ANNA UNIVERSITY, CHENNAI

NON- AUTONOMOUS COLLEGES

AFFILIATED TO ANNA UNIVERSITY

M.E. ENGINEERING DESIGN

REGULATIONS 2025

PROGRAMME OUTCOMES (POs):

PO	Programme Outcomes
PO1	An ability to independently carry out research /investigation and development work to solve practical problems
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program

PROGRAMME SPECIFIC OUTCOMES (PSOS)

PSO	Programme Specific Outcomes
PSO1	Apply advanced principles of mechanics, materials, and computational methods to design, analyze, and optimize mechanical systems and components using modern tools and simulation techniques.
PSO2	Develop innovative and sustainable engineering solutions through integrated product design, lifecycle management, and advanced manufacturing processes.

ANNA UNIVERSITY, CHENNAI

POST GRADUATE CURRICULUM (NON-AUTONOMOUS AFFILIATED INSTITUTIONS)

Programme: M.E. Engineering Design **Regulations:** 2025

Abbreviations:

BS –Basic Science (Mathematics)

ES – Engineering Science (General (**G**), Programme Core (**PC**), Programme Elective (**PE**))

SD – Skill Development

PW – Project Work

L –LaboratoryCourse

T – Theory

LIT –Laboratory Integrated Theory

TCP –Total Contact Period(s)

Semester I

S. No.	Course Code	Course Title	Type	Periods per week			TCP	Credits	Category
				L	T	P			
1.	MA25C06	Applied Mathematical and Statistical Modelling	LIT	3	1	0	4	4	BS
2.	ED25C01	Topology Optimization and Generative Design	T	3	0	0	3	3	ES (PC)
3.	ED25C02	Advanced Mechanics of Materials	T	3	0	0	3	3	ES (PC)
4.	ED25C03	Design and Analysis of Advanced Mechanisms	LIT	3	0	2	5	4	ES (PC)
5.	ED25C04	Design Practice with CAD Tools Laboratory	L	0	0	4	4	2	ES (PC)
6.	ED25C05	Multi Body Dynamics Laboratory	L	0	0	4	4	2	ES (PC)
7.	ED25101	Technical Seminar	-	0	0	2	2	1	SD
Total Credits							**25**	**19**	

Semester II

S. No.	Course Code	Course Title	Type	Periods per week			TCP	Credits	Category
				L	T	P			
1.	ED25C08	Finite Element Methods	LIT	2	0	4	6	4	ES (PC)
2.	ED25C09	Vibration, Fracture, and Failure Analysis	T	3	0	0	3	3	ES (PC)
3.	ED25201	Computational Fluid Dynamics	LIT	2	0	2	4	3	ES (PC)
4.		Programme Elective – I	T	3	0	0	3	3	ES (PE)
5.		Programme Elective – II	T	3	0	0	3	3	ES (PE)
6.		Programme Elective – III	T	3	0	0	3	3	ES (PE)
7.		Industry Oriented Course I	-	1	0	0	1	1	SD
8.	ED25C10	Research Article Replication Practice	L	0	0	2	2	1	ES (PC)
9.		Self-Learning Course	-	-	-	-	-	1	-
						Total Credits	**27**	**22**	

Semester III

S. No.	Course Code	Course Title	Type	Periods per week			TCP	Credits	Category
				L	T	P			
1.		Programme Elective - IV	T	3	0	0	3	3	ES (PE)
2.		Programme Elective - V	T	3	0	0	3	3	ES (PE)
3.		Programme Elective - VI	T	3	0	0	3	3	ES (PE)
4.		Programme Elective - VII	T	3	0	0	3	3	ES (PE)
5.		Industry Oriented Course II	-	1	0	0	1	1	SD
6.	ED25301	Project Work I	-	0	0	12	12	6	SD
						Total Credits	**25**	**19**	

Semester IV

S. No.	Course Code	Course Title	Type	Periods per week			TCP	Credits	Category
				L	T	P			
1.	ED25401	Project Work II	-	0	0	24	24	12	SD
						Total Credits	**24**	**12**	

PROGRAMME ELECTIVE COURSES (PE)

S. No.	Course Code	Course Title	Periods			Total Contact Periods	Credits
			L	T	P		
1.	ED25C11	Design with Advanced Materials	3	0	0	3	3
2.	ED25C06	Integrated Product Design and Development	3	0	0	3	3
3.	ED25C07	Design for Sustainability	3	0	0	3	3
4.	ED25C12	Composite Materials and Mechanics	3	0	0	3	3
5.	ED25C13	Quality Concepts in Design	3	0	0	3	3
6.	ED25001	Bearing Design and Rotor Dynamics	3	0	0	3	3
7.	CD25C02	Solid Freeform Manufacturing	3	0	0	3	3
8.	CD25C03	Product Lifecycle Management	3	0	0	3	3
9.	ED25C14	Design of Hydraulic and Pneumatic Systems	3	0	0	3	3
10.	ED25C15	Mechanical Measurements and Analysis	3	0	0	3	3
11.	ED25C16	Surface Engineering	3	0	0	3	3
12.	ED25002	Computer Graphics	3	0	0	3	3
13.	ED25C17	Vehicle Dynamics	3	0	0	3	3
14.	ED25003	Advanced Finite Element Analysis	3	0	0	3	3
15.	ED25C18	Advanced Machine Tool Design	3	0	0	3	3
16.	ED25C19	Material Handling Systems and Design	3	0	0	3	3
17.	ED25C20	Creativity and Innovation Management	3	0	0	3	3

Semester I

MA25C06	Applied Mathematical and Statistical Modelling	L	T	P	C
		3	1	0	4

Course Objectives:

- To equip students with advanced mathematical techniques, specifically Fourier Transforms, for formulating and solving partial differential equations that model fundamental mechanical engineering phenomena such as heat transfer, vibrations, and fluid flow.
- To provide a strong foundation in statistical inference, enabling students to estimate population parameters (like material properties and process capabilities) from experimental data and assess the quality and reliability of these estimators.
- To enable students to design efficient, structured experiments and apply appropriate statistical tests to make valid, data-driven decisions for comparing processes, optimizing designs, and solving complex engineering problems.

Fourier Transform: Definitions, Properties, Transform of elementary functions, Dirac delta function, Convolution theorem, Parseval's identity, Solutions to partial differential equations: Heat equation, Wave equation, Laplace and Poison's equations.

Estimation Theory: Unbiasedness, Consistency, Efficiency and sufficiency, Maximum likelihood estimation, Method of moments.

Testing of Hypothesis: Sampling distributions, Small and large samples, Tests based on Normal, t, Chi square, and F distributions for testing of means, variance and proportions, Analysis of r x c tables, Goodness of fit, independent of attributes.

Design of Experiments: Analysis of variance, One way and two-way classifications, Completely randomized design, Randomized block design, Latin square design, 2^2 Factorial design.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%.

References:

1. Andrews, L. C., & Shivamoggi, B. K. (2003). Integral transforms for engineers. Prentice Hall of India.
2. Devore, J. L. (2014). Probability and statistics for engineering and the sciences, Cengage Learning.
3. Johnson, R. A., Miller, I., & Freund, J. (2015). Miller and Freund's probability and statistics for engineers, Pearson Education Asia.

E-resources:

1. https://www.edx.org/learn/probability-and-statistics/massachusetts-institute-of-technology-probability-the-science-of-uncertainty-and-data
2. https://www.itl.nist.gov/div898/handbook/
3. https://ocw.mit.edu/courses/2-830j-control-of-manufacturing-processes-sma-6303-spring-2008

ED25C01	Topology Optimization and Generative Design	L	T	P	C
		3	0	0	3

Course Objective:

This course aims to provide students with a comprehensive understanding of optimization techniques applied to mechanical engineering design, with a focus on topology optimization and generative design. It introduces mathematical formulations and programming methods such as linear, nonlinear, and integer optimization, along with sensitivity and gradient-based approaches. Students will explore topology optimization techniques including SIMP and level set methods for efficient material distribution, and learn generative design principles using rule-based and AI-driven systems integrated with additive manufacturing. The course also addresses advanced topics such as multi-objective optimization, robust and reliability-based design, and sustainability considerations. By the end of the course, students will be equipped to apply computational and algorithmic methods to develop optimized, innovative, and practical engineering solutions.

Fundamentals of Optimization in Mechanical Engineering: Introduction to Optimization Techniques, Importance of Optimization in Mechanical Design, Applications of Topology Optimization and Generative Design in Mechanical Systems. Mathematical Formulation of Optimization Problems, Mathematical Programming Methods: Linear, Nonlinear, and Integer Programming Sensitivity Analysis and Gradient-Based Methods

Activities: Manual Formulation of Optimization Problems: Students will identify a simple mechanical design problem (e.g., truss structure) and manually define its objective function, design variables, and constraints. This helps in understanding mathematical modeling of real-world problems.

Python Implementation of Gradient-Based Optimization:Implement a basic gradient-based method (like steepest descent) to minimize a simple function (e.g., weight minimization of a cantilever beam). Students analyze convergence behavior and parameter effects.

Principles of Topology Optimization: Introduction to Topology Optimization, Problem Formulation and Design Domain, Material Distribution Methods (SIMP, Level Set), Optimization Algorithms for Topology Optimization, Case Studies and Applications in Mechanical Components

Activities: Topology Optimization Using 2D SIMP Method: Use open-source tools or coding to perform 2D topology optimization of a bracket. Students modify boundary conditions and volume fraction to observe material distribution changes.

Generative Design and Computational Techniques: Overview of Generative Design Principles, Evolutionary Algorithms for Design Generation, Rule-Based and AI-Based Generative Systems, Integration with Additive Manufacturing, Generative Design Tools and Case Studies

Activities: Generative Design with CAD Software: Perform a generative design study using CAD Sofware for a component (e.g., bike stem or connecting rod). Analyze various generated design options based on load paths and constraints.

