODUCTIONS AND DESIGN OF HOISTS 9**
Types, selection and applications, 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.

**UNIT II DRIVES OF HOISTING GEAR 9**
Hand and power drives - Traveling gear - Rail traveling mechanism - cantilever and mono rail cranes-slewing ,jib and luffing gear-cog wheel drive-selecting the motor ratings.

**UNIT III CONVEYORS 9**
Types-description-design and applications of Belt conveyors, apron conveyors and escalators Pneumatic conveyors, Screw conveyors and vibratory conveyors.

**UNIT IV ELEVATORS 9**
Bucket elevators: design - loading and bucket arrangements - Cage elevators - shaft way, guides, counter weights, hoisting machine, safety devices.

**UNIT V INTEGRATED DESIGN 9**
Integrated Design of systems - Valve Gear Mechanisms, Portable Air Compressor, Hay-Balelifter, Cam Testing Machine and Gear Box Design more than six speed.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:** Upon completion of this course, the students will be able to:
**CO1** design hoists used in any material handling applications.
**CO2** design drive mechanisms and hoisting gear for different material handling applications.
**CO3** design different conveyor systems for material handling applications.
**CO4** design bucket, cage and forklift elevators for to and fro transportation of materials in vertical direction.
**CO5** design of integrated mechanical system for machine tools, power transmission and engine parts

**REFERENCES:**

1. Alexandrov,M.,MaterialsHandlingEquipments,MIRPublishers,1981.
2. Boltzharol, A.,MaterialsHandlingHandbook,TheRonaldPressCompany,1958.
3. Norton.LRobert."MachineDesign–AnIntegratedApproach"PearsonEducation,2nd Edition, 2005.
4. Rudenko,N.,Materialshandlingequipment,ELnveePublishers,1970.
5. Spivakovsy,A.O.and Dyachkov,V.K., Conveying Machines, VolumesI and II,MIR Publishers,1985.


**APPROVED DATA BOOKS:**

1. P.S.G. Tech., "Design Data Book", Kalaikathir Achchagam, Coimbatore, 2003.
2. Lingaiah. K. and Narayana Iyengar, "Machine Design Data Hand Book", Vol. 1 & 2, Suma Publishers, Bangalore, 1983


| CO | PO | | | | | |
|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** |
| **1** | 2 | | 3 | 2 | 2 | 3 |
| **2** | 2 | | 3 | 2 | 2 | 3 |
| **3** | 2 | | 3 | 2 | 2 | 3 |
| **4** | 2 | | 3 | 2 | 2 | 3 |
| **5** | 2 | | 3 | 2 | 2 | 3 |
| **Avg.** | 2 | | 3 | 2 | 2 | 3 |

| PD3251 | CREATIVITY AND INNOVATION MANAGEMENT | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**COURSE OBJECTIVES:**

To understand and apply the principles and concepts in Creativity and Innovation Management for Product Design and Development.

**UNIT I CREATIVITY THEORY, HEURISTICS & MODEL 9**

Directed creativity: Five Mental Actions in Directed Creativity – Five Factors Driving the Need for Creativity and Innovation in Organizations – Two Key Challenges on the Road to Innovation – Quality Management & Creativity and Innovation – Proper Definition of Creativity & Innovation with Practical Advice – A High-level Model of Mechanics of Mind – Role of Perception in Creative Thinking with Practical Advice – Role of Memory in Creative Thinking with Practical Advice – Role of Judgment in Creative Thinking with Practical Advice – Amabile's Seven Heuristics on Creativity – Perkin's Ten Heuristics on Creativity – Plsek's Eight Heuristics on Creativity – Model of Directed Creativity Process.

**UNIT II CREATIVITY PRINCIPLES & TOOLS 9**

Creative Thinking Tools: Trans-disciplinary Analogy – Stepping Stones – Dreamscape –Manipulative Verbs – Three basic principles: Attention – Escape – Movement – Tools for Preparation Phase – Tools for Imagination Phase – Harvesting Ideas – Eight Steps to Transforming Organization – Tools for Development and Action Phase – Idea Enhancement Checklist – Documenting Idea – Techniques for Action Phase.

