

**ANNA UNIVERSITY, CHENNAI**  
**AFFILIATED INSTITUTIONS**  
**M.E. ENGINEERING DESIGN**  
**REGULATIONS 2017**  
**CHOICE BASED CREDIT SYSTEM**

**PROGRAMME EDUCATIONAL OBJECTIVES (PEOs) :**

Enable the students :

- I. To develop an aptitude to use fundamental engineering principles to conceptualize, create, model, test and evaluate designs within the context of local and global needs.
- II. To understand and explore the behaviour of existing and new materials suitable for the design needs.
- III. To develop innovative technologies and find solutions to contemporary issues in Engineering Design using modern engineering tools and methods.
- IV. To pursue advanced education, research and development and other creative/ innovative efforts in their professional career.

**PROGRAMME OUTCOMES (POs):**

On successful completion of the programme,

1. Graduates will demonstrate knowledge of mathematics, science and engineering.
2. Graduates will demonstrate an ability to design a system, component or process as per needs and specifications.
3. Graduates will have the ability to use the computer aided design tools to design a component or system.
4. Graduate will demonstrate an ability to design and conduct experiments, analyze, interpret, and validate data in the area of design engineering.
5. Graduate will demonstrate skills to use modern engineering tools, software and equipment to analyze multidisciplinary problems.
6. Graduate will have the knowledge of material behaviour under various circumstances exist which can be utilize for the material selection process
7. Graduate will have the knowledge of mechanisms behaviour and its design by analytical method and using software tools.
8. Graduates will demonstrate knowledge of professional and ethical responsibilities in the field of mechanical design.
9. Graduate will communicate their technical knowledge.
10. Graduate will develop confidence for self-education and ability for life-long learning and research.

### Mapping of PEOs with POs

Programme Educational Objectives	Programme Outcomes								
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
I		√	√	√	√	√		√	
II		√	√	√	√	√	√	√	
III	√	√	√	√	√		√	√	√
IV		√		√	√			√	√

		<b>Subjects</b>	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>
<b>YEAR 1</b>	<b>SEM 1</b>	Engineering Fracture Mechanics	√	√	√	√					√
		Computer Applications in Design	√	√	√		√				
		Quality Concepts in Design			√			√		√	√
		Applied Mathematics for Engineers	√		√					√	√
		Advanced Finite Element Analysis	√	√	√		√			√	√
		Professional Elective I									
		CAD Laboratory			√		√		√	√	√
		Advanced Analysis and Simulation Laboratory			√		√		√	√	√
	<b>SEM 2</b>	Mechanical Behavior of Materials				√		√		√	√
		Integrated Mechanical Design	√	√	√	√	√			√	
		Vibration Analysis and Control	√	√	√	√	√			√	√
		Mechanisms Design and Simulation	√	√	√	√	√			√	
		Professional Elective I									
		Professional Elective II									
Vibration Laboratory			√	√				√	√		
Design Project		√	√	√	√	√	√	√	√	√	
<b>YEAR 2</b>	<b>SEM 3</b>	Product Lifecycle Management	√	√	√	√	√			√	
		Professional Elective III									
		Professional Elective IV									
		Project Work Phase I	√	√	√	√	√	√	√	√	√
	<b>SEM 4</b>	Project Work Phase II	√	√	√	√	√	√	√	√	√

## Professional Electives

ELECTIVES	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
<b>SEMESTER I</b>									
Additive Manufacturing and Tooling			√		√			√	√
Design of Material Handling Equipments	√			√				√	√
Optimization Techniques in Design	√			√				√	√
Design of Pressure Vessels and Piping	√			√					√
Information Analytics	√			√				√	√
<b>SEMESTER II</b>									
Advanced Metal Forming Techniques Plates and shell		√						√	√
Surface Engineering	√			√	√			√	√
Tribology in Design			√	√				√	√
Modal Analysis of Mechanical Systems	√	√	√	√	√			√	
Advanced Mechanics of Materials	√			√					√
<b>SEMESTER III</b>									
Bearing Design and Rotor Dynamics	√	√	√	√					
Composite Materials and Mechanics	√	√	√	√	√			√	√
Design for Manufacture, Assembly and Environments		√	√	√	√			√	√
Design of Hydraulic and Pneumatic systems			√	√				√	√
Computational Fluid Dynamics	√	√	√	√	√			√	√
Biomechanics									
Design for Internet of Things									
Product Design for Sustainability	√	√	√	√	√			√	√

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**CHOICE BASED CREDIT SYSTEM**  
**I TO IV SEMESTERS (FULL TIME) CURRICULUM AND SYLLABUS**

**SEMESTER I**

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
<b>THEORY</b>								
1.	MA5156	Applied Mathematics for Engineers	FC	4	4	0	0	4
2.	ED5191	Engineering Fracture Mechanics	PC	3	3	0	0	3
3.	ED5151	Computer Applications in Design	PC	3	3	0	0	3
4.	ED5152	Quality Concepts in Design	PC	3	3	0	0	3
5.	ED5153	Advanced Finite Element Analysis	PC	3	3	0	0	3
6.		Professional Elective I	PE	3	3	0	0	3
<b>PRACTICAL</b>								
7.	ED5161	CAD Laboratory	PC	4	0	0	4	2
8.	ED5162	Advanced Analysis and Simulation Laboratory	PC	4	0	0	4	2
<b>TOTAL</b>				<b>27</b>	<b>19</b>	<b>0</b>	<b>8</b>	<b>23</b>

**SEMESTER II**

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
<b>THEORY</b>								
1.	ED5251	Mechanisms Design and Simulation	PC	3	3	0	0	3
2.	ED5252	Mechanical Behavior of Materials	PC	3	3	0	0	3
3.	ED5253	Integrated Mechanical Design	PC	3	3	0	0	3
4.	ED5254	Vibration Analysis and Control	PC	3	3	0	0	3
5.		Professional Elective II	PE	3	3	0	0	3
6.		Professional Elective III	PE	3	3	0	0	3
<b>PRACTICAL</b>								
7.	ED5261	Vibration Laboratory	PC	2	0	0	2	1
8.	ED5211	Design Project	EEC	4	0	0	4	2
<b>TOTAL</b>				<b>24</b>	<b>18</b>	<b>0</b>	<b>6</b>	<b>21</b>

**SEMESTER III**

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
<b>THEORY</b>								
1.	PD5091	Product Lifecycle Management	PC	3	3	0	0	3
2.		Elective IV	PE	3	3	0	0	3
3.		Elective V	PE	3	3	0	0	3
<b>PRACTICAL</b>								
4.	ED5311	Project Work Phase I	EEC	12	0	0	12	6
<b>TOTAL</b>				<b>21</b>	<b>9</b>	<b>0</b>	<b>12</b>	<b>15</b>

**SEMESTER IV**

<b>SL. NO</b>	<b>COURSE CODE</b>	<b>COURSE TITLE</b>	<b>CATEGORY</b>	<b>CONTACT PERIODS</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>PRACTICAL</b>								
1.	ED5411	Project Work Phase II	EEC	24	0	0	24	12
<b>TOTAL</b>				<b>24</b>	<b>0</b>	<b>0</b>	<b>24</b>	<b>12</b>

**TOTAL CREDITS TO BE EARNED FOR THE AWARD OF THE DEGREE = 71**

**FOUNDATION COURSES (FC)**

<b>SL. NO.</b>	<b>COURSE CODE</b>	<b>COURSE TITLE</b>	<b>CATEGORY</b>	<b>CONTACT PERIODS</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
1.	MA5156	Applied Mathematics for Engineers	FC	4	4	0	0	4

**PROFESSIONAL CORE (PC)**

<b>SL. NO.</b>	<b>COURSE CODE</b>	<b>COURSE TITLE</b>	<b>CATEGORY</b>	<b>CONTACT PERIODS</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
1.	ED5191	Engineering Fracture Mechanics	PC	3	3	0	0	3
2.	ED5151	Computer Applications in Design	PC	3	3	0	0	3
3.	ED5152	Quality Concepts in Design	PC	3	3	0	0	3
4.	ED5153	Advanced Finite Element Analysis	PC	3	3	0	0	3
5.	ED5161	CAD Laboratory	PC	4	0	0	4	2
6.	ED5162	Advanced Analysis and Simulation Laboratory	PC	4	0	0	4	2
7.	ED5251	Mechanisms Design and Simulation	PC	3	3	0	0	3
8.	ED5252	Mechanical Behavior of Materials	PC	3	3	0	0	3
9.	ED5253	Integrated Mechanical Design	PC	4	3	0	0	3
10.	ED5254	Vibration Analysis and Control	PC	3	3	0	0	3
11.	ED5261	Vibration Laboratory	PC	2	0	0	2	1
12.	PD5091	Product Lifecycle Management	PC	3	3	0	0	3

**LIST OF ELECTIVES FOR M.E. ENGINEERING DESIGN****SEMESTER I (Elective I)**

SL. NO	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	ED5071	Optimization Techniques in Design	PE	3	3	0	0	3
2.	ED5072	Design of Pressure Vessel and Piping	PE	3	3	0	0	3
3.	ED5091	Design of Material Handling Equipments	PE	3	3	0	0	3
4.	CC5292	Additive Manufacturing and Tooling	PE	3	3	0	0	3
5.	ED5073	Information Analytics	PE	3	3	0	0	3

**SEMESTER II (Elective II & III)**

SL. NO	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	ED5001	Plates and Shells	PE	3	3	0	0	3
2.	ED5002	Modal Analysis of Mechanical Systems	PE	3	3	0	0	3
3.	ED5003	Advanced Metal Forming Techniques	PE	3	3	0	0	3
4.	ED5074	Tribology in Design	PE	3	3	0	0	3
5.	ED5004	Surface Engineering	PE	3	3	0	0	3
6.	ED5092	Advanced Mechanics of Materials	PE	3	3	0	0	3

**SEMESTER III (Elective IV & V)**

SL. NO	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	ED5075	Design for Internet of Things	PE	3	3	0	0	3
2.	ED5005	Design of Hydraulic and Pneumatic Systems	PE	3	3	0	0	3
3.	ED5006	Bearing Design and Rotor Dynamics	PE	3	3	0	0	3
4.	ED5076	Product Design for Sustainability	PE	3	3	0	0	3
5.	ED5093	Computational Fluid Dynamics	PE	3	3	0	0	3
6.	CC5291	Design for Manufacture, Assembly and Environments	PE	3	3	0	0	3
7.	ED5077	Biomechanics	PE	3	3	0	0	3
8.	ED5078	Composite Materials and Mechanics	PE	3	3	0	0	3



**EMPLOYABILITY ENHANCEMENT COURSES (EEC)**

<b>SL. NO.</b>	<b>COURSE CODE</b>	<b>COURSE TITLE</b>	<b>CATEGORY</b>	<b>CONTACT PERIODS</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
1.	ED5211	Design Project	EEC	4	0	0	4	2
2.	ED5311	Project Work Phase I	EEC	12	0	0	12	6
3.	ED5411	Project Work Phase II	EEC	24	0	0	24	12

**OBJECTIVES :**

This course is designed to enrich the knowledge in various advanced mathematical techniques such as matrix theory, calculus of variations, probability and random variables, Laplace transforms and Fourier transforms. The fundamental concepts in these areas will be more useful for the students to model the engineering problems and solving them by applying these methods.