Advanced Concepts and Future Trends: Multi-Objective Optimization and Trade-Off Strategies, Optimization Under Uncertainty, Robust and Reliability-Based Design, Sustainability in Design Optimization, Future Challenges and Research Trends in Topology Optimization and Generative Design

Activities: Multi-Objective Trade-off Analysis using Pareto Fronts: Use Python or Excel to generate Pareto fronts for two conflicting objectives (e.g., stiffness vs. weight). Students interpret the trade-off and identify optimal design decisions.

Case Study Presentation on Sustainable Generative Design: In groups, students research and present a real-world case (e.g., Airbus bracket or Nike Flyprint shoe) that uses generative design for sustainability. Focus on how design choices reduce material use or carbon footprint.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (5%), Project (10%), Assignment (10%), Practical (25%), Review of Question papers (IES, SSC, GATE) (20%), Internal Examinations (30%)

References:

1. Belegundu, A. D., and Chandrupatla, T. R., Optimization Concepts and Applications in Engineering, Cambridge University Press, 2011.
2. Chong, E. K. P., and Zak, S. H., Introduction to Optimization, Wiley, 2013.
3. Boyd, S., and Vandenberghe, L., Convex Optimization, Cambridge University Press, 2004.
4. Bohnacker, H., Gross, B., Laub, J., and Lazzeroni, C., Generative Design: Visualize, Program, and Create with Processing, Princeton Architectural Press, 2012.
5. Adeli, H., Advanced Structural Optimization, Chapman & Hall/CRC, 1994.

	COURSE OUTCOME (CO)	PO	PSO1	PSO2
CO1	Apply optimization techniques (linear, nonlinear, integer programming) to solve mechanical design problems, focusing on material distribution and design efficiency.	PO1 (3), PO3 (2)	3	2
CO2	Implement gradient-based optimization methods for practical problems, such as minimizing weight in mechanical systems, and analyze convergence behavior.	PO1 (3), PO2 (2)	3	2
CO3	Perform topology optimization using SIMP and level set methods for efficient material distribution in mechanical components, and evaluate the optimization results.	PO1 (3), PO3 (3)	3	3
CO4	Use generative design principles, evolutionary algorithms, and AI-driven systems for design generation, with a focus on integrating with additive manufacturing.	PO2 (3), PO3 (3)	3	3

ED25C02	Advanced Mechanics of Materials	L	T	P	C
		3	0	0	3

Course Objective:

The objective of this course is to provide students with an in-depth understanding of the theory of elasticity and advanced stress analysis techniques essential for the design and evaluation of mechanical and structural components. The course emphasizes the formulation and solution of stress-strain relations, equilibrium equations, and compatibility conditions in various coordinate systems. It covers the analysis of flat plates, curved beams, torsional members, and rotating bodies, along with the evaluation of contact stresses and deflections. Students will develop the ability to apply analytical and energy methods to solve complex solid mechanics problems encountered in real-world engineering applications.

Elasticity: 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

Activities: Use MATLAB/ANSYS to visualize 3D stress states and Airy's stress function solutions, Apply failure theories to real-life engineering components (e.g., pressure vessel, shaft).

Stresses In Flat Plates and Curved Members: 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.

Activities: Analyze deflection of a rectangular plate under UDL using ANSYS, Compare analytical vs FEM solutions for curved beams, Write a technical note on applications of plate theory in aerospace or civil structures.

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

Activities: Find the shear center for an open thin-walled section experimentally (e.g., channel section), Use FEM to analyze torsional stresses in rectangular and hollow thin-walled tubes, Students design a beam subjected to unsymmetrical bending and justify choice of section.

Stresses in Rotating Members and Contact Stresses: 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

Activities: Calculate allowable speeds for rotating discs (e.g., turbine blade roots, flywheels), Use ANSYS/ABAQUS to simulate stress in rotating discs with varying thickness, Mini project on predicting failure in machine components under contact stresses.
Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%
Assessment Methodology: Quiz (5%), Project (10%), Assignment (10%), Practical (25%), Review of Question papers (IES, SSC, GATE) (20%), Internal Examinations (30%)
References: 1. Boresi, A. P., & Schmidt, R. J. (2009). *Advanced mechanics of materials*. Wiley India Pvt. Ltd. 2. Hibbeler, R. C. (2011). *Mechanics of materials*. Prentice Hall. 3. Cook, R. D., & Young, W. C. (1999). *Advanced mechanics of materials*. Prentice Hall. 4. Chandramouli, P. N. (2017). *Theory of elasticity*. Yes Dee Publishing. 5. Srinath, L. S. (2010). *Advanced mechanics of solids*. Tata McGraw-Hill. 6. Timoshenko, S., & Goodier, J. N. (2010). *Theory of elasticity*. Tata McGraw-Hill.

	Description of CO	PO	PSO1	PSO2
CO1	Understand and apply fundamental concepts of elasticity, stress-strain relations, and equilibrium equations to analyze mechanical components under various loading conditions.	PO3 (3)	1	3
CO2	Analyze stresses and deflections in flat plates, curved beams, and torsional members using analytical and energy methods.	PO3 (3)	2	3
CO3	Evaluate stresses in rotating members and contact stresses in mechanical components for design and failure analysis.	PO1 (3), PO3 (2)	3	2
CO4	Develop problem-solving skills to formulate and solve complex solid mechanics problems encountered in real-world engineering applications.	PO1 (3), PO2 (2)	2	3

ED25C03	Design and Analysis of Advanced Mechanisms	L	T	P	C
		3	0	2	4

Course Objective:

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

Introduction: 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 mechanismsEquivalent mechanisms.

Activities: Create Mobility Calculations for Various Mechanisms, Build and Classify Real-life Mechanisms Using LEGO/Modeling Kits,Identify and Compare Serial vs Parallel Robot Structures,Simulation of Basic Compliant Mechanism in a CAD Tool

Kinematic Analysis: 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,DenavitHartenberg Parameters, Forward and inverse kinematics of robot manipulators.

Activities: Vector Loop Equation Modeling in software,Acceleration and Jerk Analysis for Four-bar Linkage, Forward & Inverse Kinematics of a Robot Arm (2 or 3 DOF), Create a Physical Model of a Complex Mechanism

Path Curvature Theory, Coupler Curve: 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 sixbarmechanisms,straight line mechanisms.

Activities: Graphical Construction of Inflection Circle and Centrodes,Simulation of a Four-Bar Coupler Curve Using software,Demonstration of Cusp and Crunode with Coupler Curve,Build a Straight Line Mechanism (e.g., Peaucellier or Scott-Russell)

Synthesis of Four Bar Mechanisms: Type synthesis, Number synthesis, Associated Linkage Concept. Dimensional synthesis, function generation, path generation, motion generation. Graphical methods-Pole technique inversion techniquepoint position reduction-two, three and four position synthesis of four-bar mechanisms. Analytical methods- Freudenstein’s Equation-Bloch’s Synthesis.

Activities: Graphical Synthesis Using Three-Position Path Generation,Use software to Solve Freudenstein’s Equation, Pole and Inversion Technique Exercise Using CAD
Case Study: Mechanism Design for a Real-world Application

Synthesis of Coupler Curve Based Mechanisms: Cognate Linkages-parallel motion Linkages. Design of six bar mechanisms-single dwell-double dwelldouble stroke. Geared five bar mechanism-multi-dwell.

Activities : Design and Simulate Cognate Mechanisms for Identical Coupler Curves,Build a Working Model of a Dwell Mechanism,Synthesize a Geared Five-Bar Mechanism in Software,Study and Presentation: Application of Multi-Dwell in Packaging Industry

CAM Mechanisms: CAM Mechanisms- determination of optimum size of CAMs. Mechanism defects.

Activities: Design a CAM Profile Using CAM Design Software, Simulation of CAM Follower System for Different Motions, Case Study: Identify Defects in Existing CAM Mechanism Designs, 3D Print a Custom CAM Profile and Test Mechanism Motion

Weightage: Continuous Assessment: 50%, End Semester Examinations: 50%

Assessment Methodology: Quiz (5%), Project (10%), Assignment (10%), Practical (25%), Review of Question papers (IES, SSC, GATE) (20%), Internal Examinations (30%)

References:

1. Ghosh, A., & Mallik, A. K. (1999). Theory of mechanism and machines. EWLP.
2. Waldron, K. J., & Kinzel, G. L. (2016). Kinematics, dynamics and design of machinery. John Wiley & Sons.
3. Norton, R. L. (2012). Design of machinery. Tata McGraw-Hill.
4. Sandor, G. N., & Erdman, A. G. (1984). Advanced mechanism design: Analysis and synthesis. Prentice Hall.
5. Uicker, J. J., Pennock, G. R., & Shigley, J. E. (2017). Theory of machines and mechanisms. Oxford University Press.

	Description of CO	PO	PSO1	PSO2
CO1	Apply kinematic analysis methods to design and simulate the motion of basic mechanisms (e.g., four-bar, slider-crank).	PO1 (3), PO2 (2)	3	2
CO2	Synthesize and design complex mechanisms, such as four-bar and six-bar linkages, to meet specific motion generation or path generation objectives.	PO1 (3), PO3 (3)	3	3
CO3	Analyze and synthesize compliant mechanisms and path curvature theory to optimize motion and performance of mechanical systems.	PO1 (3), PO3 (2)	3	2
CO4	Design and simulate CAM mechanisms, including optimizing cam profiles and testing different motion types using simulation software.	PO1 (3), PO2 (3)	3	3

ED25C04	Design Practice with CAD Tools Laboratory	L	T	P	C
		0	0	4	2

Course Objective:

The objective of this course is to equip students with the fundamental and practical knowledge of engineering drawing standards and CAD tools, enabling them to interpret and create accurate 2D and 3D representations of mechanical components and assemblies. The course aims to develop skills in applying BIS conventions, tolerancing, and geometric dimensioning, constructing orthographic projections, producing part and assembly drawings, and simulating basic kinematic mechanisms using CAD software for real-world mechanical applications.