**UNIT III CREATIVITY DESIGN & APPLICATION 9**

ICEDIP: Inspiration, Clarification, Distillation, Perspiration, Evaluation and Incubation – Norman's Three Levels of Emotional Design: Visceral, Behavioral and Reflective – Application of Creativity in Process Design & Reengineering – Application of Creativity in Customer Needs Analysis – Application of Creativity in Innovative Product and Service Design – Symptoms of Stuck Thinking - Seven Tools in Creative Problem Solving and Incremental Quality Improvement.

**UNIT IV INNOVATION PRINCIPLES & PRACTICES 9**

Routine and Inventive Problems – Difficulty of a Problem – Psychological Inertia – Methods of Creativity Activation – Checklists and Questionnaires – Morphological Box – Decision Aids – Problem Solving and Information – Requirements for Inventive Problem Solving – Necessary Qualities for the Solver of Non-routine Problems – Altshuller's Engineering Parameters – Altshuller's Inventive Principles – Altshuller's Contradiction Matrix Algorithm.

**UNIT V INNOVATION MANAGEMENT 9**

Disruptive Innovation Model – Disruption at Work: How Minimills Upended Integrated Steel Companies – Two Types of Disruption: New-Market Disruptions – Low-End Disruptions – Three Litmus Tests – Three Approaches to Creating New-Growth Businesses – New Market Disruptions: Three Case Histories – Product Architectures and Integration – Process of commoditation and de-commoditation – Two Processes of StrategyFormulation – Role of Senior Executive in Leading New Growth

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:** Upon completion of this course, the students will be able to:

**CO1** Apply the heuristics of theory of creativity in new product design and development.
**CO2** Apply the tools for creativity in new product design and development.
**CO3** Apply the design principles of creativity in new product design and development.
**CO4** Apply the various innovation principles and practices in new product design and development.
**CO5** Apply the principles of innovation management in new product design and development.

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

**REFERENCES:**


1. Paul E. Plsek, “Creativity, Innovation and Quality”, ASQ Quality Press, Milwaukee, Wisconsin, 2000.
2. Donald A. Norman, “Emotional Design”, Perseus Books Group, New York, 2004.
3. Geoffrey Petty, “How to be better at Creativity”, The Industrial Society, 1999.
4. Semyon D. Savransky, “Engineering of Creativity – TRIZ”, CRC Press, New York, USA, 2000.
5. Clayton M. Christensen and Michael E. Raynor, “The Innovator’s Solution”, Harvard Business School Press, Boston, USA, 2003.


| CO | PO | | | | | |
|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** |
| **1** | 3 | 1 | 2 | 2 | 1 | 2 |
| **2** | 3 | 1 | 2 | 2 | 1 | 2 |
| **3** | 3 | 1 | 2 | 2 | 1 | 2 |
| **4** | 3 | 1 | 2 | 2 | 1 | 2 |
| **5** | 3 | 1 | 2 | 2 | 1 | 2 |
| **Avg.** | 3 | 1 | 2 | 2 | 1 | 2 |




Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

| IC3253 | COMPUTATIONAL FLUID DYNAMICS FOR MOBILITY SYSTEMS | L | T | P | C |
|---|---|---|---|---|---|
| | | 2 | 0 | 2 | 3 |

**COURSE OBJECTIVES**

1. To make the students to understand the basic principles of fluid flow, heat transfer, computational fluid dynamics (CFD) and its applications
2. To enlighten the students on the fundamental governing equations and turbulence models used in CFD solvers
3. To enable the students to understand grid generation techniques and post processing techniques.

**UNIT I INTRODUCTION 6**

Introduction to fluid flow and heat transfer – Mathematical description of fluid flow and heat transfer, incompressible and compressible flows, turbulent flows, boundary layer theory. Introduction to Computational Fluid Dynamics (CFD) – Objectives, modelling process, 2D and 3D simulations, advantages, limitations, application domains, software tools.