**UNIT I MATRIX THEORY****12**

The Cholesky decomposition - Generalized Eigenvectors - Canonical basis - QR factorization - Least squares method - Singular value decomposition.

**UNIT II CALCULUS OF VARIATIONS****12**

Concept of variation and its properties – Euler’s equation – Functional dependant on first and higher order derivatives – Functionals dependant on functions of several independent variables – Variational problems with moving boundaries – Isoperimetric problems - Direct methods : Ritz and Kantorovich methods.

**UNIT III PROBABILITY AND RANDOM VARIABLES****12**

Probability – Axioms of probability – Conditional probability – Baye’s theorem - Random variables - Probability function – Moments – Moment generating functions and their properties – Binomial, Poisson, Geometric, Uniform, Exponential, Gamma and Normal distributions – Function of a random variable.

**UNIT IV LAPLACE TRANSFORM TECHNIQUES FOR PARTIAL DIFFERENTIAL EQUATIONS****12**

Laplace transform - Definitions - Properties – Transform error function - Bessel’s function - Dirac delta function - Unit step functions – Convolution theorem – Inverse Laplace transform : Complex inversion formula – Solutions to partial differential equations : Heat equation - Wave equation.

**UNIT V FOURIER TRANSFORM TECHNIQUES FOR PARTIAL DIFFERENTIAL EQUATIONS****12**

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 Poisson’s equations.

**TOTAL : 60 PERIODS****OUTCOMES :**

After completing this course, students should demonstrate competency in the following skills:

- Apply various methods in matrix theory to solve system of linear equations.
- Maximizing and minimizing the functional that occur in various branches of engineering disciplines.
- Computation of probability and moments, standard distributions of discrete and continuous random variables and functions of a random variable.
- Application of Laplace and Fourier transforms to initial value, initial–boundary value and boundary value problems in Partial Differential Equations.

**REFERENCES :**

1. Andrews L.C. and Shivamoggi, B. "Integral Transforms for Engineers", Prentice Hall of India Pvt. Ltd., New Delhi, 2003.
2. Bronson, R. "Matrix Operations", Schaum’s outline series, 2<sup>nd</sup> Edition, McGraw Hill, 2011.
3. James, G., "Advanced Modern Engineering Mathematics ", 3<sup>rd</sup> Edition, Pearson Education, 2004.
4. Johnson, R.A., Miller, I and Freund J., "Miller and Freund’s Probability and Statistics for Engineers", Pearson Education, Asia, 8<sup>th</sup> Edition, 2015.
5. O’Neil, P.V., "Advanced Engineering Mathematics ", Thomson Asia Pvt. Ltd., Singapore, 2003.
6. Sankara Rao, K., "Introduction to Partial Differential Equations", Prentice Hall of India Pvt. Ltd., New Delhi, 1997.

**OBJECTIVE:**

- To impart knowledge on mechanics of cracked components of different modes by which these components fail under static load conditions.
- To impart knowledge on mechanics of cracked components of different modes by which these components fail under fatigue load conditions.

**UNIT I ELEMENTS OF SOLID MECHANICS 9**

The geometry of stress and strain, elastic deformation, plastic and elasto-plastic deformation – limit analysis – Airy’s function – field equation for stress intensity factor.

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

Two dimensional elastic fields – Analytical solutions yielding near a crack front – Irwin’s approximation - plastic zone size – Dugdale model – determination of J integral and its relation to crack opening displacement.

**UNIT III ENERGY BALANCE AND CRACK GROWTH 9**

Griffith analysis – stable and unstable crack growth –Dynamic energy balance – crack arrest mechanism –K1c test methods - R curves - determination of collapse load.

**UNIT IV FATIGUE CRACK GROWTH CURVE 9**

Empirical relation describing crack growth law – life calculations for a given load amplitude – effects of changing the load spectrum -- rain flow method– external factors affecting the K1c values.- leak before break analysis.

**UNIT V APPLICATIONS OF FRACTURE MECHANICS 9**

Crack Initiation under large scale yielding – thickness as a design parameter – mixed mode fractures - crack instability in thermal and residual stress fields - numerical methods

**TOTAL: 45 PERIODS****OUTCOME:**

- It helps the engineers to get familiarized with the design of components that contain crack under static load condition.
- It helps the engineers to get familiarized with the design of components that contain crack and its growth under fatigue load condition.

**REFERENCES:**

1. David Broek, "Elementary Engineering Fracture Mechanics ", Fiffthoff and Noerdhoff International Publisher, 1978.
2. John M.Barson and Stanely T.Rolfe Fatigue and fracture control in structures Prentice hall Inc. Englewood cliffs. 1977
3. Kare Hellan, "Introduction of Fracture Mechanics", McGraw-Hill Book Company, 1985.
4. Preshant Kumar, "Elements of Fracture Mechanics", Wheeler Publishing, 1999.
5. Tribikram Kundu, "Fundamentals of Fracture Mechanics", Ane Books Pvt. Ltd. New Delhi/ CRC Press, 1st Indian Reprint, 2012

**OBJECTIVE:**

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

**UNIT I INTRODUCTION TO COMPUTER GRAPHICS FUNDAMENTALS 9**

Output primitives (points, lines, curves etc.), 2-D & 3-D transformation (Translation, scaling, rotation) windowing - view ports - clipping transformation.

**UNIT II CURVES AND SURFACES MODELLING 9**

Introduction to curves - Analytical curves: line, circle and conics – synthetic curves: Hermite cubic spline- Bezier curve and B-Spline curve – curve manipulations.

Introduction to surfaces - Analytical surfaces: Plane surface, ruled surface, surface of revolution and tabulated cylinder – synthetic surfaces: Hermite bicubic surface- Bezier surface and B-Spline surface- surface manipulations.

**UNIT III NURBS AND SOLID MODELING 9**

NURBS- Basics- curves, lines, arcs, circle and bi linear surface. Regularized Boolean set operations - primitive instancing - sweep representations - boundary representations – constructive solid Geometry - comparison of representations - user interface for solid modeling.

**UNIT IV VISUAL REALISM 9**

Hidden – Line – Surface – solid removal algorithms shading – coloring. Introduction to parametric and variational geometry based software's and their principles creation of prismatic and lofted parts using these packages.

**UNIT V ASSEMBLY OF PARTS AND PRODUCT DATA EXCHANGE 9**

Assembly modeling - interferences of positions and orientation - tolerances analysis – mass property calculations - mechanism simulation.

Graphics and computing standards– Open GL Data Exchange standards – IGES, STEP etc– Communication standards.

**TOTAL : 45 PERIODS****OUTCOMES:**

- It helps the students to get familiarized with the computer graphics application in design.
- This understanding reinforces the knowledge being learned and shortens the overall learning curve which is necessary to solve CAE problems that arise in engineering.

**REFERENCES:**

- David F. Rogers, James Alan Adams “Mathematical elements for computer graphics” second edition, Tata McGraw-Hill edition.2003
- Donald Hearn and M. Pauline Baker “Computer Graphics”, Prentice Hall, Inc., 1992.
- Foley, Wan Dam, Feiner and Hughes – Computer graphics principles & practices, Pearson Education – 2003.
- Ibrahim Zeid Mastering CAD/CAM – McGraw Hill, International Edition, 2007.
- William M Neumann and Robert F.Sproull “Principles of Computer Graphics”, Mc Graw Hill Book Co. Singapore, 1989.

**OBJECTIVE:**

- To impart knowledge on various concepts in engineering design and principles of implementing quality in a product or service through tools such as quality houses, control charts, statistical process control method, failure mode effect analysis and various strategies of designing experiments, methods to uphold the status of six sigma and improve the reliability of a product.

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

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

**UNIT II DESIGN FOR QUALITY 9**

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

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

Basic methods: Refining geometry and layout, general process of product embodiment - Embodiment checklist- Advanced methods: systems modeling, mechanical embodiment principles- MEA method - linking fault states to systems modeling - Basis of SIX SIGMA –Project selection for SIX SIGMA- SIX SIGMA problem solving- SIX SIGMA in service and small organizations - SIX SIGMA and lean production –Lean SIX SIGMA and services

**UNIT IV DESIGN OF EXPERIMENTS 9**

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

**UNIT V STATISTICAL CONSIDERATION AND RELIABILITY 9**

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

**TOTAL: 45 PERIODS****OUTCOME:**

- It helps the students to get familiarized with various concepts in design, quality and reliability principles in the design of an engineering product or a service.

**REFERENCES:**

- Dieter, George E., "Engineering Design - A Materials and Processing Approach", McGraw Hill, International Editions, Singapore, 2000.
- Fundamentals of Quality control and improvement 2nd edition, Amitava Mitra, Pearson Education Asia, 2002.
- Montgomery, D.C., Design and Analysis of experiments, John Wiley and Sons, 2003.
- Phillip J.Rose, Taguchi techniques for quality engineering, McGraw Hill, 1996.
- Product Design And Development, Karl t. Ulrich, Steven D. Eppinger, Tata Mcgraw-Hill- 3<sup>rd</sup> Edition, 2003.
- Product Design Techniques in Reverse Engineering and New Product Development, Kevin Otto & Kristin Wood, Pearson Education (LPE), 2001.

**OBJECTIVE:**

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

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

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

**UNIT II NON-LINEAR PROBLEMS 9**

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

**UNIT III DYNAMIC PROBLEM 9**

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

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

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

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

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

**OUTCOMES:**

- The students will understand the Finite Element Formulation of Plate and Shell Elements and its application.
- The students will be able to gain knowledge in material & geometric non-and plasticity.
- The students will be able to solve problems under dynamic conditions by applying various techniques.
- The students can arrive at the solutions for fluid mechanics and heat transfer problems.
- The students will acquire knowledge in error norms, convergence rates and refinement.
- The students will solve the real world engineering problems using FEA.

**TOTAL: 45 PERIODS****REFERENCES:**

- Bathe K.J., "Finite Element Procedures in Engineering Analysis", Prentice Hall, 1990.
- Cook R.D., "Concepts and Applications of Finite Element Analysis", John Wiley and Sons Inc., New York, 1989.
- Zienkiewicz, O.C. and Taylor, R.L., "The Finite Element Method", Fourth Edition, Volumes 1 &2, McGraw Hill International Edition, Physics Services, 1991.