Study exercise

1. Code of practice for Engineering Drawing, BIS/ASME specifications – Welding symbols, riveted joints, keys, fasteners – Reference to hand book for the selection of standard components like bolts, nuts, screws, keys etc.
2. Limits, Fits – Tolerancing of individual dimensions – Specification of Fits – Preparation of production drawings and reading of part and assembly drawings, basic principles of Geometric Dimensioning & Tolerancing.
3. Drawing, Editing, Dimensioning, Layering, Hatching, Block, Array, Detailing, Detailed Drawing.

Sketching for solid modeling

4. Orthographic projection of mechanical parts: Hexagonal Nut, Sectioned Hollow stepped shaft, L – Bracket, Slotted Blocks, other similar parts.

Part Drawing, Assembly and Geometrical Properties

5. Bearings – Bush Bearing, Taper bearing
6. Valves – Safety and Non-return Valves.
7. Couplings – Flange, Oldham’s, Muff, Gear couplings.
8. Joints – Universal, Knuckle, Gib & Cotter, Strap, Sleeve & Cotter joints.
9. Engine parts – Piston, Connecting Rod, Crosshead (vertical and horizontal), Stuffing box, Multi-plate clutch.
10. Machine Components – Screw Jack, Machine Vice, Lathe Tail Stock, Lathe Chuck, Plummer Block, Vane and Gear pumps.

Kinematics

11. Simulation of slider crank mechanism
12. Simulation of crank and rocker mechanism

Weightage: Continuous Assessment: 60%, End Semester Examinations: 40%

Assessment Methodology: Quiz (5%), Project (10%), Assignment (10%), Practical (25%), Review of Question papers (IES, SSC, GATE) (20%), Internal Examinations (30%)

	Description of CO	PO	PSO1	PSO2
CO1	Apply engineering drawing standards, BIS/ASME specifications, and tolerancing principles for mechanical components.	PO1 (3), PO3 (2)	2	2
CO2	Create accurate 2D orthographic projections and detailed part drawings of mechanical components using CAD tools.	PO1 (3), PO3 (3)	3	2
CO3	Develop assembly drawings and interpret geometric properties of machine components and joints.	PO1 (2), PO3 (3)	3	2
CO4	Simulate basic kinematic mechanisms (slider crank, crank and rocker) using CAD software for mechanical applications.	PO1 (3), PO3 (3)	3	2

ED25C05	Multi Body Dynamics Laboratory	L	T	P	C
		0	0	4	2

Course Objective:

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

Weightage: Continuous Assessment: 60%, End Semester Examinations: 40%

Assessment Methodology: Quiz (5%), Project (10%), Assignment (10%), Practical (25%), Review of Question papers (IES, SSC, GATE) (20%), Internal Examinations (30%)

	Course Outcome (CO)	PO	PSO1	PSO2
CO1	Analyze and simulate free fall, projectile motion, and pendulum dynamics to understand basic motion and forces in mechanical systems.	PO1 (3), PO3 (2)	3	2
CO2	Perform kinematic and dynamic analysis of four-bar and slider-crank mechanisms, including their inversions, to understand mechanical system behavior.	PO1 (3), PO2 (2)	3	2
CO3	Design and simulate CAM profiles for various follower output motions to understand motion generation in mechanical systems.	PO1 (3), PO3 (2)	3	3
CO4	Conduct vibration analysis (SDOF and MDOF) and evaluate the dynamic behavior of mechanical systems under different excitation conditions.	PO1 (3), PO2 (3)	3	2
CO5	Design a virtual product using commercial software, integrating multi-body dynamics principles in product design and analysis.	PO2 (3), PO3 (3)	3	3

Semester II

ED25C08	Finite Element Methods	L	T	P	C
		2	0	4	4

Course Objective:

The objective of this course is to equip students with a fundamental understanding of the finite element method and its applications in solving engineering problems. It aims to develop the ability to formulate, model, and analyze one- and two-dimensional boundary value problems using variational and weighted residual methods. The course emphasizes isoparametric formulation, numerical integration, and the application of FEM in dynamic and nonlinear systems, enabling students to critically evaluate structural and thermal problems with appropriate meshing and solution strategies.

Fundamentals of Finite Element Analysis and 1D Problems

Historical background – Basic concepts of FEM – Weighted residual methods – Variational formulation of boundary value problems – Ritz method – Finite element modeling – Element equations – Linear and higher-order shape functions – Bar and beam elements – Applications to one-dimensional heat transfer problems.

2D Finite Element Problems and Elasticity

Boundary value problems in two dimensions – Linear and higher-order triangular and quadrilateral elements – Poisson's and Laplace's equations – Weak formulation – Element matrices and vectors – Scalar variable problems – Introduction to theory of elasticity – Plane stress, plane strain, and axisymmetric formulation – Principle of virtual work – Energy method for matrix formulation.

Isoparametric Formulation and Numerical Integration

Natural coordinate systems – Lagrangian interpolation polynomials – Isoparametric formulation – Shape functions for 1D and 2D elements – Serendipity elements – Jacobian transformation – Numerical integration using Gauss quadrature – One-point, two-point, and three-point integration.

Eigenvalue and Nonlinear Finite Element Analysis

Dynamic analysis – Equations of motion – Consistent and lumped mass matrices – Free vibration of bars, beams, and shafts – Eigenvalue problem solutions – Introduction to transient field problems – Nonlinear analysis: solution techniques – Material nonlinearity (plasticity, visco-plasticity) – Geometric nonlinearity – Contact problems – Stress stiffening – Meshing strategies: free and mapped – Mesh quality and error estimation.

Lab exercises:

1. Formulation and Solution of 1D Bar Problems Using Finite Element Method
2. Analysis of 1D Beam Elements under Static Loading using FEM Software
3. Temperature Distribution in a 1D Fin Geometry using Weighted Residual Method
4. Stress Analysis of 2D Plane Structures Using Triangular and Quadrilateral Elements

5. Iso-parametric Mapping and Jacobian Calculation for 2D Elements
6. Implementation of Gauss Quadrature for Numerical Integration in FEM
7. Modal Analysis of a Cantilever Beam to Determine Natural Frequencies
8. Nonlinear Static Analysis of a Component with Contact Interfaces using FEM Tools

Weightage: Continuous Assessment: 50%, End Semester Examinations: 50%

Assessment Methodology:

1. Assessment Test 1 – 30%
2. Assessment Test 2 – 30%
3. Laboratory – 40%

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	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain FEM fundamentals, 1D/2D problems, isoparametric formulation, and nonlinear analysis	PO1 (3), PO3 (2)	3	2
CO2	Apply FEM techniques to model and solve structural and thermal problems	PO1 (3), PO2 (3)	3	3
CO3	Estimate errors, meshing needs, and eigenvalues in FEM solutions	PO1 (3), PO3 (3)	3	3
CO4	Analyze FEM results for accuracy, optimization, and problem-solving	PO3 (3)	3	3

ED25C09	Vibration, Fracture, and Failure Analysis	L	T	P	C
		3	0	0	3

Course Objective:

To equip students with fundamental and advanced knowledge of mechanical vibrations, fracture mechanics, and failure analysis, enabling them to analyze the dynamic behavior of mechanical systems, predict failure modes, and apply diagnostic techniques for identifying and preventing structural failures in engineering components.

Fundamentals of Vibration

Basics of mechanical vibration – Classification: free and forced vibration, damped and undamped systems – Single degree-of-freedom systems – Natural frequency – Damping models – Forced vibration response – Resonance – Vibration isolation – Introduction to multi-degree-of-freedom systems – Modal analysis.

Fracture Mechanics

Introduction to fracture mechanics – Linear elastic fracture mechanics (LEFM) – Stress intensity factor – Griffith's energy balance – Modes of crack opening – Fracture toughness – Crack tip plasticity – Fatigue crack growth – Paris' Law – Experimental determination of fracture parameters – Concept of R-curves.

Failure Theories and Analysis

Theories of failure: maximum principal stress, maximum shear stress, distortion energy theory – Ductile vs brittle failure – Creep and fatigue failures – High-cycle and low-cycle fatigue – S-N curve – Miner's rule – Failure analysis methodology – Case studies of failed mechanical components.

Condition Monitoring and Vibration-based Fault Diagnosis

Principles of condition monitoring – Vibration signature analysis – Frequency spectrum analysis – Time-domain and frequency-domain features – Fault detection techniques – Crack detection in shafts and rotors – Vibration sensors and instrumentation – Case studies on vibration-based failure analysis.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (10%), Assignments (20%), Case Study report (20%), Internal Examinations (50%)

References:

1. Rao, S. S., Mechanical Vibrations, 6th Edition, Pearson Education, 2017.
2. Timoshenko, S. P., and Young, D. H., Vibration Problems in Engineering, 5th Edition, John Wiley & Sons, 1990.
3. Anderson, T. L., Fracture Mechanics: Fundamentals and Applications, 4th Edition, CRC Press, 2017.
4. Bannantine, J. A., Comer, J. J., and Handrock, J. L., Fundamentals of Metal

Fatigue Analysis, Prentice Hall, 1990.
5. Juvinall, R. C., and Marshek, K. M., Fundamentals of Machine Component Design, 6th Edition, Wiley, 2017.
6. ASM International, Metals Handbook, Volume 11: Failure Analysis and Prevention, 10th Edition, ASM International, 2002.