**UNIT II GOVERNING EQUATIONS 6**

Mass and momentum conservation equations, Energy conservation equation, Equation of state, Species transport equations, Scalar transport equations. Turbulence models – RANS, LES and DNS models.

**UNIT III GRID GENERATION AND POST PROCESSING TECHNIQUES 6**

Surface preparation, Volume meshing – cell types, structured, unstructured and hybrid meshing. Considerations for accurate and fast solutions. Mesh generation techniques, dynamic meshing, overset meshing, mesh size control, y+ and wall layer, adaptive mesh refinement, grid independence study. Post processing techniques – Vector plot, scalar plot, streamline plot, flow animation, x-y plot, surface area and mass flow integrated reports

**UNIT IV NUMERICAL METHODS 6**

Finite volume method, Discretization schemes – First order, higher order and hybrid schemes, stability of schemes. Steady and unsteady flow solvers – CG and AMG solvers, SIMPLE, SIMPLER & PISO solution algorithms. Initial and boundary conditions, material properties, solver control, convergence criteria, parallel processing.

**UNIT V ADVANCED CFD SIMULATIONS 6**

Compressible flow, conjugate heat transfer, VOF, MRF, porous media, radiation, combustion and emission simulations. Fluid flow and heat transfer modelling of IC engine, thermal systems, power generation and storage systems, turbomachinery etc. Introduction to fluid-structure interaction modelling

**30 PERIODS**

**LABORATORY EXPERIMENTS (30 PERIODS):**

1. Prepare a closed surface geometry for a given application as per given dimensions
2. Clean-up a raw geometry for the given flow domain and mark different boundaries
3. Prepare surface mesh and volume mesh as per given size and quality criteria
4. Prepare volume meshing with different grid controls like wall layering, boundary refinement, etc.
5. Perform a simple fluid flow analysis as per given problem description
6. Perform a simple heat transfer analysis as per given problem description
7. Perform an advanced CFD analysis as per given problem description

**TOTAL : 60 PERIODS**

**COURSE OUTCOMES:**

On successful completion of this course the student will be able to

**CO1** Understand the basic principles of fluid flow, heat transfer, computational fluid dynamics (CFD) and its applications

**CO2** Analyse the governing equations and boundary conditions

**CO3** Create grid for any simulation domain and post process various simulations

**CO4** Setup solvers and perform all common simulations
**CO5** Perform advance fluid flow and heat transfer simulations

**REFERENCES**:


1. Versteeg and Malalasekera, N, “An Introduction to computational Fluid Dynamics The Finite Volume Method,” Pearson Education, Ltd., Second Edition, 2014.
2. Ghoshdastidar, P.S., “Computer Simulation of Flow and Heat Transfer”, Tata McGraw-Hill Publishing Company Limited, New Delhi, 1998.
3. Muralidhar, K., and Sundararajan, T., “Computational Fluid Flow and Heat Transfer”, Narosa Publishing House, New Delhi, 2003.
4. Subas and V.Patankar “Numerical heat transfer fluid flow”, Hemisphere Publishing Corporation,1980.
5. Jiyuan Tu, Guan Heng Yeoh, Chaogun Liu, “Computational Fluid Dynamics A Practical Approach” Butterworth – Heinemann An Imprint of Elsevier, Madison, U.S.A., 2008
6. John D. Anderson . JR. “Computational Fluid Dynamics The Basics with Applications” McGraw-Hill International Editions, 1995.


**CO – PO MAPPING:**

| CO | PO | | | | | |
|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** |
| **1** | 3 | 2 | 1 | 1 | 1 | 1 |
| **2** | 3 | 1 | 2 | 1 | 1 | - |
| **3** | 3 | 1 | 2 | 3 | 1 | - |
| **4** | 3 | 1 | 2 | 3 | 3 | - |
| **5** | 3 | 2 | 2 | 3 | 3 | 3 |
| **Avg** | 3 | 2 | 2 | 2 | 3 | 2 |

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025