ED5161

**CAD LABORATORY**

**L T P C**  
**0 0 4 2**

**OBJECTIVE:**

- To impart knowledge on how to prepare drawings for various mechanical components using any commercially available 3D modeling software's
  
- ❖ **CAD** Introduction.
- ❖ **Sketcher**
- ❖ **Solid modeling** – Extrude, Revolve, Sweep, etc and Variational sweep, Loft ,etc
- ❖ **Surface modeling** – Extrude, Sweep, Trim ..etc and Mesh of curves, Free form etc
- ❖ **Feature manipulation** – Copy, Edit, Pattern, Suppress, History operations etc.
- ❖ **Assembly**-Constraints, Exploded Views, Interference check
- ❖ **Drafting** - Layouts, Standard & Sectional Views, Detailing & Plotting.
- ❖ **CAD data Exchange formats** - IGES, PDES, PARASOLID, DXF and STL

Exercises in Modeling and drafting of Mechanical Components - Assembly using Parametric and feature based Packages like PRO-E / SOLID WORKS /CATIA / NX etc

**OUTCOME:**

- With laboratory classes, it helps the students to get familiarized with the computer applications in design and preparing drawings for various mechanical components.

**TOTAL: 60 PERIODS**

ED5162

**ADVANCED ANALYSIS AND SIMULATION LABORATORY**

**L T P C**  
**0 0 4 2**

**OBJECTIVES:**

- To give exposure to software tools needed to analyze engineering problems.
- To expose the students to different applications of simulation and analysis tools.

**A. SIMULATION**

1. MATLAB basics, Dealing with matrices, Graphing-Functions of one variable and two variables
2. Use of Matlab to solve simple problems in vibration
3. Mechanism Simulation using Multibody Dynamic software

**B. ANALYSIS**

1. Force and Stress analysis using link elements in Trusses, cables etc.
2. Stress and deflection analysis in beams with different support conditions.
3. Stress analysis of flat plates and simple shells.
4. Stress analysis of axi – symmetric components.
5. Thermal stress and heat transfer analysis of plates.
6. Thermal stress analysis of cylindrical shells.
7. Vibration analysis of spring-mass systems.
8. Model analysis of Beams.
9. Harmonic, transient and spectrum analysis of simple systems.

**TOTAL: 60 PERIODS**

**OUTCOME:**

- Upon completion of this course, the Students can model, analyse and simulate experiments to meet real world system and evaluate the performance.

**OBJECTIVE:**

- To develop a thorough understanding of the various mechanisms and its design and simulation with an ability to effectively use the various mechanisms in real life problems.

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

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

**UNIT II KINEMATIC ANALYSIS****9**

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

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

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

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

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

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

Cognate Linkages-parallel motion Linkages. Design of six bar mechanisms-single dwell-double dwell-double stroke. Geared five bar mechanism-multi-dwell. Cam Mechanisms- determination of optimum size of cams. Mechanism defects. Study and use of Mechanism using Simulation Soft-ware packages. Students should design and fabricate a mechanism model as term project.

**TOTAL : 45 PERIODS****\*\* a Term Project must be given for Assessment – 3 (Compulsory)****OUTCOME:**

- It helps the students to get familiarized with the advanced mechanisms which are necessary to design and simulate mechanisms.

**REFERENCES:**

- Amitabha Ghosh and Asok Kumar Mallik, "Theory of Mechanism and Machines", EWLP, Delhi, 1999.
- Kenneth J, Waldron, Gary L. Kinzel, "Kinematics, Dynamics and Design of Machinery", John Wiley-sons, 1999.
- Ramamurti, V., "Mechanics of Machines", Narosa, 2005.
- Robert L.Norton., "Design of Machinery",Tata McGraw Hill, 2005.
- Sandor G.N., and Erdman A.G., "Advanced Mechanism Design Analysis and Synthesis", Prentice Hall, 1984.
- Uicker, J.J., Pennock, G. R. and Shigley, J.E., "Theory of Machines and Mechanisms", Oxford University Press, 2005.



**OBJECTIVE:**

- To know the mechanical behavior of both metallic and non-metallic materials under different loading and temperature conditions.

**UNIT I BASIC CONCEPTS OF MATERIAL BEHAVIOR 10**

Elasticity in metals and polymers– Strengthening mechanisms, work hardening, solid solutioning, grain boundary strengthening, poly phase mixture, precipitation, particle, fibre and dispersion strengthening. Effect of temperature, strain and strain rate on plastic behaviour – Super plasticity – . Griffith's theory,– Ductile, brittle transition in steel – High temperature fracture, creep – Larson Miller parameter – Deformation and fracture mechanism maps.

**UNIT II BEHAVIOUR UNDER DYNAMIC LOADS AND DESIGN APPROACHES 10**

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

**UNIT III SELECTION OF MATERIALS 10**

Motivation for selection, cost basis and service requirements – Selection for mechanical properties, strength, toughness, fatigue and creep – Selection for surface durability corrosion and wear resistance – Relationship between materials selection and processing – Case studies in materials selection with relevance to aero, auto, marine, machinery and nuclear applications – Computer aided materials selection.

**UNIT IV MODERN METALLIC MATERIALS 8**

Dual phase steels, High strength low alloy (HSLA) steel, Transformation induced plasticity (TRIP) Steel, Maraging steel, Nitrogen steel – Intermetallics, Ni and Ti aluminides – smart materials, shape memory alloys – Metallic glass and nano crystalline materials.

**UNIT V NON METALLIC MATERIALS 7**

Polymeric materials – Formation of polymer structure – Production techniques of fibers, foams, adhesives and coating – structure, properties and applications of engineering polymers – Advanced structural ceramics, WC, TiC, TaC, Al<sub>2</sub>O<sub>3</sub>, SiC, Si<sub>3</sub>N<sub>4</sub> CBN and diamond – properties, processing and applications.

**TOTAL : 45 PERIODS****OUTCOME:**

- To familiarize the researchers in the area of material behavior under different loading and selection of materials for the design of engineering structures.

**REFERENCES:**

- Ashby M.F., materials selection in Mechanical Design 2nd Edition, Butter worth 1999.
- Charles, J.A., Crane, F.A.A. and Fumess, J.A.G., Selection and use of engineering materials, (34d edition), Butterworth-Heiremann, 1997.
- Flinn, R.A., and Trojan, P.K., Engineering Materials and their Applications, (4<sup>th</sup> Edition) Jaico, 1999.
- George E.Dieter, Mechanical Metallurgy, McGraw Hill, 1988
- Metals Hand book, Vol.10, Failure Analysis and Prevention, (10th Edition), Jaico, 1999.
- Thomas H. Courtney, Mechanical Behavior of Materials, (2nd edition), McGraw Hill, 2000

**OBJECTIVE:**

- To know the integrated design procedure of different machine elements for mechanical applications.

**UNIT I FUNDAMENTALS AND DESIGN OF SHAFTS 9**

Phases of design – Standardization and interchangeability of machine elements - Process and Function Tolerances – Individual and group tolerances – Selection of fits for different design situations – Design for assembly and modular constructions – Concepts of integration –BIS, ISO, DIN, BS, ASTM Standards. Oblique stresses – Transformation Matrix – Principal stresses – Maximum shear stress - Theories of Failure – Ductile vs. brittle component design - Analysis and Design of shafts for different applications – integrated design of shaft, bearing and casing – Design for rigidity

**UNIT II DESIGN OF GEARS AND GEAR BOXES 9**

Principles of gear tooth action – Gear correction – Gear tooth failure modes – Stresses and loads – Component design of spur, helical, bevel and worm gears – Design for sub assembly – Integrated design of speed reducers and multi-speed gear boxes – application of software packages.

**UNIT III BRAKES & CLUTCHES 9**

Dynamics and thermal aspects of brakes and clutches – Integrated design of brakes and clutches for machine tools, automobiles and mechanical handling equipments.

**UNIT IV INTEGRATED DESIGN 18**

Integrated Design of systems consisting of shaft, bearings, springs, motor, gears, belt, rope, chain, pulleys, Cam & Follower, flywheel etc. Example - Design of Elevators, Escalators, Gear Box, Valve gear Mechanisms, Machine Tools

**TOTAL: 45 PERIODS**

**The Pattern of Question Paper will consist of one Question from Unit – 4 for 50% of total marks.**

**\*\* a Term Project must be given for Assessment – 3 (Compulsory)**

**OUTCOME:**

- This will familiarize the students with the concepts of integration of design of machines and structures.

**REFERENCES:**

- Alexandrov, M., Materials Handling Equipments, MIR Publishers, 1981.
- Boltzharol, A., Materials Handling Handbook, The Ronald Press Company, 1958.
- Maitra G.M., “Hand Book of Gear Design”, Tata McGraw Hill, 1985.
- Newcomb, T.P. and Spur, R.T., “Automobile Brakes and Braking Systems”, Chapman and Hall, 2nd Edition, 1975.
- Norton L. R., “Machine Design – An Integrated Approach” Pearson Education, 2005
- Prasad. L. V., “Machine Design”, Tata McGraw Hill, New Delhi, 1992.
- Shigley, J.E., “Mechanical Engineering Design”, McGraw Hill, 1986.

**APPROVED DATA BOOKS**

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

**OBJECTIVE:**

- To understand the Fundamentals of Vibration and its practical applications
- To understand the working principle and operations of various vibration measuring instruments
- To understand the various Vibration control strategies

**UNIT I FUNDAMENTALS OF VIBRATION 10**

Introduction -Sources of Vibration-Mathematical Models- Displacement, velocity and Acceleration- Review Of Single Degree Freedom Systems -Vibration isolation Vibrometers and accelerometers - Response To Arbitrary and non- harmonic Excitations – Transient Vibration – Impulse loads- Critical Speed Of Shaft-Rotor systems.

**UNIT II TWO DEGREE FREEDOM SYSTEM 7**

Introduction-Free Vibration Of Undamped And Damped - Forced Vibration With Harmonic Excitation System –Coordinate Couplings And Principal Coordinates

**UNIT III MULTI-DEGREE FREEDOM SYSTEM AND CONTINUOUS SYSTEM 9**

Multi Degree Freedom System –Influence Coefficients and stiffness coefficients- Flexibility Matrix and Stiffness Matrix – Eigen Values and Eigen Vectors-Matrix Iteration Method –Approximate Methods: Dunkerley, Rayleigh's, and Holzer Method -Geared Systems-Eigen Values & Eigen vectors for large system of equations using sub space, Lanczos method - Continuous System: Vibration of String, Shafts and Beams

**UNIT IV VIBRATION CONTROL 9**

Specification of Vibration Limits –Vibration severity standards- Vibration as condition Monitoring tool-Vibration Isolation methods- -Dynamic Vibration Absorber, Torsional and Pendulum Type Absorber- Damped Vibration absorbers-Static and Dynamic Balancing-Balancing machines-Field balancing – Vibration Control by Design Modification- - Active Vibration Control

**UNIT V EXPERIMENTAL METHODS IN VIBRATION ANALYSIS 10**

Vibration Analysis Overview - Experimental Methods in Vibration Analysis.-Vibration Measuring Instruments - Selection of Sensors- Accelerometer Mountings. -Vibration Exciters-Mechanical, Hydraulic, Electromagnetic And Electrodynamics –Frequency Measuring Instruments-. System Identification from Frequency Response -Testing for resonance and mode shapes

**TOTAL :45 PERIODS****OUTCOME:**

- This course will help the students to understand the basics of vibration and its importance in engineering field.
- The students are equipped with the working operations of various vibration measuring instruments, vibration control and analysis techniques.