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain fundamentals of vibration, fracture mechanics, failure theories, and condition monitoring	PO1 (1), PO2 (1)	1	1
CO2	Apply vibration, fracture mechanics, and failure analysis techniques to solve engineering problems	PO2 (2), PO3 (2)	2	2
CO3	Estimate critical parameters such as natural frequency, stress intensity factor, fatigue life, and system responses	PO3 (2), PO4 (2)	2	2
CO4	Analyze vibration signals, failure modes, and condition monitoring data for fault diagnosis	PO4 (2), PO5 (2)	2	2

ED25201	Computational Fluid Dynamics	L	T	P	C
		2	0	2	3

Course Objective:

To equip students with a solid foundation in the principles and numerical techniques of computational fluid dynamics, enabling them to model, analyze, and solve complex fluid flow and heat transfer problems relevant to engineering design using modern CFD tools and turbulence models.

Fundamentals of CFD and Governing Equations

Introduction to CFD – Applications in Engineering Design – Types of fluid flow – Fundamental conservation equations: mass, momentum, energy – Classification of PDEs: hyperbolic, parabolic, elliptic – Initial and boundary conditions – Simplification of Navier-Stokes equations for various flow regimes – Non-dimensionalization – Reynolds number and its significance.

Discretization and Solution Techniques

Introduction to numerical methods – Finite Difference Method (FDM) – Finite Volume Method (FVM) – Finite Element Method (FEM) – Grid generation and mesh quality – Structured vs unstructured meshes – Discretization of governing equations – Upwind, central and hybrid schemes – Stability, consistency and convergence – SIMPLE and PISO algorithms – Time-marching methods: explicit and implicit schemes.

Turbulence Modelling and Applications

Introduction to turbulence – Reynolds Averaged Navier-Stokes (RANS) equations – Eddy viscosity concept – Turbulence models: k-ε, k-ω, SST – Wall functions – Near-wall modeling – Heat transfer and multi-physics in CFD – Case studies using commercial CFD solvers – CFD for component design and optimization – Validation and verification of CFD results.

Lab Exercises:

1. Mesh Generation and Grid Independence Study
2. Simulation of Laminar Flow in a Circular Pipe
3. Turbulent Boundary Layer Flow over a Flat Plate
4. Conjugate Heat Transfer in a Heated Channel
5. Transient Flow Over a Cylinder and Vortex Shedding Analysis
6. Mixing Flow Analysis in a Tee Junction

Weightage: Continuous Assessment: 50%, End Semester Examinations: 50%

Assessment Methodology and weightage:

Assessment Exams (50%), Assignment/Case Study (10%), Quiz/Problem (10%), Virtual demonstration/Software Analysis (10%), Flipped Classroom (10%), Review of GATE & IES questions (10%)

References:

1. Versteeg and Malalasekera, N, “An Introduction to computational Fluid Dynamics, Finite

Volume Method,” Pearson Education, Ltd., Second Edition, 2014.
2. Subas and V. Patankar “Numerical heat transfer fluid flow”, CRC Press, 2018.
3. Jiyuan Tu, Gaun-Heng Yeoh, Chaoqun Liu, Computational Fluid Dynamics: A practical approach, Elsevier, 2018.
4. Chung T.J, Computational Fluid Dynamics, Cambridge University Press, 2014.
5. Randall J. LeVeque, Finite Volume Methods for Hyperbolic Problems, Cambridge University Press, 2004.
6. Vladimir D. Liseikin, Grid Generation Methods, Springer, 2017.
7. Moukalled F, Mangani L, Darwish M, The Finite Volume Method in Computational Fluid Dynamics, Springer, 2016.
8. Hirsch Ch, Numerical Computation of Internal and External Flows: The Fundamentals of Computational Fluid Dynamics, Elsevier, 2007.
9. Oleg Zikanov, Essential Computational Fluid Dynamics, Wiley, 2019.

CO	Course Outcome	POs	PSO1	PSO2
CO1	Explain CFD fundamentals, governing equations, and flow classification	PO1, PO3	2	1
CO2	Apply numerical methods (FDM, FVM, FEM) and CFD tools for fluid flow and heat transfer problems	PO1, PO3	2	2
CO3	Estimate and model turbulence effects using RANS and other turbulence models	PO3, PO2	2	2
CO4	Analyze and validate CFD simulations, and optimize engineering components	PO3, PO2	2	2

ED25C10	Research Article Replication Practice	L	T	P	C
		0	0	2	1

Course Objective:

The objective of this course is to develop students' ability to critically analyze, interpret, and replicate published research articles in their field of study. It aims to enhance understanding of research methodologies, experimental design, data analysis, and result validation by engaging students in hands-on replication of existing scholarly work. Through this process, students will gain insights into research rigor, reproducibility, and ethical practices in scholarly communication.

List of exercises:

1. Selection of a Research Article for Replication
2. Objective and Methodology Extraction from Published Research
3. Literature Benchmarking and Related Work Mapping
4. Reconstructing the Experimental or Simulation Setup
5. Dataset Creation or Acquisition for Replication
6. Algorithm or Model Reconstruction and Implementation
7. Simulation Execution and Output Validation
8. Graphical and Tabular Result Reproduction
9. Error and Deviation Analysis in Replication
10. Replicating Statistical and Hypothesis Tests
11. Preparation of Replication Research Report
12. Oral Presentation and Peer Review of Replication Work

Weightage: Continuous Assessment: 60%, End Semester Examinations: 40%

Assessment Methodology: Quiz (5%), Project (10%), Assignment (10%), Practical (25%), Review of Question papers (IES, SSC, GATE) (20%), Internal Examinations (30%)

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain research methodologies, article structure, and replication principles	PO1 (3), PO3 (2)	3	2
CO2	Apply experimental, simulation, and data analysis techniques to replicate research	PO1 (3), PO2 (3)	3	3
CO3	Analyze replication results, estimate errors, and validate outcomes	PO3 (3)	3	3

Semester III

ED25301	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.

  Note: A project topic must be selected by the students in consultation with their guides. The progress of the project is evaluated based on a minimum of three reviews. The review committee may be constituted by the Head of the Department. A project report is required at the end of the semester. The project work is evaluated jointly by external and internal examiners constituted by the Head of the Department based on oral presentation and the project report.

Semester IV

ED25401	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.

Note: A project topic must be selected by the students in consultation with their guides. The progress of the project is evaluated based on a minimum of three reviews. The review committee may be constituted by the Head of the Department. A project report is required at the end of the semester. The project work is evaluated jointly by external and internal examiners constituted by the Head of the Department based on oral presentation and the project report.

PROGRAMME ELECTIVE COURSES

ED25C11	Design with Advanced Materials	L	T	P	C
		3	0	0	3

Course Objective:

This course is designed to equip students with a comprehensive understanding of metallic materials and their applications. It aims to develop the ability to analyse various strengthening and failure mechanisms in metals and to apply metallurgical parameters effectively in the design of advanced materials. Students will gain insight into the relationship between material selection and processing methods, enabling informed decisions in engineering design. The course also fosters innovation by encouraging the development of novel materials through a deep understanding of the properties and behaviour of existing metallic systems. Additionally, students will critically analyse the use of different materials across a range of engineering applications.

Basic Concepts of Material Behavior

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

Activities Based Learning:

1. Case study discussion on material behavior in real-world engineering failures
2. Virtual presentation on microstructural changes during strengthening
3. Group presentation on strengthening mechanisms with example materials

Behavior Under Cyclic Loads and Failure Design

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, Stresslife, strain-life and fail - safe design approaches- Fracture of nonmetallic Materials – Failure analysis, sources of failure, procedure of failure analysis.

Activities Based Learning:

1. Simulation on fatigue crack propagation and S-N curves
2. Numerical analysis on fracture toughness and fatigue design
3. Failure analysis report based on a real-world case
4. Mind map creation on design approaches under fatigue loading

Materials Selection and Design Integration

Material selection based on function, objectives, constraints, and service requirements- Free variables in selection- Relationship between material selection and processing- Case studies in advanced materials selection with relevance to aero, auto, marine, machinery and nuclear applications.

Activities Based Learning:

1. Project on material selection for a specific engineering product
2. Interactive seminar on Ashby’s material selection charts
3. Group debate on trade-offs in materials selection
4. Industry-based mini-case analysis of material choice and processing

Advanced Steels and Intermetallics

Steels-Advanced high strength steel, Dual phase (DP) steel, Transformation induced plasticity (TRIP) Steel, Maraging steel and Q&P steels- Nitrogen steels, austenitic steels- ntermetallic compounds: Ni and Ti aluminides- Overview of alloy families: Al, Mg, Cu- Introduction to superalloys: iron, cobalt, and nickel base.

Activities Based Learning:

1. Comparative chart activity on different advanced steels
2. Individual assignment on intermetallic properties and applications
3. Video-based discussion on heat treatment of steels
4. Discussion on superalloy classifications and usage

Metal Matrix Composites (MMC) and Emerging Metallic Systems

Definition, characteristics, and applications of MMCs- Fabrication techniques and challenges-Performance evaluation of MMCs- Examples of MMCs used in aerospace, automotive, and military applications.

Activities Based Learning:

1. Case study: MMCs in aerospace structural components
2. Design task: Choose MMCs for a lightweight structure
3. Presentation: Comparison between conventional metals and MMCs
4. Poster creation on fabrication methods of MMCs

Non-Metallic and Composite Materials

Polymers: structure formation, properties, applications, environmental impact-Advanced ceramics: WC, TiC, TaC, Al_2O_3, SiC, Si_3N_4, CBN, diamond- Fracture and deformation of ceramics- Glasses, clay products, and refractory ceramics-Composite materials: GFRP and CFRP laminated composites

Activities Based Learning:

1. Industrial visit to observe polymer and ceramic manufacturing
2. Case analysis of failure in ceramic-based components
3. Team presentation on CFRP and GFRP in automotive or aviation
4. Comparative table on mechanical properties of metals vs non-metals

(**Note:** Split the activities among the students (Maximum of three/ group) such that all the activities are covered)

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Mandated Activities with weightage:
Assignments (20%), Quiz (10%), Virtual demonstration (15%), Flipped Classroom (5%).

Assessment Methodology:
Quiz - 10%
Assignments - 20%
Virtual Demonstration - 15%
Flipped Classroom - 5%
Internal Examinations - 50%

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..

E-Resources:

www.astm.org/labs/pages/131350.html

CO	Course Outcome	POs	PSO1	PSO2
CO1	Explain fundamental material behavior, strengthening mechanisms, and failure modes	PO1 (2), PO3 (1)	2	1
CO2	Apply fatigue, fracture, and failure analysis techniques to engineering components	PO1 (2), PO3 (2)	2	2
CO3	Estimate material performance and select suitable materials for design applications	PO2 (2), PO3 (2)	2	2
CO4	Analyze advanced steels, intermetallics, MMCs, and composites for engineering applications	PO2 (2), PO3 (2)	2	2

ED25C06	Integrated Product Design and Development	L	T	P	C
		3	0	0	3

Course Objective:

This course aims to provide a comprehensive understanding of the generic product development process, including product planning and customer need analysis. It enhances students' abilities to set product specifications and effectively generate, select, and test design concepts. Emphasis is placed on product architecture, industrial design, and Design for Manufacturing (DFM) principles. The course also introduces prototyping techniques, robust design through Design of Experiments (DoE), and the importance of patenting innovations. Additionally, it integrates economic principles and project management practices essential for successful new product development.

Introduction to Product Development: Overview of Product Development, Characteristics of Successful Products, Product Development Teams and Organizations- Challenges, Duration and Cost of Product Development, Product Development Process (Generic and Front-End), Process Flows and Opportunity Identification.

Activities: Brainstorming Session: Identifying latent vs stated needs for a new product

Product Planning and Customer Needs: Product Planning Process, Identifying and Understanding Customer Needs, Importance of Latent Needs, Establishing Target and Final Specifications

Activities: Design Review Meeting: Present and defend a selected product concept

Concept Generation, Selection and Testing: Concept Generation Activities- Concept Selection: Screening and Scoring- Concept Testing Techniques and Caveats

Activities: Use mind maps to visually expand product features and functions

Product Architecture and Industrial Design: Product Architecture, Definition, Planning, and System, Level Design; Delayed Differentiation and Platform Planning; Industrial Design, Need, Process, Management, Quality Assessment.

Activities: Product Platform Case Study: Explore delayed differentiation in brands (e.g., Dell, Toyota)

Design for Manufacturing (DFM) Principles: DFM Process Overview- Integration of Design and Manufacturing Early in the Development Cycle- Cost and Complexity Considerations; Cross-functional Collaboration for Manufacturability.

Activities: Presentation: Pros and cons of different DFM strategies in a selected industry

Prototyping, Economics & Project Management: Prototyping: Principles, Planning, and Technologies, Product Development Economics, Cost Estimation and Analysis, Project Management: Task Representation, Planning, Execution, Postmortem Evaluation of Projects. **Activities:** Prototype Demo: Create and explain a low-fidelity prototype (paper or digital)
Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%
Assessment Methodology: Quiz (5%), Project (10%), Assignment (10%), Practical (25%), Review of Question papers (IES, SSC, GATE) (20%), Internal Examinations (30%)
References: 1. Ulrich, K. T., Eppinger, S. D., & Goyal, A. (2012). Product design and development, McGraw-Hill Education (India) Pvt. Ltd. 2. Crow, K. (n.d.). Concurrent engineering/integrated product development [Workshop book]. DRM Associates. 3. Otto, K. N., & Wood, K. L. (2016). Product design: Techniques in reverse engineering and new product development. Pearson Education, Inc. 4. Rosenthal, S. (1992). Effective product design and development. Business One Irwin. 5. Pugh, S. (1991). Total design: Integrated methods for successful product engineering. Addison Wesley Publishing.

	Description of CO	PO	PSO1	PSO2
CO1	Understand and apply the generic product development process including product planning,customer needs analysis, and specification setting.	PO3 (3)	1	2
CO2	Generate, select, and test product concepts effectively using brainstorming, screening, scoring, and testing techniques.	PO1 (3), PO3 (2)	2	3
CO3	Apply principles of product architecture, industrial design, and Design for Manufacturing (DFM) to optimize product development for manufacturability and cost.	PO1 (3), PO3 (3)	3	2
CO4	Plan and manage product prototyping, economic analysis, and project execution using tools such as Design of Experiments (DoE) and project management techniques.	PO1 (3), PO2 (2), PO3 (3)	2	3

ED25C07	Design for Sustainability	L	T	P	C
		3	0	0	3

Course Objective:

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

Foundations of Sustainable Design: Understanding sustainability through design**-** Challenges and evolution toward sustainable solutions**-** Product lifecycle design and eco-efficient product-service systems (PSS)**-** Eco-design principles, strategies, and green design methodologies

Activities: Lifecycle Mapping and Eco-Design Redesign

Design for Sustainable Behaviour (DSB): Behavioral change through design**-** Comprehensive Action Determination Model (CADM), Methods and tools to support sustainable behaviour**-** Individual cognitive vs context-driven approaches**-** Frameworks and future research in DSB

Activities: Designing for Sustainable User Behavior Using CADM

Design for Environment (DE): Global, regional, and local environmental objectives**-** Lifecycle assessment (LCA) methods and tools, Environmentally responsible product assessment (e.g., AT&T method), Design techniques: minimizing material use, disassembly, recyclability, energy efficiency.

Activities: Lifecycle Assessment of Competing Product Designs

Product-Service Systems and Systemic Sustainability Design: Transition from product to integrated product-service design- Categories and practices of PSS for sustainability- Systemic design at regional/territorial levels- Regulatory frameworks, innovation levels, and evolution of sustainable design.

Activities:

Conceptualizing a Sustainable Product-Service System (PSS)

Systemic Design Case Study: Regional Sustainability in Practice

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Assessment Methodology: Quiz (5%), Project (10%), Assignment (10%), Practical (25%), Review of Question papers (IES, SSC, GATE) (20%), Internal Examinations (30%)

References:

1. Ceschin, F., & Gaziulusoy, I. (2020). Design for sustainability: A multi-level framework from products to socio-technical system. Routledge.
2. Boothroyd, G. (1980). Design for assembly automation and product design. Marcel Dekker.

3. Bralla, J. G. (1999). Design for manufacture handbook. McGraw-Hill.
4. Boothroyd, G., Heartz, W., & Nike, P. (1994). Product design for manufacture. Marcel Dekker.
5. Dickson, J. R., & Corroda, P. (1995). Engineering design and design for manufacture: A structural approach. Field Stone Publishers.
6. Fixel, J. (1996). Design for the environment. McGraw-Hill.
7. Graedel, T. E., & Allenby, B. R. (1996). Design for the environment. Pearson.
8. Otto, K., & Wood, K. (2009). Product design (4th impression). Pearson.

E-resources:

1. Massachusetts Institute of Technology, Department of Civil & Environmental Engineering. (2006). *Design for Sustainability* (Course No. 1.964, Fall 2006). MIT OpenCourseWare. Retrieved from https://ocw.mit.edu/courses/1-964-design-for-sustainability-fall-2006/
2. University of Melbourne, Department of Mechanical Engineering. (2023). *Sustainable and Life Cycle Engineering* (Subject Code: MCEN90060). University of Melbourne Handbook. Retrieved from https://handbook.unimelb.edu.au/2023/subjects/mcen90060
3. Jolliet, O. (2023). *Life Cycle Assessment*. University of Michigan. Coursera Online Course. Retrieved from https://www.coursera.org/learn/life-cycle-assessment

Other Resources:

Science and Technology of Materials": https://ocw.mit.edu/courses/3-016-science-and-technology-of-materials-fall-2009/

	Description of CO	PO	PSO1	PSO2
CO1	Understand the foundations of sustainable design, including eco-design principles, lifecycle thinking, and sustainable product-service systems.	PO1 (3), PO3 (3)	1	1
CO2	Analyze and apply design strategies to influence sustainable behavior using models like the Comprehensive Action Determination Model (CADM).	PO1 (3), PO3 (3)	2	3
CO3	Conduct lifecycle assessment (LCA) and environmentally responsible product evaluations to minimize environmental impact in design.	PO1 (3), PO3 (3)	3	2
CO4	Develop sustainable product-service systems and systemic design approaches addressing regional and global sustainability challenges.	PO1 (3), PO2 (2), PO3 (3)	2	3

ED25C12	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.

Introduction to Composite Materials

Definition of composite materials, matrix materials – polymers, metals, ceramics; reinforcements – particles, whiskers, inorganic fibers, metal filaments, advanced fibers – carbon and graphite fibers, ceramic fibers, fiber fabrication, natural composites – wood, jute. Advantages and drawbacks of composites over monolithic materials, mechanical properties and applications of composites. Particulate-reinforced composites, dispersion-strengthened composites, fiber-reinforced composites, rule of mixtures, characteristics of fiber-reinforced composites, manufacturing of fibers and composites.

Manufacturing of Composites

Manufacturing process of epoxy resins and fibers, 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, vapor state processing. Ceramic matrix composites (CMCs) – hot pressing, reaction bonding process, infiltration technique, direct oxidation. Interfaces in composites.