**REFERENCES**

1. Ramamurti. V, "Mechanical Vibration Practice with Basic Theory", Narosa, New Delhi, 2000.
2. Rao, S.S., "Mechanical Vibrations," Addison Wesley Longman, 1995.
3. S. Graham Kelly & Shashidar K. Kudari, "Mechanical Vibrations", Tata McGraw–Hill Publishing Com. Ltd New Delhi, 2007
4. Thomson, W.T. – "Theory of Vibration with Applications", CBS Publishers and Distributors, New Delhi, 1990

ED5261

VIBRATION LABORATORY

L T P C  
0 0 2 1

**OBJECTIVES**

- Introduce basic aspects of vibrational analysis, considering both single and multi-degree-of freedom systems. Discuss the use of exact and approximate methods in the analysis of complex systems.
  - ❖ To study the forced vibration of the beam for different damping.
  - ❖ To determine the radius of gyration 'k' of a given compound pendulum.
  - ❖ To determine the radius of gyration of trifilar suspension.
  - ❖ To determine the radius of gyration of given bar using bi-filler suspension.
  - ❖ To verify the dunker lay's rule viz.
  - ❖ To study the pressure profile of lubricating conditions of load and speed.
  - ❖ To determine the natural frequency of undamped torsional vibration of a single rotor shaft system.
  - ❖ To determine the natural frequency of undamped torsional vibration of two rotor shaft system.
  - ❖ To determine the frequency of undamped free vibration of an equivalent spring mass system.
  - ❖ To determine the frequency of damped force vibration of a spring mass system.

**TOTAL:30 PERIODS**

**OUTCOMES**

- Upon completion of the course students shall be able to: Derive the equations of motion for vibratory systems. Linearize nonlinear systems so as to allow a linear vibrational analysis. Compute the natural frequency (or frequencies) of vibratory systems and determine the system's modal response. Determine the overall response based upon the initial conditions and/or steady forcing input. Design a passive vibration absorber to ameliorate vibrations in a forced system.

ED5211

DESIGN PROJECT

L T P C  
0 0 4 2

**OBJECTIVE:**

- It is proposed to carryout detailed design calculations and analysis of any mechanical component or mechanical system. This helps the students to get familiar with respect to the design methodologies applied to any component or mechanical system subjected to static, dynamic and thermo-mechanical loads.

Each student is required to select any new component or an integrated mechanical system that involves various sub components which are to be designed as per design standards and further required to be analyzed for optimum dimensions with respect to the strength and stiffness.

**OUTCOME:**

- It helps the students to get familiarized with respect to design standards, design calculations and analysis in designing any mechanical component or system.

**TOTAL: 60 PERIODS**

**OBJECTIVE:**

- To understand history, concepts and terminology of PLM
- To understand functions and features of PLM/PDM
- To understand different modules offered in commercial PLM/PDM tools
- To understand PLM/PDM implementation approaches
- To understand integration of PLM/PDM with other applications

**UNIT I HISTORY, CONCEPTS AND TERMINOLOGY OF PLM 9**

Introduction to PLM, Need for PLM, opportunities of PLM, Different views of PLM - Engineering Data Management (EDM), Product Data Management (PDM), Collaborative Product Definition Management (cPDM), Collaborative Product Commerce (CPC), Product Lifecycle Management (PLM). PLM/PDM Infrastructure – Network and Communications, Data Management, Heterogeneous data sources and applications.

**UNIT II PLM/PDM FUNCTIONS AND FEATURES 9**

User Functions –Data Vault and Document Management, Workflow and Process Management, Product Structure Management, Product Classification and Programme Management. Utility Functions – Communication and Notification, data transport, data translation, image services, system administration and application integration.

**UNIT III DETAILS OF MODULES IN A PDM/PLM SOFTWARE 9**

Case studies based on top few commercial PLM/PDM tools

**UNIT IV ROLE OF PLM IN INDUSTRIES 9**

Case studies on PLM selection and implementation (like auto, aero, electronic) - other possible sectors, PLM visioning, PLM strategy, PLM feasibility study, change management for PLM, financial justification of PLM, barriers to PLM implementation, ten step approach to PLM, benefits of PLM for–business, organisation, users, product or service, process performance.

**UNIT V BASICS ON CUSTOMISATION/INTEGRATION OF PDM/PLM SOFTWARE 9**

PLM Customization, use of EAI technology (Middleware), Integration with legacy data base, CAD, SLM and ERP

**TOTAL: 45 PERIODS****OUTCOMES:**

The students will be able to

1. Understand history, concepts and terminology of PLM.
2. Apply the functions and features of PLM/PDM.
3. Understand different modules offered in commercial PLM/PDM tools.
4. Understand PLM/PDM implementation approaches.
5. Integrate PLM/PDM with other applications.
6. Analyse the case studies.

**REFERENCES**

1. Antti Saaksvuori and Anselmi Immonen, "Product Lifecycle Management", Springer Publisher, 2008 (3<sup>rd</sup> Edition).
2. International Journal of Product Lifecycle Management, Inderscience Publishers
3. Ivica Crnkovic, Ulf Asklund and Annita Persson Dahlqvist, "Implementing and Integrating Product Data Management and Software Configuration Management", Artech House Publishers, 2003.
4. John Stark, "Global Product: Strategy, Product Lifecycle Management and the Billion Customer Question", Springer Publisher, 2007.
5. John Stark, "Product Lifecycle Management: 21st Century Paradigm for Product Realisation", Springer Publisher, 2011 (2<sup>nd</sup> Edition).
6. Michael Grieves, "Product Life Cycle Management", Tata McGraw Hill, 2006.

**ED5311**

**PROJECT WORK PHASE I**

**L T P C**  
**0 0 12 6**

**OBJECTIVES:**

- To identify a specific problem for the current need of the society and collecting information related to the same through detailed review of literature.
- To develop the methodology to solve the identified problem.
- To train the students in preparing project reports and to face reviews and viva-voce examination.

**SYLLABUS:** The student individually works on a specific topic approved by the head of the division under the guidance of a faculty member who is familiar in this area of interest. The student can select any topic which is relevant to the area of engineering design. The topic may be theoretical or case studies. At the end of the semester, a detailed report on the work done should be submitted which contains clear definition of the identified problem, detailed literature review related to the area of work and methodology for carrying out the work. The students will be evaluated through a viva-voce examination by a panel of examiners including one external examiner.

**TOTAL: 180 PERIODS**

**OUTCOME:**

- At the end of the course the students will have a clear idea of their area of work and they will be in a position to carry out the remaining phase II work in a systematic way.

**ED5411**

**PROJECT WORK PHASE II**

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

**OBJECTIVES:**

- To solve the identified problem based on the formulated methodology.
- To develop skills to analyze and discuss the test results, and make conclusions.

**SYLLABUS:**

The student should continue the phase I work on the selected topic as per the formulated methodology under the same supervisor. At the end of the semester, after completing the work to the satisfaction of the supervisor and review committee, a detailed report should be prepared and submitted to the head of the department. The students will be evaluated based on the report submitted and the viva-voce examination by a panel of examiners including one external examiner

**TOTAL: 360 PERIODS**

**OUTCOME:**

- On completion of the project work students will be in a position to take up any challenging practical problem in the field of engineering design and find better solutions to it.

**ED5071**

**OPTIMIZATION TECHNIQUES IN DESIGN**

**L T P C**  
**3 0 0 3**

**OBJECTIVE:**

- To impart knowledge on various categories of existing engineering problems and solutions to such problems through different optimization techniques and approaches.

**UNIT I UNCONSTRAINED OPTIMIZATION TECHNIQUES**

**10**

Introduction to optimum design - General principles of optimization – Problem formulation & their classifications - Single variable and multivariable optimization, Techniques of unconstrained minimization – Golden section, Random, pattern and gradient search methods – Interpolation methods.







**OUTCOME:**

- The course would familiarize the student on the technique to select suitable material handling equipment and design them based on the need.

**REFERENCES**

1. Alexandrov, M., Materials Handling Equipments, MIR Publishers, 1981.
2. Boltzharol, A., Materials Handling Handbook, The Ronald Press Company, 1958.
3. Lingaiah. K. and Narayana Iyengar, "Machine Design Data Hand Book", Vol. 1 & 2, Suma Publishers, Bangalore, 1983
4. P.S.G. Tech., "Design Data Book", Kalaikathir Achchagam, Coimbatore, 2003.
5. Rudenko, N., Materials handling equipment, ELnvee Publishers, 1970.
6. Spivakovsy, A.O. and Dyachkov, V.K., Conveying Machines, Volumes I and II, MIR Publishers, 1985.

**CC5292****ADDITIVE MANUFACTURING AND TOOLING****L T P C**  
**3 0 0 3****OBJECTIVE:**

To educate students with fundamental and advanced knowledge in the field of Additive manufacturing technology and the associated Aerospace, Architecture, Art, Medical and industrial applications

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

Need - Development of AM systems – AM process chain - Impact of AM on Product Development - Virtual Prototyping- Rapid Tooling – RP to AM - Classification of AM processes-Benefits-Applications.

**UNIT II REVERSE ENGINEERING AND CAD MODELING:****9**

Basic concept- Digitization techniques – Model reconstruction – Data Processing for Rapid Prototyping: CAD model preparation, Data requirements – Geometric modeling techniques: Wire frame, surface and solid modeling – data formats - Data interfacing, Part orientation and support generation, Support structure design, Model Slicing, Tool path generation-Software for AM- Case studies.

**UNIT III LIQUID BASED AND SOLID BASED ADDITIVE MANUFACTURING SYSTEMS****9**

Stereolithography Apparatus (SLA): Principle, pre-build process, part-building and post-build processes, photo polymerization of SL resins, part quality and process planning, recoating issues, materials, advantages, limitations and applications. Solid Ground Curing (SGC): working principle, process, strengths, weaknesses and applications. Fused deposition Modeling (FDM): Principle, details of processes, process variables, types, products, materials and applications. Laminated Object Manufacturing (LOM): Working Principles, details of processes, products, materials, advantages, limitations and applications - Case studies.

**UNIT IV POWDER BASED ADDITIVE MANUFACTURING SYSTEMS****9**

Selective Laser Sintering (SLS): Principle, process, Indirect and direct SLS- powder structures, materials, post processing, surface deviation and accuracy, Applications. Laser Engineered Net Shaping (LENS): Processes, materials, products, advantages, limitations and applications– Case Studies.

**UNIT V TOOLING****9**

Classification, Soft tooling, Production tooling, Bridge tooling, direct and indirect tooling, Fabrication processes, Applications Case studies automotive, aerospace and electronics industries

**TOTAL: 45 PERIODS**

**OUTCOMES:**

The students will be able to

1. Understand history, concepts and terminology of additive manufacturing
2. Apply the reverse engineering concepts for design development
3. Understand the variety of additive manufacturing techniques
4. Design and develop newer tooling models
5. Analyse the cases relevant to mass customization and some of the important research challenges associated with AM and its data processing tools

**REFERENCES:**

1. Chua, C.K., Leong K.F. and Lim C.S., "Rapid prototyping: Principles and applications", second edition, World Scientific Publishers, 2010.
2. Gebhardt, A., "Rapid prototyping", Hanser Gardener Publications, 2003.
3. Gibson, I., Rosen, D.W. and Stucker, B., "Additive Manufacturing Methodologies: Rapid Prototyping to Direct Digital Manufacturing", Springer, 2010.
4. Hilton, P.D. and Jacobs, P.F., Rapid Tooling: Technologies and Industrial Applications, CRC press, 2005.
5. Kamrani, A.K. and Nasr, E.A., "Rapid Prototyping: Theory and practice", Springer, 2006.
6. Liou, L.W. and Liou, F.W., "Rapid Prototyping and Engineering applications : A tool box for prototype development", CRC Press, 2011.

**ED5073****INFORMATION ANALYTICS****L T P C  
3 0 0 3****OBJECTIVE:**

- To expose the students with fundamental concepts and the tools needed to understand emerging role of information analytics in the organisation.

**UNIT – I DATA ANALYTICS LIFE CYCLE 9**

Introduction to Big data Business Analytics - State of the practice in analytics role of data scientists - Key roles for successful analytic project - Main phases of life cycle - Developing core deliverables for stakeholders.

**UNIT – II STATISTICS 9**

Sampling Techniques - Data classification, Tabulation, Frequency and Graphic representation - Measures of central value - Arithmetic mean, Geometric mean, Harmonic mean, Mode, Median, Quartiles, Deciles, Percentile - Measures of variation – Range, IQR, Quartile deviation, Mean deviation, standard deviation, coefficient variance, skewness, Moments & Kurtosis.

**UNIT – III PROBABILITY AND HYPOTHESIS TESTING 9**

Random variable, distributions, two dimensional R.V, joint probability function, marginal density function. Random vectors - Some special probability distribution - Binomial, Poison, Geometric, uniform, exponential, normal, gamma and Erlang. Multivariate normal distribution - Sampling distribution – Estimation - point, confidence - Test of significance, 1& 2 tailed test, uses of t distribution, F-distribution,  $\chi^2$  distribution.

**UNIT – IV PREDICTIVE ANALYTICS 9**

Predictive modeling and Analysis - Regression Analysis, Multicollinearity , Correlation analysis, Rank correlation coefficient, Multiple correlation, Least square, Curve fitting and good ness of fit.

**UNIT – V TIME SERIES FORECASTING AND DESIGN OF EXPERIMENTS 9**

Forecasting Models for Time series: MA, SES, TS with trend, season - Design of Experiments, one way classification, two way classification, ANOVA, Latin square, Factorial Design.

**TOTAL: 45 PERIODS**

## OUTCOMES:

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

1. Understand the importance of data analysis in the design of new products.
2. Carry out statistical analysis.
3. Do probability analysis and hypothesis testing.
4. Perform predictive analysis.
5. Learn the effect of forecasting methods and to apply for business process.
6. Build a reliable, scalable, distributed information system.

## REFERENCES:

1. Alberto Cordoba, "Understanding the Predictive Analytics Lifecycle", Wiley, 2014.
2. Chris Eaton, Dirk Deroos, Tom Deutsch et al., "Understanding Big Data", McGraw Hill, 2012.
3. James R Evans, "Business Analytics – Methods, Models and Decisions", Pearson 2013.
4. R. N. Prasad, Seema Acharya, "Fundamentals of Business Analytics", Wiley, 2015.
5. S M Ross, "Introduction to Probability and Statistics for Engineers and Scientists", Academic Foundation, 2011.

**ED5001**

**PLATES AND SHELLS**

**L T P C**

**3 0 0 3**

## OBJECTIVE:

- To impart knowledge on the behavior of plates and shell elements, their places of utility and of course the design procedure of such elements in practical applications.

### **UNIT I GENERAL INTRODUCTION**

**7**

Review of equations of elasticity- kinematics, compatibility equations, stress measures- equations of motions- constitutive relations- transformation of stresses, strains and stiffness-energy principles and variational methods in elasticity- virtual work-external and internal virtual work variational operator- functionals - Euler Lagrange equations- energy principles- Hamilton's principle- principle of minimum total potential- applications

### **UNIT II CLASSICAL THEORY OF PLATES**

**10**

Plates as structural elements- stress and moment resultants- assumptions made in the classical theory- displacement fields and strains- equations of equilibrium in Cartesian coordinates and in polar coordinates- boundary conditions – bending of rectangular plates with various boundary conditions and loading- symmetrical and asymmetrical bending of circular plates-limitations of classical theory- finite element analysis(elementary treatment only; discussion of various elements used and their capabilities- not for examination)

### **UNIT III BUCKLING ANALYSIS OF RECTANGULAR PLATES**

**10**

Buckling of simply supported plates under compressive forces- governing equations- the Navier solution- biaxial compression of a plate - uniaxial compression of a plate- buckling of plates simply supported on two opposite edges- Levy's solution- buckling of plates with various boundary conditions- general formulation- finite element analysis(elementary treatment only; discussion of various elements used and their capabilities- not for examination)

### **UNIT IV VIBRATION OF PLATES**

**9**

Governing equations for natural flexural vibrations of rectangular plates- natural vibrations of plates simply supported on all edges- vibration of plates with two parallel sides simply supported- Levy's solution- vibration of plates with different boundary conditions- Rayleigh-Ritz method- Natural vibration of plates with general boundary conditions- transient analysis of rectangular plates- finite element analysis(elementary treatment only; discussion of various elements used and their capabilities- not for examination)

**UNIT V ANALYSIS OF THIN ELASTIC SHELLS OF REVOLUTION****9**

Classification of shell surfaces- geometric properties of shells of revolution- general strain displacement relations for shells of revolution- stress resultants- equations of motion of thin shells analytical solution for thin cylindrical shells- membrane theory- flexure under axisymmetric loads shells with double curvature- geometric considerations- equations of equilibrium- bending of spherical shells- vibration of cylindrical shells- finite element analysis(elementary treatment only; discussion of various elements used and their capabilities- not for examination)

**TOTAL: 45 PERIODS****OUTCOME:**

- After undergoing this course, the students would be in a position to understand the behavior of these commonly occurring structural elements in engineering design and would have developed the capability to design and analyse them in their normal design practice.

**REFERENCES:**

1. Dr. N. Subramanian, Principles of Space Structures , Wheeler Publishing Co. 1999
2. K. Baskar and T.K. Varadan, "Plates- Theories and Applications", Ane Books Pvt. Ltd., New Delhi, 2013
3. Ramasamy, G.S., Design and Construction of Concrete Shells Roofs, CBS Publishers, 1986
4. Reddy, J.N., "Theory and Analysis of Elastic Plates & Shells", C.R.C. Press, NY, USA, 2<sup>nd</sup> Edition 2002
5. Szilard, R., Theory and Analysis of Plates, Prentice Hall Inc., 1995
6. Timoshenko, S. and Krieger S.W. Theory of Plates and Shells, McGraw Hill Book Company New York 1990.
7. Timoshenko, S. Theory of Plates and Shells, McGraw Hill, 1990
8. Wilhelm Flügge, Stresses in Shells, Springer – Verlag, 1962

**ED5002 MODAL ANALYSIS OF MECHANICAL SYSTEMS****L T P C  
3 0 0 3****OBJECTIVE:**

- To impart knowledge on modal testing and modal analysis of single and multi- degree of freedom systems.

**UNIT I INTRODUCTION****6**

Introduction to Modal Testing – Applications of Modal Testing – Philosophy of Modal Testing – Summary of Theory – Summary of Measurement Methods – Summary of Analysis – Review of Test Procedure.

**UNIT II VIBRATIONS****12**

Introduction – Single Degree of Freedom (SDOF) System Theory – Presentation and Properties of FRF Data for SDOF System – Undamped Multi-degree of freedom (MDOF) system – Proportional Damping – Hysteretic Damping – General Case – Viscous Damping – General Case – Characteristics and presentation of MDOF – FRF Data – Complete and incomplete models - Nonsinusoidal vibration and FRF Properties – Analysis of Weakly Nonlinear Structures.

**UNIT III MOBILITY MEASUREMENT TECHNIQUES****10**

Introduction – Basic Measurement System – Structure preparation – Excitation of the Structure – Transducers and Amplifiers – Analyzers – Digital Signal Processing – Use of Different Excitation types – Calibration – Mass Cancellation – Rotational Mobility Measurement – Measurement on Non linear structures – Multi point excitation methods.

**UNIT IV MODAL PARAMETER EXTRACTION METHODS****11**

Introduction – Preliminary checks of FRF Data – SDOF Modal Analysis-I – Peak-amplitude – DOF Modal Analysis-II – Circle Fit Method – SDOF Modal Analysis III – Inverse Method –Residuals – MDOF curve-fitting procedures – MDOF curve fitting in the Time Domain – Global or Multi- Curve fitting – Non linear systems.

**UNIT V MATHEMATICAL MODELS****6**

Introduction – Modal Models – Display of Modal Model – Response Models – Spatial Models – Mobility Skeletons and System Models.

**TOTAL: 45 PERIODS****OUTCOME:**

- The students will become exposed to modal testing and techniques used for measurement of modal parameters.

**REFERENCES:**

1. Ewins D J, "Modal Testing: Theory and Practice ", John Wiley & Sons Inc., 1988
2. Nuno Manuel Mendes Maia et al, "Theoretical and Experimental Modal Analysis", Wiley John & sons, 1997.

**ED5003 ADVANCED METAL FORMING TECHNIQUES****L T P C  
3 0 0 3****OBJECTIVES:**

- To study the concepts of latest metal forming techniques and their applications in metal forming industry.
- To study the thermo mechanical regimes and its requirements of metal forming

**UNIT I INTRODUCTION TO THEORY OF PLASTICITY AND FORMING****9**

Theory of plastic deformation – Yield criteria – Tresca and Von-mises – Distortion energy – Stress strain relation – Mohr's circle representation of a state of stress – cylindrical and spherical coordinate system – upper and lower bound solution methods – thermo elastic Elasto plasticity – elasto visco plasticity.