Lamina Constitutive Equations

Lamina assumptions – macroscopic viewpoint, generalized Hooke's Law, reduction to homogeneous orthotropic lamina, isotropic limit case, orthotropic stiffness matrix (Qij), 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 using computer tools.

Lamina Strength Analysis and Laminated Plate Analysis

Maximum stress and strain criteria, Von-Mises yield criterion for isotropic materials, Hill's criterion for anisotropic materials, Tsai-Hill and Tsai-Wu failure criteria, tensor polynomial criterion. Prediction of laminate failure, equilibrium equations of motion, energy formulations, governing equations for plates – static bending analysis, buckling analysis, free vibration analysis, natural frequency prediction.

Thermo-Structural Analysis of Laminates

Fabrication and residual stresses in FRP laminated composites, coefficient of thermal expansion (CTE), modification of Hooke's Law and laminate constitutive equations, orthotropic lamina CTEs. Stress and moment resultants due to cooling during fabrication, calculations for thermo-mechanical stresses in FRP laminates, thermally quasi-isotropic laminates, case studies on classical laminate theory (CLT) for evaluating residual stresses in multi-layered isotropic structures such as electronic packages.

Applications and Advanced Topics in Composite Design

Real-world case studies and applications of composite material design, implementation of classical laminate theory (CLT), impact and fatigue behavior, durability analysis, hybrid composites, smart composites with embedded sensors, environmental considerations and recycling of composites.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Mandated Activities with weightage:

Assignments (20%), Quiz (10%), Virtual demonstration (15%), Flipped Classroom (5%)

Assessment Methodology:

Quiz - 10%
Assignments - 20%
Virtual Demonstration - 15%
Flipped Classroom - 5%
Internal Examinations - 50%

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", McGrawHill, 1998
4. Issac M Daniel and OriIshai, "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.

E-Resources:

https://nptel.ac.in/courses/112/104/112104251
NPTEL Course: Composite Materials by IIT Kanpur – Covers mechanics, manufacturing, and applications of composite materials.
https://www.coursera.org/learn/composite-materials
Coursera: Introduction to Composite Materials – Offers practical understanding and analysis tools for composite structures.

https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-20-structural-mechanics-spring-2003/
MIT OpenCourseWare: Structural Mechanics – Includes advanced topics on composite and anisotropic materials.

CO	Course Outcome (CO)	PO Mapping	PSO1	PSO2
CO1	Explain fundamentals, lamina theory, laminated plates, thermo-structural effects, and applications	PO1 (2), PO3 (1)	2	1
CO2	Apply lamina/laminate analysis, failure criteria, and thermo-mechanical calculations	PO2 (2), PO3 (2)	2	2
CO3	Estimate stresses, strength, residual stresses, and natural frequencies	PO1 (2), PO3 (2)	2	2
CO4	Analyze performance, failure, and durability of composite structures	PO3 (1), PO4 (2)	1	2

ED25C13	Quality Concepts in Design	L	T	P	C
		3	0	0	3

Course Objective:

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.

Design Fundamentals, Methods and Material Selection

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.

Design for Quality

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 factorsRunning the experiments –Conducting the analysis-Selecting and conforming factor-Set points-reflecting and repeating

Failure Mode Effects Analysis, Design for Six Sigma and Design for Safety

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

Design of Experiments

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.

Statistical Tools for Quality and Process Analysis

Frequency Distributions and Histograms- Run Charts- Stem-and-Leaf Plots- Pareto Diagrams- Cause and Effect Diagrams (Ishikawa)- Box Plots- Probability Distributions- Statistical Process Control (SPC)- Scatter Diagrams- Multivariable Chart- Matrix Plots and 3D Plots.

Reliability Engineering and Failure Analysis

Reliability Concepts- Survival and Failure Analysis- Series and Parallel System Reliability- Mean Time Between Failures (MTBF)- Weibull Distribution.

Activities Based Learning:

1. Morphology Mapping & Benchmarking Challenge
2. TRIZ-Based Ideation for Innovative Product
3. House of Quality Construction for a New Product
4. Mini Design of Experiments (DOE) on a Simple System
5. FMEA Case Study on a Consumer Product
6. Six Sigma Roleplay: DMAIC in a Manufacturing Scenario
7. Statistical Visualization Lab Using Real Data
8. Reliability Analysis of a Series/Parallel System

(**Note:** Split the activities among the students (Maximum of three/ group) such that all the activities are covered)

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (10%), Assignments (20%), Case Study report (20%), Internal Examinations (50%)

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	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain engineering design principles, quality concepts, and reliability fundamentals	PO1 (3), PO3 (2)	3	2
CO2	Apply design methods, TRIZ, DOE, FMEA, and Six Sigma tools in practical scenarios	PO1 (3), PO2 (3)	3	3
CO3	Estimate product reliability, process performance, and statistical measures for quality analysis	PO1 (3), PO3 (3)	3	3
CO4	Analyze design outcomes, experimental results, and quality metrics for improvement and decision-making	PO3 (3)	3	3

ED25001	Bearing Design and Rotor Dynamics	L	T	P	C
		3	0	0	3

Course Objective:

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.

Classification and Selection of Bearings

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

Design and Performance of Rolling and Journal Bearings

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

Vibration and Instability in Rotating Systems

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

Balancing of Rotors

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

Conditioning Monitoring

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.

Advanced Applications and Integration

Integration of bearing design, balancing, and condition monitoring- Smart bearing technologies- Predictive maintenance using AI/ML- Industry 4.0 in rotary machine health monitoring.

Activities Based Learning:

1. Use an online tool or simulation software to visualize load behavior in different bearing types.nge
2. Calculate dimensions and load-carrying capacity of a pivoted journal bearing.
3. Plot fatigue life vs. load for different rolling bearing types.
4. Apply Rayleigh's method for shaft critical speed using software.
5. Process vibration data from rotor test rigs using FFT.
6. Choose appropriate sensors for balancing flexible rotors in a machine.
7. Analyze real or simulated vibration data to detect fault patterns.
8. Brainstorm potential machine learning models for fault prediction in bearings.
9. Simulate or review an industry's rotary equipment and suggest integration of condition monitoring systems.
10. Design a predictive maintenance plan using vibration sensors and IoT.

*(**Note:** Split the activities among the students (Maximum of three/ group) such that all the activities are covered)*

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (10%), Assignments (15%), Case Study report (15%), Internal Examinations (40%)

Assessment Weightage:

1. Assessment Test 1 – 30%
2. Assessment Test 2 – 30%
3. ABL – 40%

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	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain types, selection, and operating principles of bearings and rotor systems	PO1 (3), PO3 (2)	2	1
CO2	Apply bearing design, rotor balancing, and vibration analysis methods	PO2 (3), PO3 (3)	2	2
CO3	Estimate bearing performance, fatigue life, and critical speeds of rotors	PO1 (3), PO3 (3)	2	2
CO4	Analyze rotor vibrations, instability, and condition monitoring data for fault diagnosis	PO3 (3), PO4 (2)	1	2

CD25C02	Solid Freeform Manufacturing	L	T	P	C
		3	0	0	3

Course Objective:

This course imparts knowledge on the evolution of Solid Freeform Manufacturing (SFM) and the role of Design for Additive Manufacturing (DfAM) in enhancing quality. It covers various SFM technologies and hybrid processes. Emphasis is laid on material science and its influence on manufacturing. Applications across industries like aerospace, automotive, and biomedical are also explored.

Introduction

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.

Design for Additive Manufacturing (DfAM)

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.

Vat Polymerization, Material Extrusion & Sheet Lamination Technologies

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 – MaterialsCapabilities- Limitations and Applications. Ultrasonic Additive Manufacturing (UAM) - Process - Parameters –Capabilities- Applications. Case Studies.

Powder Bed Fusion, Binder Jetting, Material Jetting

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 Technologies

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.

Materials and Applications Of SFM

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.

Activities Based Learning:

1. Use an online tool or simulation software to visualize load behavior in different bearing types.nge
2. Calculate dimensions and load-carrying capacity of a pivoted journal bearing.
3. Plot fatigue life vs. load for different rolling bearing types.
4. Apply Rayleigh’s method for shaft critical speed using MATLAB.
5. Process vibration data from rotor test rigs using FFT.
6. Choose appropriate sensors for balancing flexible rotors in a machine.
7. Analyze real or simulated vibration data to detect fault patterns.
8. Brainstorm potential machine learning models for fault prediction in bearings.
9. Simulate or review an industry’s rotary equipment and suggest integration of condition monitoring systems.
10. Design a predictive maintenance plan using vibration sensors and IoT.

*(**Note:** Split the activities among the students (Maximum of three/ group) such that all the activities are covered)*

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology:

Poster Presentation - 10%
Assignment – 20%
Report preparation for Case Study – 20%
Internal Examinations – 50%

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. ISBN978- 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	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain SFM evolution, DfAM concepts, AM technologies, materials, and applications	PO1 (3), PO3 (2)	3	2
CO2	Apply DfAM guidelines, CAD modeling, process planning, and SFM techniques to design and simulate parts	PO1 (3), PO2 (3)	3	3
CO3	Estimate process parameters, part quality, material behavior, and load/fatigue in AM components	PO1 (3), PO3 (3)	3	3
CO4	Analyze SFM processes, hybrid techniques, material applications, and simulation/monitoring data for optimization	PO3 (3)	3	3

CD25C03	Product Lifecycle Management	L	T	P	C
		3	0	0	3

Course Objective:

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

Introduction to PLM

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.

PLM Environment: Business Process and Product Data

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- 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.

PLM Environment: Information Systems

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.