**UNIT II THEORY AND PRACTICE OF BULK FORMING PROCESSES****9**

Analysis of plastic deformation in Forging, Rolling, Extrusion, rod/wire drawing and tube drawing – Effect of friction – calculation of forces, work done – Process parameters, equipment used – Defects – applications – Recent advances in Forging, Rolling, Extrusion and Drawing processes – Design consideration in forming - Formability of laminated sheet - Overview of FEM applications in Metal Forming analysis.

**UNIT III SHEET METAL FORMING****9**

Formability studies – Conventional processes – H E R F techniques – Superplastic forming techniques – Hydro forming – Stretch forming – Water hammer forming – Principles and process parameters – Advantage, Limitations and application

**UNIT IV POWDER METALLURGY AND SPECIAL FORMING PROCESSES****9**

Overview of P/M technique – Advantages – applications – Powder preform forging – powder rolling – Tooling, process parameters and applications. - Orbital forging – Isothermal forging – Hot and cold isostatic pressing – High speed extrusion – Rubber pad forming – Fine blanking – LASER beam forming.

**UNIT V ELECTROMAGNETIC FORMING AND ITS APPLICATIONS****9**

Electromagnetic Forming Process – Electro – Magnetic Forming Machines – Process Variables – Coils and Dies – Effect of Resistivity and Geometry – EM tube and sheet forming, stamping, shearing and welding – Applications – Finite Element Analysis of EM forming.

**TOTAL: 45 PERIODS****OUTCOME:**

- The course would familiarize the students on the latest metal forming techniques and help them decide on the suitable method to form the metals for various industrial applications.

## REFERENCES:

1. Altan T., Metal forming – Fundamentals and applications – American Society of Metals, Metals park, 2003.
2. Altan.T, Soo-Ik-Oh, Gegel, HL – Metal forming, fundamentals and Applications, American Society of Metals, Metals Park, Ohio, 1983.
3. ASM Hand book, Forming and Forging, Ninth edition, Vol – 14, 2003
4. Dieter G.E., Mechanical Metallurgy (Revised Edition II) McGraw Hill Co., 2004
5. Marciniak,Z., Duncan J.L., Hu S.J., 'Mechanics of Sheet Metal Forming', Butterworth-Heinemann An Imprint of Elsevier, 2006
6. Proc. Of National Seminar on "Advances in Metal Forming" MIT, March 2000
7. Proceedings of International Workshop on EMFT 2010, Anna University
8. SAE Transactions, Journal of Materials and Manufacturing Section 5, 1993-2007
9. Shiro Kobayashi, Soo-Ik-Oh-Altan, T, Metal forming and Finite Element Method, Oxford University Press, 2001.

**ED5074**

**TRIBOLOGY IN DESIGN**

**L T P C**  
**3 0 0 3**

## OBJECTIVE:

- To impart knowledge in the friction , wear and lubrication aspects of machine components
- To understand the material properties which influence the tribological characteristics of surfaces.
- To understand the analytical behavior of different types bearings and design of bearings based on analytical /theoretical approach

### **UNIT I SURFACE INTERACTION AND FRICTION**

**7**

Topography of Surfaces – Surface features-Properties and measurement – 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

### **UNIT II WEAR AND SURFACE TREATMENT**

**8**

Types of wear – Mechanism of various types of wear – Laws of wear –Theoretical wear models- Wear of Metals and Non metals – Surface treatments – Surface modifications – surface coatings methods- Surface Topography measurements –Laser methods – instrumentation – International standards in friction and wear measurements

### **UNIT III LUBRICANTS AND LUBRICATION REGIMES**

**8**

Lubricants and their physical properties- Viscosity and other properties of oils –Additives-and selection of Lubricants- Lubricants standards ISO,SAE,AGMA, BIS standards – Lubrication Regimes –Solid Lubrication-Dry and marginally lubricated contacts- Boundary Lubrication-Hydrodynamic lubrication — Elasto and plasto hydrodynamic - Magneto hydrodynamic lubrication – Hydro static lubrication – Gas lubrication.

### **UNIT IV THEORY OF HYDRODYNAMIC AND HYDROSTATIC LUBRICATION**

**12**

Reynolds Equation,-Assumptions and limitations-One and two dimensional Reynolds Equation-Reynolds and Sommerfeld boundary conditions- Pressure wave, flow, load capacity and friction calculations in Hydrodynamic bearings-Long and short bearings-Pad bearings and Journal bearings-Squeeze film effects-Thermal considerations-Hydrostatic lubrication of Pad bearing- Pressure , flow , load and friction calculations-Stiffness considerations- Various types of flow restrictors in hydrostatic bearings

### **UNIT V HIGH PRESSURE CONTACTS AND ELASTO HYDRODYNAMIC LUBRICATION**

**10**

Rolling contacts of Elastic solids- contact stresses – Hertzian stress equation- Spherical and cylindrical contacts-Contact Fatigue life- Oil film effects- Elasto Hydrodynamic lubrication Theory- Soft and hard EHL-Reynolds equation for elasto hydrodynamic lubrication- - Film shape within and

outside contact zones-Film thickness and friction calculation- Rolling bearings- Stresses and deflections-Traction drives

**TOTAL: 45 PERIODS**

**OUTCOME:**

- Ability to select material / surface properties based on the tribological requirements
- Methodology for deciding lubricants and lubrication regimes for different operating conditions
- Analysis ability of different types of bearings for given load / speed conditions.

**REFERENCES:**

1. Cameron, A. "Basic Lubrication Theory", Ellis Herward Ltd., UK, 1981
2. G.W.Stachowiak & A.W .Batchelor , Engineering Tribology, Butterworth - Heinemann, UK, 2005
3. Halling, J. (Editor) – "Principles of Tribology ", Macmillian – 1984.
4. Rabinowicz.E, "Friction and Wear of materials", John Willey & Sons ,UK,1995
5. S.K.Basu, S.N.Sengupta & B.B.Ahuja , "Fundamentals of Tribology", Prentice – Hall of India Pvt Ltd , New Delhi, 2005
6. Williams J.A. "Engineering Tribology", Oxford Univ. Press, 1994.

**ED5004**

**SURFACE ENGINEERING**

**L T P C  
3 0 0 3**

**OBJECTIVE:**

- To impart knowledge on surface engineering and surface modification methods that will come in handy to solve the industrial problems. This will also serve as a precursor for future research in the same field.

**UNIT I            FRICTION**

**7**

Topography of Surfaces – Surface features – Properties and measurement – 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

**UNIT II           WEAR**

**6**

Introduction – Abrasive wear, Erosive, Cavitation, Adhesion, Fatigue wear and Fretting Wear- Laws of wear – Theoretical wear models – Wear of metals and non metals – International standards in friction and wear measurements

**UNIT III          CORROSION**

**10**

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

**UNIT IV          SURFACE TREATMENTS**

**12**

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, Applications of coatings and surface treatments in wear and friction control – Characteristics of Wear resistant coatings – New trends in coating technology – DLC – CNC – Thick coatings – Nano-engineered coatings – Other coatings, Corrosion resistant coatings

**UNIT V ENGINEERING MATERIALS****10**

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

**TOTAL: 45 PERIODS****OUTCOME:**

- It helps the students to get familiarized with the various theories and practice on surface engineering and surface modification methods which are necessary to solve the industrial practical problems that arise and also for the research.

**REFERENCES**

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

**ED5092****ADVANCED MECHANICS OF MATERIALS****L T P C  
3 0 0 3****OBJECTIVE:**

- To know the fundamentals of mechanics of materials under various loading conditions.

**UNIT I ELASTICITY****9**

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

**UNIT II SHEAR CENTER AND UNSYMMETRICAL BENDING****10**

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

**UNIT III STRESSES IN FLAT PLATES AND CURVED MEMBERS****10**

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

**UNIT IV TORSION OF NON-CIRCULAR SECTIONS****7**

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

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

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

**TOTAL : 45 PERIODS****OUTCOME:**

- It helps the students to be familiarized with the stresses under different loading conditions.



## REFERENCES:

1. Allan F. Bower, "Applied Mechanics of Solids", CRC press – Special Indian Edition -2012,
2. Arthur P Boresi, Richard J. Schmidt, "Advanced mechanics of materials", John Wiley, 2002.
3. G H Ryder Strength of Materials Macmillan, India Ltd, 2007.
4. K. Baskar and T.K. Varadan, "Theory of Isotropic/Orthotropic Elasticity", Ane Books Pvt. Ltd., New Delhi, 2009
5. Robert D. Cook, Warren C. Young, "Advanced Mechanics of Materials", Mc- millan pub. Co., 1985.
6. Srinath. L.S., "Advanced Mechanics of solids", Tata McGraw Hill, 1992.
7. Timoshenko and Goodier, "Theory of Elasticity", McGraw Hill.1951

ED5075

DESIGN FOR INTERNET OF THINGS

L T P C  
3 0 0 3

## OBJECTIVE:

- To impart knowledge on state of art IoT architecture, data and knowledge management and use of devices in IoT technology

### UNIT-I INTRODUCTION

9

Machine to Machine (M2M) to IoT-The Vision-Introduction, From M2M to IoT, M2M towards IoT-the global context, A use case example, Differing Characteristics.

### UNIT-II IoT STRUCTURE

9

**M2M to IoT – A Market Perspective**– Introduction, Some Definitions, M2M Value Chains, IoT Value Chains, An emerging industrial structure for IoT, The international driven global value chain and global information monopolies. **M2M to IoT-An Architectural Overview**– Building an architecture, Main design principles and needed capabilities, An IoT architecture outline, standards considerations.

### UNIT-III IoT NETWORKING

9

**M2M and IoT Technology Fundamentals**- Devices and gateways, Local and wide area networking, Data management, Business processes in IoT, Everything as a Service (XaaS), M2M and IoT Analytics, Knowledge Management.

### UNIT-IV IoT ARCHITECTURE

9

**IoT Architecture-State of the Art** – Introduction, State of the art, **Architecture Reference Model**- Introduction, Reference Model and architecture, IoT reference Model.

### UNIT-V ARCHITECTURE MODELING

9

**IoT Reference Architecture**- Introduction, Functional View, Information View, Deployment and Operational View, Other Relevant architectural views. **Real-World Design Constraints**- Introduction, Technical Design constraints-hardware is popular again, Data representation and visualization, Interaction and remote control. **Industrial Automation**- Service-oriented architecture-based device integration, SOCRADES: realizing the enterprise integrated Web of Things, IMC-AESOP: from the Web of Things to the Cloud of Things, **Commercial Building Automation**- Introduction, Case study: phase one-commercial building automation today, Case study: phase two- commercial building automation in the future.