PLM Environment: Project Management

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.

Activities Based Learning:

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.

*(**Note:** Split the activities among the students (Maximum of three/ group) such that all the activities are covered)*

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology:

Poster Presentation - 10%

Assignment – 20%

Report preparation for Case Study – 20%

Internal Examinations – 50%

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	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain PLM concepts, paradigms, benefits, business processes, and PLM environment	PO1 (3), PO3 (2)	3	2
CO2	Apply PLM software tools for CAD parts, specifications, and engineering BOM creation	PO1 (3), PO2 (3)	3	3
CO3	Estimate product data requirements, project timelines, and process efficiency in PLM initiatives	PO1 (3), PO3 (3)	3	3
CO4	Analyze PLM processes, project management activities, and database queries for optimization and decision-making	PO3 (3)	3	3

ED25C14	Design of Hydraulic and Pneumatic Systems	L	T	P	C
		3	0	0	3

Course Objective:

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.

Fluid Power Principles and Hydraulic Pumps

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.

Hydraulic Actuators and Control Components

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 selectionApplications – Fluid Power ANSI Symbols – Problems.

Hydraulic Circuits and Systems

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.

Pneumatic Systems

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.

Electro Pneumatic Systems

Electro Pneumatic System – Elements – Relay ladder diagram – timer circuits – Problems, PLC – Logic ladder diagram – Controlling Fluid power actuators.

Trouble Shooting and Applications

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.

Activities Based Learning:

1. Hands-on experiment or simulation to demonstrate pressure transmission and mechanical advantage using Pascal's principle.
2. Disassemble or simulate various hydraulic actuators to understand internal construction and function.
3. Teams troubleshoot faulty hydraulic circuits presented via simulation or physical trainer kits.
4. Create pneumatic circuits for a given task using single/multi-cylinder setups.
5. Students sketch and explain a low-cost pneumatic/hydraulic system for a given industrial task.
6. Students build or simulate a small working model integrating hydraulic and pneumatic components.
7. Final presentation and demonstration of integrated system with documented learning outcomes.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (10%), Assignments (20%), Case Study report (20%), Internal Examinations (50%)

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	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain fundamental principles of fluid power, hydraulic and pneumatic systems	PO1 (1), PO2 (1)	1	1
CO2	Apply hydraulic and pneumatic components, circuits, and electro-pneumatic systems	PO2 (2), PO3 (2)	2	2
CO3	Estimate system performance, sizing, and selection of pumps, actuators, and valves	PO3 (2), PO4 (2)	2	2
CO4	Analyze hydraulic/pneumatic circuits, troubleshoot faults, and optimize designs	PO4 (2), PO5 (1)	2	1

ED25C15	Mechanical Measurements and Analysis	L	T	P	C
		3	0	0	3

Course Objective:

This course equips students with fundamental knowledge of force and strain measurement techniques. It enables understanding of vibration measurement and its practical applications. Students will learn the basics of acoustics and wind flow measurements. The course also covers methods of distress measurement in materials and structures. Finally, it introduces principles and applications of non-destructive testing for evaluating component integrity.

Forces and Strain Measurement

Strain gauge, Rosette, 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.

Vibration Measurements

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

Acoustics, Wind Flow and Distress Measurements

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

Non Destructive Testing Methods

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.

Activities Based Learning:

1. Strain Gauge Calibration and Load Testing
2. Photoelasticity Demonstration with a Model Under Load
3. Vibration Measurement Using LVDT and Accelerometers
4. Signal Visualization with CRO and Data Acquisition System
5. Performance Testing of Vibration Meters and Seismographs

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (10%), Assignments (15%), Case Study report

(15%), Internal Examinations (40%)

References:

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. Srinath LS, Raghavan Mr, Lingaiah K, Gargesha G, Pant B and Ramachandra, K," Experimental Stress Analysis", Tata McGraw Hill Company, New Delhi, 1984
6. Sirohi, R.S.and Radha krishna, H.C, "Mechanical Measurements", New Age International (P) Ltd, 3rd Edition 1997

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain principles of force, strain, vibration, acoustics, flow, and NDT measurement techniques	PO1 (3), PO3 (2)	3	2
CO2	Apply measurement instruments and experimental techniques for force, vibration, and NDT evaluation	PO1 (3), PO2 (3)	3	3
CO3	Estimate stresses, vibration parameters, flow characteristics, and structural distress levels	PO1 (3), PO3 (3)	3	3
CO4	Analyze measured data to assess structural integrity, damage, and component performance	PO3 (3)	3	3

ED25C16	Surface Engineering	L	T	P	C
		3	0	0	3

Course Objective:

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.

Friction, Wear and Lubrication

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.

Corrosion

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.

Surface Treatments and Engineering Materials

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

Surface Measuring Instruments

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.

Activities Based Learning:

1. Experiment to Measure Friction Coefficients for Different Material Pairs

2. Study on Corrosion Prevention by Coatings and Inhibitors
3. Case Study Analysis on Application of Titanium and Nickel-based Alloys
4. AFM/STM Observation of Nano-Scale Surface Features
5. Tribometer Use for Friction and Wear Characterization

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (10%), Assignments (20%), Case Study report (20%), Internal Examinations (50%)

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	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain principles of friction, wear, corrosion, surface treatments, and surface characterization techniques	PO1 (3), PO3 (2)	3	2
CO2	Apply surface engineering methods, corrosion prevention techniques, and surface measurement instruments	PO1 (3), PO2 (3)	3	3
CO3	Estimate friction coefficients, wear rates, corrosion behavior, and surface property parameters	PO1 (3), PO3 (3)	3	3
CO4	Analyze surface failures, coating performance, and material behavior to solve industrial problems	PO3 (3)	3	3

ED25002	Computer Graphics	L	T	P	C
		3	0	0	3

Course Objective:

The primary objective of this course is to equip students with a comprehensive understanding of computer graphics principles, algorithms, and modeling techniques essential for engineering applications. The course aims to build foundational knowledge in 2D and 3D graphics, scan-conversion algorithms, and geometric transformations. It develops the ability to model curves, surfaces, and solids using analytical and synthetic methods, including advanced tools such as NURBS. Students will gain proficiency in visibility determination and rendering techniques to simulate realistic graphics. Additionally, the course introduces concepts of assembly modeling, tolerance analysis, and product lifecycle management to integrate design, simulation, and visualization skills relevant to modern computer-aided design environments.

Fundamentals of Computer Graphics and Scan Conversion

Introduction to Computer Graphics, Scan-conversion of Lines: Digital Differential Analyzer (DDA) Algorithm, Bresenham's Line Drawing Algorithm, Scan-conversion of Circles and Ellipses: Bresenham's Circle Drawing Method, Midpoint Circle Algorithm, Drawing Ellipses and Other Conics

2D and 3D Transformations and Clipping

Introduction to 2D and 3D Transformations, Transformation Matrix, 2D Transformations: Identity, Scaling, Rotation, Translation, Reflection, Shear, Rotation about Arbitrary Point, Combined Transformations. Clipping Techniques: 2D Clipping: Point, Line, Polygon Clipping, 3D Viewing and Clipping, Text Clipping

Curve and Surface Modeling

Introduction to Curves: Analytical Curves: Line, Circle, Conics, Synthetic Curves: Hermite Cubic Spline, Bézier Curve, B-Spline Curve, Curve Manipulations, Introduction to Surfaces: Analytical Surfaces: Plane, Ruled, Revolution, Tabulated Cylinder, Synthetic Surfaces: Hermite Bicubic, Bézier, B-Spline, Surface Manipulations

NURBS and Solid Modeling Techniques

NURBS Basics: Curves, Lines, Arcs, Circle, Bilinear Surface, Solid Modeling Techniques: Regularized Boolean Set Operations, Primitive Instancing, Sweep Representations, Boundary Representations, Constructive Solid Geometry (CSG) Comparison of Solid Representations, User Interface for Solid Modeling

Visibility, Rendering, and Shading Techniques

Visible and Hidden Surface Removal: Coherence, Bounding Volumes, Back Face Culling, Painter's Algorithm, Z-Buffer, Floating Horizon, Roberts Algorithm, Object Rendering: Lighting and Illumination Models, Shading Techniques: Flat, Gouraud, Phong, Polygon Mesh Shading, Advanced Effects: Transparency, Shadows, Texture Ray Tracing, Ray Casting, Radiosity, Color Models

Assembly Modeling and Product Lifecycle

Assembly of Parts: Design for Manufacture (DFM), Design for Assembly (DFA), Computer-Aided DFMA, Position & Orientation Inferences, Tolerance Analysis, Center of Gravity & Mass Property Calculation, Mechanism Simulation, Product Lifecycle Management (PLM): Product Development and Management, Models for New Product Development, Graphics & Computing Standards, Data Exchange Standards

Activities Based Learning exercises:

1. **Manual Implementation of Bresenham's Line and Circle Algorithms**
   Plot pixels on graph paper and replicate the same using code; observe the difference in pixel placement and accuracy.
2. **Hands-on 2D Transformations Using Paper Cutouts**
   Physically perform translation, rotation, scaling, reflection, and clipping on shape cutouts to understand transformation matrices.
3. **Sketching and Interpreting Bézier Curves**
   Manually construct Bézier curves using control points and then compare results with simulation software.
4. **Solid Modeling Using CAD Tools**
   Design simple components by applying Boolean operations and sweep features to reinforce constructive solid geometry concepts**.**
5. **Shadow and Visibility Demonstration Using 3D Block Models**
   Use a torchlight on physical models to simulate surface visibility, shading, and hidden surface removal principles.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (10%), Assignments (15%), Case Study report (15%), Internal Examinations (40%)

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	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain fundamentals of computer graphics, scan-conversion, 2D/3D transformations, and visibility techniques	PO1 (3), PO3 (2)	1	1
CO2	Apply graphics algorithms, curve/surface modeling, solid modeling, and assembly modeling using CAD tools	PO2 (3), PO3 (3)	2	2
CO3	Estimate errors in scan conversion, curve approximations, and tolerance calculations in assembly models	PO3 (3), PO4 (2)	1	2
CO4	Analyze complex graphics systems, rendering techniques, and PLM integration for realistic simulations	PO4 (3), PO5 (2)	2	2

ED25C17	Vehicle Dynamics	L	T	P	C
		3	0	0	3

Course Objective:

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.