**TOTAL: 45 PERIODS**

## OUTCOMES:

At the end of the course the student will be able to:

1. Understand the vision of IoT from a global context.
2. Determine the Market perspective of IoT.
3. Use of Devices, Gateways and Data Management in IoT.
4. Build state of the art architecture in IoT.
5. Understand the design constraints in the real world.
6. Apply of IoT in Industrial and Commercial Building Automation and Real World Design Constraints.

**REFERENCES:**

1. Francis daCosta, "Rethinking the Internet of Things: A Scalable Approach to Connecting Everything", 1<sup>st</sup> Edition, A press Publications, 2013.
2. Jan Holler, Vlasios Tsiatsis, Catherine Mulligan, Stefan Avesand, Stamatis Karnouskos, David Boyle, "From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence", 1<sup>st</sup> Edition, Academic Press, 2014.
3. Vijay Madiseti and Arshdeep Bahga, "Internet of Things (A Hands-on-Approach)", 1<sup>st</sup> Edition, VPT, 2014.

**ED5005 DESIGN OF HYDRAULIC AND PNEUMATIC SYSTEMS****L T P C  
3 0 0 3****OBJECTIVE:**

- To impart students on the science, use and application of hydraulics and pneumatics as fluid power in Industry. Also to impart knowledge on the methodology of basic and advanced design of pneumatics and hydraulics systems.

**UNIT I OIL HYDRAULIC SYSTEMS AND HYDRAULIC ACTUATORS****7**

Hydraulic Power Generators – Selection and specification of pumps, pump characteristics. Linear and Rotary Actuators – selection, specification and characteristics, Hydrostatic drives, types, selection.

**UNIT II CONTROL AND REGULATION ELEMENTS****10**

Pressure - direction and flow control valves - relief valves, non-return and safety valves – actuation systems, Proportional Electro hydraulic servo valves.

**UNIT III HYDRAULIC CIRCUITS****8**

Reciprocation, quick return, sequencing, synchronizing circuits - accumulator circuits – industrial circuits - press circuits - hydraulic milling machine - grinding, planning, copying, - forklift, earth mover circuits design methodology- design and selection of components - safety and emergency mandrels – Cascade method.

**UNIT IV PNEUMATIC SYSTEMS AND CIRCUITS****10**

Pneumatic fundamentals - control elements, position and pressure sensing, Pneumatic equipments- selection of components - design calculations - logic circuits - switching circuits - fringe conditions modules and these integration - sequential circuits - cascade methods – mapping methods - step counter method - compound circuit design - combination circuit design- Karnaugh - Veitch map.

**UNIT V ELECTROMAGNETIC & ELECTRONIC CONTROL OF HYDRAULIC & PNEUMATIC CIRCUIT****10**

Electrical control of pneumatic circuits – use of relays, counters, timers, ladder diagrams, use of microprocessor in circuit design – use of PLC in hydraulic and pneumatic circuits – Fault finding– application -fault finding - hydro pneumatic circuits - use of microprocessors for sequencing - PLC, Low cost automation - Robotic circuits.

**TOTAL : 45 PERIODS****OUTCOME:**

- It helps students to get knowledge on the need, use and application of fluid power and make them familiar to industrial design that lead to automation.

**REFERENCES:**

1. Andrew Parr, "Hydraulic and Pneumatics" (HB), Jaico Publishing House, 1999.
2. Antony Esposito, "Fluid Power with Applications", Prentice Hall, 1980.
3. Bolton. W., "Pneumatic and Hydraulic Systems ", Butterworth –Heinemann, 1997.
4. Dudleyt, A. Pease and John J. Pippenger, "Basic fluid power", Prentice Hall, 1987.
5. K.Shanmuga Sundaram, "Hydraulic and Pneumatic Controls: Understanding made Easy" S.Chand & Co Book publishers, New Delhi, 2006 (Reprint 2009)

**OBJECTIVE:**

- To know about different types of bearings available for machine design and their operating principles
- To design hydrodynamic/ hydrostatic / rolling bearing for given specifications and analyze the bearings for their performance
- To understand the bearing behavior under dynamic conditions

**UNIT I CLASSIFICATION AND SELECTION OF BEARINGS****6**

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

**UNIT II DESIGN OF FLUID FILM BEARINGS****10**

Design and performance analysis of Thrust and Journal bearings – Full, partial, fixed and pivoted journal bearings design procedure-Minimum film thickness – lubricant flow and delivery – power loss, Heat and temperature distribution calculations- Design based on Charts & Tables and Experimental curves-Design of Foil bearings-Air Bearings- Design of Hydrostatic bearings-Thrust and Journal bearings- Stiffness consideration - flow regulators and pump design

**UNIT III SELECTION AND DESIGN OF ROLLING BEARINGS****10**

Contact Stresses in Rolling bearings- Centrifugal stresses-Elasto hydrodynamic lubrication-Fatigue life calculations- Bearing operating temperature- Lubrication- Selection of lubricants-Internal clearance – Shaft and housing fit- -Mounting arrangements-Materials for rolling bearings-Manufacturing methods- Ceramic bearings-Rolling bearing cages-bearing seals selection

**UNIT IV DYNAMICS OF HYDRODYNAMIC BEARINGS****10**

Hydrodynamic Lubrication equation for dynamic loadings-Squeeze film effects in journal bearings and thrust bearings -Rotating loads , alternating and impulse loads in journal bearings – Journal centre Trajectory- Analysis of short bearings under dynamic conditions- Finite difference solution for dynamic conditions

**UNIT V ROTOR DYNAMICS****9**

Rotor vibration and Rotor critical speeds- support stiffness on critical speeds- Stiffness and damping coefficients of journal bearings-computation and measurements of journal bearing coefficients -Mechanics of Hydro dynamic Instability- Half frequency whirl and Resonance whip-Design configurations of stable journal bearings

**TOTAL: 45 PERIODS****OUTCOME:**

- Acquisition of knowledge in the analysis of all types of bearings.
- Ability to make specifications of all types of bearings
- Skill for conducting dynamic / vibration analysis and trouble shooting of bearings

**REFERENCES:**

1. Cameron, A. "Basic Lubrication Theory", Ellis Herward Ltd., UK, 1981
2. G.W.Stachowiak & A.W .Batchelor , Engineering Tribology, Butterworth-Heinemann, UK, 2005
3. Halling, J. (Editor) – "Principles of Tribology ", Macmillian – 1984.
4. Neale, M.J. "Tribology Hand Book", Butterworth Heinemann, United Kingdom 2001.
5. S.K.Basu, S.N.Sengupta & B.B.Ahuja , "Fundamentals of Tribology", Prentice –Hall of India Pvt Ltd , New Delhi, 2005
6. Williams J.A. "Engineering Tribology", Oxford Univ. Press, 1994.

**OBJECTIVE:**

- To understand the basic concepts of sustainability.
- To gain knowledge about the tools and techniques for sustainable design.
- To improve the design by assessing the customer needs.

**UNIT-I BASIC CONCEPTS IN SUSTAINABILITY****9**

Understanding the language of sustainable engineering design, construction and operation. Natural resources terminology. Carrying capacity. Sustainable development, corporate responsibility, biophysical constraints, environmental management.

**UNIT-II TOOLS AND TECHNIQUES****9**

Sustainable Engineering Design Tools – Life cycle analysis, carbon foot printing. Life cycle assessment (LCA), Types of LCA's: baseline, comparative, streamlined. LCA inventory analysis: process or input-output. Hybrid inventory analysis. Sustainable Product Design. Whole systems design. Light weighting and materials reduction. Designing for a lifetime. Design for durability, repair and upgrade, disassembly and recycling. Energy use in design. Reducing energy losses in design.

**UNIT-III FOUNDATIONAL CONCEPTS & PRINCIPLES FOR SUSTAINABLE BREAKTHROUGH DESIGN****9**

Infrastructure for managing flows of materials, energy and activities; sustainable value creation approaches for all stakeholders, environmental design characteristics; design changes & continual improvement; inclusive sustainable design principles, crowd sourcing, multiple-objective designs; infrastructures that support system thinking; knowledge management for sustainable design, learning systems and experimentation; smart data systems, understanding variation.

**UNIT-IV SUSTAINABLE DESIGN****9**

Industrial ecology, multiple life cycle design, principles of design, green engineering, cradle to cradle design, The Natural Step, biomimicry, design for reuse, dematerialization, modularization, design for flexibility, design for disassembly, design for inverse manufacturing, design for the environment, etc.

**UNIT-V CUSTOMER AND USER NEEDS ASSESSMENT****9**

Identification & breakdown structures that describe customers & stakeholders, green marketing, socially conscious consumerism, sources of customer information, collecting information, analyzing customer behavior, translating the voice of the customer, use analysis, structuring customer needs, service gap analysis, prioritizing customer needs, strategic design, Kano technique.

**TOTAL: 45 PERIODS****OUTCOMES**

The student will

1. Understand the concept of sustainability in terms of design, construction and development.
2. Gain knowledge in engineering design tools and life cycle assessment.
3. Be able to apply sustainable value creation approaches, design changes & continual improvement.
4. Carry out sustainable design, green engineering, flexible design etc.
5. Able to design according to the customer needs.
6. Design the products that are environmental friendly.

**REFERENCES**

1. Clarke, Abigail & John K. Gershenson 2006. Design for the Life Cycle. Life-cycle Engineering Laboratory, Department of Mechanical Engineering-Engineering Mechanics, Michigan Technological University.
2. Finster, Mark P., 2013. Sustainable Perspectives to Design and Innovation.

3. Ramaswamy, Rohit, 1996. Design and Management of Service Processes: Keeping Customers for Life, Prentice Hall.
4. Schmitt, Brent, Customer Experience Management, Wiley and Sons, 2003.

**ED5093**

**COMPUTATIONAL FLUID DYNAMICS**

**L T P C**  
**3 0 0 3**

**OBJECTIVES**

- This course aims to introduce numerical modeling and its role in the field of heat, fluid flow and combustion it will enable the students to understand the various discretisation methods and solving methodologies and to create confidence to solve complex problems in the field of heat transfer and fluid dynamics.
- To develop finite volume discretized forms of the CFD equations.
- To formulate explicit & implicit algorithms for solving the Euler Equations & Navier Stokes Equations.

**UNIT I GOVERNING DIFFERENTIAL EQUATIONS AND DISCRETISATION TECHNIQUES**

**8**

Basics of Heat Transfer, Fluid flow – Mathematical description of fluid flow and heat transfer – Conservation of mass, momentum, energy and chemical species - Classification of partial differential equations – Initial and Boundary Conditions – Discretisation techniques using finite difference methods – Taylor’s Series - Uniform and non-uniform Grids, Numerical Errors, Grid Independence Test.

**UNIT II DIFFUSION PROCESSES : FINITE VOLUME METHOD**

**10**

Steady one-dimensional diffusion, Two and three dimensional steady state diffusion problems, Discretisation of unsteady diffusion problems – Explicit, Implicit and Crank- Nicholson’s schemes, Stability of schemes.