Tyre Mechanics

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

Steering and Vertical Dynamics

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- 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, HInfinite, Skyhook damping.

Longitudinal Dynamics and Control

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.

Lateral Dynamics

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.

Activities Based Learning:

1. Simulation of Tractive and Cornering Forces using Magic Formula Model
2. Wet Surface Performance Comparison of Tyres
3. Modeling a Quarter-Car Suspension System in MATLAB/Simulink
4. ABS and Traction Control Simulation
5. Influence of Suspension Geometry on Cornering using CAD and Motion Study

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (10%), Assignments (20%), Case Study report (20%), Internal Examinations (50%)

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	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain fundamentals of tyre mechanics, steering, suspension, and vehicle dynamics	PO1 (1), PO3 (1)	1	1
CO2	Apply vehicle dynamics principles and modeling techniques for tyre forces, suspension, and control systems	PO2 (2), PO3 (2)	2	2
CO3	Estimate performance parameters like rolling resistance, cornering forces, braking distance, and stability margins	PO3 (1), PO4 (2)	1	2
CO4	Analyze lateral, longitudinal, and vertical vehicle dynamics under different operating and control conditions	PO4 (2), PO5 (2)	2	2

ED25003	Advanced Finite Element Analysis	L	T	P	C
		3	0	0	3

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

BENDING OF PLATES AND SHELLS
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.

NON-LINEAR PROBLEMS
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.

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

FLUID MECHANICS, HEAT TRANSFER AND ERROR ESTIMATES
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 - Error norms and Convergence rates – h-refinement with adaptivity – Adaptive refinement.

Activities Based Learning:
1. Hands-on Finite Element analysis of a Thin Plate using FEA software.
2. Simulation of Metal Forming Process
3. Vibration Analysis using FEA software.
4. Comparative Study of Explicit vs. Implicit Integration Methods
5. CFD Simulation of Incompressible Flow Through a Pipe using FEA software.
6. Heat Transfer Simulation in a Fin and Plate using FEA software.
7. Error Estimation and h-Refinement Study
8. Non-Newtonian Flow Modeling in Polymer Forming

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (10%), Assignments (15%), Case Study report (15%), Internal Examinations (40%)

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	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain fundamentals of bending of plates/shells, non-linear problems, and dynamic & fluid-thermal analysis	PO1 (3), PO3 (2)	1	1
CO2	Apply FEA/CFD techniques for plates, shells, metal forming, vibrations, and flow problems	PO2 (3), PO3 (3)	2	2
CO3	Estimate errors, convergence rates, and refine solutions using adaptive techniques	PO3 (3), PO4 (2)	1	2
CO4	Analyze dynamic, thermal, and fluid-structure interaction problems using simulation tools	PO4 (3), PO5 (2)	2	2

ED25C18	Advanced Machine Tool Design	L	T	P	C
		3	0	0	3

Course Objective:

To impart knowledge on the fundamental principles of machine tool design including drive mechanisms, structural elements, guideways, and spindles; to enable students to design machine tool components for strength, rigidity, precision, and dynamic stability; and to prepare them to address practical challenges in the development and optimization of modern machine tools.

Machine Tool Fundamentals and Drive Systems

Introduction to machine tool design – Machine tool drives and mechanisms – Constructional and operational features – Auxiliary motions in machine tools – Kinematics of machine tools – Motion transmission systems – Mechanical, hydraulic, and electric drives – Speed and feed regulation – Objectives of regulation – Layout of speed change gears – Stepped speed regulation – Multiple speed motors – Ray diagrams – Design considerations – Speed gearbox design – Feed drive mechanisms – Feed box design.

Design of Structural Elements and Guideways

Functions and requirements of machine tool structures – Design for strength and rigidity – Materials used – Static and dynamic stiffness – Constructional features: beds, housings, columns, tables, saddles, and carriages – Types and functions of guideways – Design of slideways – Clearance adjustment – Aerostatic slideways – Anti-friction and combination guideways – Power screw design – Recirculating ball screws.

Spindle Design and Dynamic Analysis

Functions and requirements of spindles – Effect of machine compliance on machining accuracy – Design of spindles and anti-friction bearings – Dynamics of machine tools – Elastic system of machine tools – Static and dynamic stiffness – Machine vibrations and their effects – Stability analysis.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (10%), Assignments (15%), Case Study report (15%), Internal Examinations (40%)

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	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain machine tool design fundamentals and components	PO1 (3), PO3 (2)	3	2
CO2	Apply design methods for drives, structures, guideways, and spindles	PO1 (3), PO2 (3)	3	3
CO3	Estimate strength, stiffness, speed, and feed parameters	PO1 (3), PO3 (3)	3	3
CO4	Analyze vibration, stability, and dynamic performance of machine tools	PO3 (3)	3	3

ED25C19	Material Handling Systems and Design	L	T	P	C
		3	0	0	3

Course Objective:

To enable students to understand, analyze, and design various material handling equipment such as hoists, conveyors, elevators, and integrated mechanical systems, with emphasis on functional requirements, safety, and performance. The course aims to develop the skills necessary for selecting suitable components, optimizing mechanical configurations, and designing reliable systems for industrial applications.

Hoisting Equipment Design

Types, selection and applications of hoisting systems – 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 – Hand and power drives – Traveling gear – Rail traveling mechanisms – Cantilever and monorail cranes – Slewing, jib and luffing gear – Cogwheel drive – Selection of motor ratings.

Conveyors and Elevators

Types, description, design and applications of belt conveyors, apron conveyors, escalators – Pneumatic conveyors – Screw conveyors – Vibratory conveyors – Bucket elevators: design, loading and bucket arrangements – Cage elevators – Shaftway – Guides – Counterweights – Hoisting machine – Safety devices.

Integrated Mechanical System Design

Integrated design of mechanical handling systems and special-purpose equipment – Design of valve gear mechanisms – Portable air compressors – Hay bale lifters – Cam testing machines – Gearbox design with more than six speed stages.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (10%), Assignments (20%), Case Study report (20%), Internal Examinations (50%)

Reference:

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.

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Understand and explain types, selection criteria, and operational principles of hoists, conveyors, and elevators	PO1 (1), PO2 (1)	1	1
CO2	Design hoisting elements, conveyor systems, and elevators with attention to load, safety, and performance	PO2 (2), PO3 (2)	2	2
CO3	Calculate and estimate mechanical parameters, motor ratings, and load distributions for material handling equipment	PO3 (1), PO4 (2)	1	2
CO4	Evaluate and analyze integrated mechanical systems for efficiency, reliability, and safety	PO4 (2), PO5 (2)	2	2

ED25C20	Creativity and Innovation Management	L	T	P	C
		3	0	0	3

Course Objective:

To equip students with a comprehensive understanding of creativity and innovation principles, methods, and tools, and to develop their ability to apply creative thinking and innovative problem-solving strategies in engineering and organizational contexts. The course also aims to cultivate skills for managing innovation, fostering a creative mindset, and transforming ideas into practical and valuable outcomes.

Creativity Theory and Heuristics

Directed creativity – Five mental actions in creativity – Factors driving creativity and innovation – Challenges in innovation – Quality management and creativity – Definition of creativity and innovation with practical examples – Mechanics of mind: perception, memory, and judgment – Amabile's seven heuristics – Perkin's ten heuristics – Plsek's eight heuristics – Model of directed creativity process.

Creativity Tools and Applications

Creative thinking tools: trans-disciplinary analogy, stepping stones, dreamscape, manipulative verbs – Principles: attention, escape, movement – Tools for preparation, imagination, and action phases – Harvesting ideas – Idea enhancement checklist – Documenting ideas – Eight steps to organizational transformation – ICEDIP model – Norman's emotional design: visceral, behavioral, reflective – Applications in process design, customer needs analysis, and product/service design – Symptoms of stuck thinking – Creative problem-solving techniques.

Innovation Principles and Inventive Problem Solving

Routine and inventive problems – Difficulty and psychological inertia – Creativity activation methods: checklists, morphological box, questionnaires – Decision aids and problem-solving tools – Requirements for inventive problem solving – Qualities of solvers of non-routine problems – Altshuller's engineering parameters, inventive principles, and contradiction matrix algorithm – Seven tools in creative problem solving and incremental improvement.

Innovation Management and Strategy

Disruptive innovation model – Case study: minimills vs integrated steel companies – New-market and low-end disruptions – Three litmus tests – Approaches to creating new-growth businesses – Product architectures and integration – Commoditization and de-commoditization – Strategy formulation processes – Role of senior executives in leading innovation and new business growth.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (10%), Assignments (20%), Case Study report (20%), Internal Examinations (50%)

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	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain creativity theories, heuristics, and innovation principles	PO1 (1)	1	1
CO2	Apply creative thinking tools and inventive problem-solving methods	PO1 (2), PO2 (2)	2	2
CO3	Analyze engineering and organizational problems using innovation frameworks	PO2 (2), PO3 (2)	2	2
CO4	Evaluate innovation strategies and manage creative initiatives for value creation	PO3 (2), PO4 (1)	2	1