**UNIT III CONVECTION - DIFFUSION PROCESSES : FINITE VOLUME METHOD**

**9**

One dimensional convection – diffusion problem, Central difference scheme, upwind scheme – Hybrid and power law discretization techniques – QUICK scheme.

**UNIT IV FLOW PROCESSES : FINITE VOLUME METHOD**

**8**

Discretisation of incompressible flow equations – Pressure based algorithms, SIMPLE, SIMPLER & PISO algorithms

**UNIT V MODELLING OF COMBUSTION AND TURBULENCE**

**10**

Mechanisms of combustion and Chemical Kinetics, Overall reactions and intermediate reactions, Reaction rate, Governing equations for combusting flows. Simple Chemical Reacting System (SCRS), Turbulence - Algebraic Models, One equation model &  $k - \epsilon$ ,  $k - \omega$  models - Standard and High and Low Reynolds number models.

**TOTAL: 45 PERIODS**

**OUTCOME:**

- On successful completion of this course the student will be able to apply the concepts of CFD to analyse the fluid flow and heat transfer in thermal systems.

**REFERENCES:**

1. Ghoshdastidar, P.S., “Computer Simulation of Flow and Heat Transfer”, Tata McGraw-Hill Publishing Company Limited, New Delhi, 1998.
2. Jiyuan Tu, Guan Heng Yeoh, Chaogun Liu, “Computational Fluid Dynamics A Practical Approach” Butterworth – Heinemann An Imprint of Elsevier, Madison, U.S.A., 2008
3. John D. Anderson . JR. “Computational Fluid Dynamics The Basics with Applications” McGraw- Hill International Editions, 1995.
4. Muralidhar, K., and Sundararajan, T., “Computational Fluid Flow and Heat Transfer”, Narosa Publishing House, New Delhi, 2003.

5. Subas and V.Patankar "Numerical heat transfer fluid flow", Hemisphere Publishing Corporation,1980.
6. Versteeg and Malalasekera, N, "An Introduction to computational Fluid Dynamics The Finite Volume Method," Pearson Education, Ltd., Second Edition, 2014.

**CC5291 DESIGN FOR MANUFACTURE, ASSEMBLY AND ENVIRONMENTS** **L T P C**  
**3 0 0 3**

**OBJECTIVES:**

- To know the concept of design for manufacturing, assembly and environment.
- To know the computer application in design for manufacturing and assembly.

**UNIT I INTRODUCTION** **5**  
 General design principles for manufacturability - strength and mechanical factors, mechanisms selection, evaluation method, Process capability - Feature tolerances Geometric tolerances - Assembly limits -Datum features - Tolerance stacks.

**UNIT II FACTORS INFLUENCING FORM DESIGN** **13**  
 Working principle, Material, Manufacture, Design- Possible solutions - Materials choice – Influence of materials on form design - form design of welded members, forgings and castings.

**UNIT III COMPONENT DESIGN - MACHINING CONSIDERATION** **8**  
 Design features to facilitate machining - drills - milling cutters - keyways - Doweling procedures, counter sunk screws - Reduction of machined area- simplification by separation - simplification by amalgamation - Design for machinability - Design for economy - Design for clampability – Design for accessibility - Design for assembly – Product design for manual assembly - Product design for automatic assembly – Robotic assembly.

**UNIT IV COMPONENT DESIGN – CASTING CONSIDERATION** **10**  
 Redesign of castings based on Parting line considerations - Minimizing core requirements, machined holes, redesign of cast members to obviate cores. Identification of uneconomical design - Modifying the design - group technology - Computer Applications for DFMA

**UNIT V DESIGN FOR THE ENVIRONMENT** **9**  
 Introduction – Environmental objectives – Global issues – Regional and local issues – Basic DFE methods – Design guide lines – Example application – Lifecycle assessment – Basic method – AT&T’s environmentally responsible product assessment - Weighted sum assessment method – Lifecycle assessment method – Techniques to reduce environmental impact – Design to minimize material usage – Design for disassembly – Design for recyclability – Design for manufacture – Design for energy efficiency – Design to regulations and standards.

**TOTAL: 45 PERIODS**

**OUTCOME:**

- To make the students get acquainted with the design for manufacturing, assembly and environment.

**REFERENCES:**

1. Boothroyd, G, 1980 Design for Assembly Automation and Product Design. New York, Marcel Dekker.
2. Boothroyd, G, Hartz and Nike, Product Design for Manufacture, Marcel Dekker, 1994.
3. Bralla, Design for Manufacture handbook, McGraw hill, 1999.
4. Dickson, John. R, and Corroda Poly, Engineering Design and Design for Manufacture and Structural Approach, Field Stone Publisher, USA, 1995.
5. Fixel, J. Design for the Environment McGraw Hill., 1996.

6. Graedel T. Allen By. B, Design for the Environment Angle Wood Cliff, Prentice Hall. Reason Pub., 1996.
7. Harry Peck , Designing for manufacture, Pitman– 1973
8. Kevin Otto and Kristin Wood, Product Design. Pearson Publication, (Fourth Impression) 2009.

<b>ED5077</b>	<b>BIOMECHANICS</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**OBJECTIVES:**

- The student should be made to:
- Be exposed to principles of mechanics.
- Learn the mechanics of physiological systems.
- Be familiar with the mathematical models used in the analysis of biomechanical systems

**UNIT I INTRODUCTION TO MECHANICS 9**

Principles of Mechanics, Vector mechanics, Mechanics of motion - Newton's laws of motion, Kinetics, Kinematics of motion, Fluid mechanics – Euler equations and Navier Stoke's equations, Visco elasticity, Constitutive equations, Stress transformations, Strain energy function.

**UNIT II BIOFLUID MECHANICS 9**

Introduction, viscosity and capillary viscometer, Rheological properties of blood, laminar flow, Couette flow and Hagen-poiseuille equation, turbulent flow. Cardiovascular system - biological and mechanical valves development, artificial heart valves testing of valves, Structure, functions, material properties and modeling of Blood vessels.

**UNIT III BIOSOLID MECHANICS 9**

Hard Tissues: Bone structure & composition mechanical properties of bone, cortical and cancellous bones, viscoelastic properties, Maxwell&Voight models – anisotropy. Soft Tissues: Structure, functions, material properties and modeling of Soft Tissues: Cartilage, Tendon, Ligament, Muscle.

**UNIT IV BIOMECHANICS OF JOINTS AND IMPLANTS 9**

Skeletal joints, forces and stresses in human joints, Analysis of rigid bodies in equilibrium, free body diagrams, types of joint, biomechanical analysis of elbow, shoulder, spinal column, hip knee and ankle. Design of orthopedic implant, specifications for a prosthetic joint, biocompatibility, requirement of a biomaterial, characteristics of different types of biomaterials, manufacturing process of implants, fixation of implants.

**UNIT V MODELING AND ERGONOMICS 9**

Introduction to Finite Element Analysis, Analysis of bio mechanical systems using Finite element methods, Graphical design. Ergonomics- Gait analysis, Design of work station, Sports biomechanics, Injury mechanics.

**TOTAL: 45 PERIODS**

**OUTCOMES:**

- At the end of the course, the student should be able to:
- Explain the mechanics of physiological systems.
- Analyze the biomechanical systems.
- Design orthopaedic applications.

## REFERENCES:

1. Duane Knudson, "Fundamentals of Biomechanics", Second Edition Springer Science Business Media, 2007
2. Jay D. Humphrey, Sherry De Lange, "An Introduction to Biomechanics: Solids and Fluids, Analysis and Design", Springer Science Business Media, 2004.
3. Marcelo Epstein, "The Elements of Continuum Biomechanics", ISBN: 978-1-119-99923-2, 2012.
4. Shrawan Kumar, "Biomechanics in Ergonomics", Second Edition, CRC Press 2007.
5. Y.C. Fung, "Bio-Mechanics- Mechanical Properties of Tissues", Springer-Verlag, 1998.

**ED5078**

**COMPOSITE MATERIALS AND MECHANICS**

**L T P C**  
**3 0 0 3**

## OBJECTIVE

- To understand the fundamentals of composite material strength and its mechanical behavior
- Understanding the analysis of fiber reinforced Laminate design for different combinations of plies with different orientations of the fiber.
- Thermo-mechanical behavior and study of residual stresses in Laminates during processing.
- Implementation of Classical Laminate Theory (CLT) to study and analysis for residual stresses in an isotropic layered structure such as electronic chips.

## UNIT I INTRODUCTION TO COMPOSITE MATERIALS

**10**

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

## UNIT II MANUFACTURING OF COMPOSITES

**10**

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

## UNIT III INTRODUCTION, LAMINA CONSTITUTIVE EQUATIONS

**12**

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

## UNIT IV LAMINA STRENGTH ANALYSIS AND ANALYSIS OF LAMINATED FLAT PLATES

**8**

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



**UNIT V THERMAL ANALYSIS****5**

Assumption of Constant Co-efficient of Thermal Expansion (C.T.E.) - Modification of Hooke's Law. Modification of Laminate Constitutive Equations. Orthotropic Lamina C.T.E's. C.T.E's for special Laminate Configurations – Unidirectional, Off-axis, Symmetric Balanced Laminates, Zero C.T.E. laminates, Thermally Quasi-Isotropic Laminates

**TOTAL: 45 PERIODS****OUTCOME**

- At the end of the course the students will be in position to understand the mechanics and design related to layered components such as fiber reinforced polymer composites, isotropic layered structures (example electronic chips) etc and its manufacturing methodologies.

**REFERENCES:**

1. Agarwal, B.D., and Broutman L.J., "Analysis and Performance of Fiber Composites", John Wiley and Sons, New York, 1990.
2. Chung, Deborah D.L., "Composite Materials: Science and Applications", Ane Books Pvt. Ltd./Springer, New Delhi, 1st Indian Reprint, 2009
3. Gibson, R.F., Principles of Composite Material Mechanics, McGraw-Hill, 1994, Second Edition - CRC press in progress.
4. Halpin, J.C., "Primer on Composite Materials, Analysis", Techomic Publishing Co., 1984.
5. Hyer, M.W., "Stress Analysis of Fiber – Reinforced Composite Materials", McGraw-Hill, 1998
6. Issac M. Daniel and Ori Ishai, "Engineering Mechanics of Composite Materials", Oxford University Press-2006, First Indian Edition - 2007
7. Madhujit Mukhopadhyay, "Mechanics of Composite Materials and Structures", University Press (India) Pvt. Ltd., Hyderabad, 2004 (Reprinted 2008)
8. Mallick, P.K. and Newman, S., (edition), "Composite Materials Technology: Processes and Properties", Hansen Publisher, Munish, 1990.
9. Mallick, P.K., Fiber –"Reinforced Composites: Materials, Manufacturing and Design", Maneeel Dekker Inc, 1993.