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

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs) :

Enable the students **:**
1. To develop an aptitude to use modern computer tools to conceptualize, create, model, analyze and evaluate designs within the context of local and global needs.
2. To become effective and excellent collaborators and innovators, participating in efforts to address and provide fast and efficient solutions.
3. To provide creative and innovative solutions to industrial design problems using computer aided tools.
4. To pursue advanced education, research and development and other creative/ innovative efforts in their professional career.

PROGRAMME OUTCOMES (POs):
1. On successful completion of the programme,
2. Graduates will demonstrate knowledge of mathematics, science and engineering.
3. Graduates will demonstrate an ability to identify, formulate and solve engineering design problems by using computer aided tools.
4. Graduate will demonstrate an ability to design and conduct experiments, analyze and interpret data in the area of design engineering though software.
5. Graduates will demonstrate an ability to design a system, component or process as per needs and specifications.
6. Graduate will demonstrate skills to use modern engineering tools, software and equipment to analyze multidisciplinary problems.
7. Graduates will demonstrate knowledge of professional and ethical responsibilities in the field of mechanical design.
8. Graduate will communicate their technical knowledge.
9. Graduate will show the understanding of impact of engineering solutions on the society and also will be aware of contemporary issues.
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		√		√	√			√	√

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

Professional Electives

ELECTIVES	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
SEMESTER I									
Additive Manufacturing and Tooling			√		√			√	√
Design of Material Handling Equipments	√			√				√	√
Optimization Techniques in Design	√			√				√	√
Design of Pressure Vessels and Piping	√			√					√
Information Analytics									
SEMESTER II									
Advanced Tool Design	√			√	√			√	√
Industrial Robotics and Expert systems	√	√	√	√	√				
Computational Fluid Dynamics	√	√	√	√	√			√	√
Tribology in Design			√	√				√	√
Experimental Methods in Stress Analysis									
Mechanical Behavior of Materials									
SEMESTER III									
Plasticity and Metal Forming	√		√	√		√			
Engineering Fracture Mechanics	√	√	√	√					√
Composite Materials and Mechanics	√	√	√	√	√			√	√
Design for Manufacture, Assembly and Environments		√	√	√	√			√	√
Design for Internet of Things									
Biomechanics									
Systems Engineering									

ANNA UNIVERSITY, CHENNAI

AFFILIATED INSTITUTIONS

REGULATIONS 2017

M.E. COMPUTER AIDED DESIGN

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
THEORY								
1.	MA5156	Applied Mathematics for Engineers	FC	4	4	0	0	4
2.	ED5092	Advanced Mechanics of Materials	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
PRACTICAL								
7.	ED5161	CAD Laboratory	PC	4	0	0	4	2
8.	ED5162	Advanced Analysis and Simulation Laboratory	PC	4	0	0	4	2
			TOTAL	27	19	0	8	23

SEMESTER II

SL. NO	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	ED5254	Vibration Analysis and Control	PC	3	3	0	0	3
2.	ED5251	Mechanisms Design and Simulation	PC	3	3	0	0	3
3.	CD5291	Computer Aided Tools for Manufacturing	PC	3	3	0	0	3
4.	ED5253	Integrated Mechanical Design	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
PRACTICAL								
7.	ED5261	Vibration Laboratory	PC	2	0	0	2	1
8.	CD5211	Design Project	EEC	4	0	0	4	2
			TOTAL	24	18	0	6	21

SEMESTER III

SL. NO	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	PD5091	Product Lifecycle Management	PC	3	3	0	0	3
2.		Professional Elective IV	PE	3	3	0	0	3
3.		Elective V	PE	3	3	0	0	3
PRACTICAL								
4.	CD5311	Project Work Phase I	EEC	12	0	0	12	6
			TOTAL	**21**	**9**	**0**	**12**	**15**

SEMESTER IV

SL. NO	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
PRACTICAL								
1.	CD5411	Project Work Phase II	EEC	24	0	0	24	12
			TOTAL	**24**	**0**	**0**	**24**	**12**

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

FOUNDATION COURSES (FC)

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

PROFESSIONAL CORE (PC)

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	ED5092	Advanced Mechanics of Materials	PC	3	3	0	0	3
2.	ED5152	Quality Concepts in Design	PC	3	3	0	0	3
3.	ED5151	Computer Applications in Design	PC	3	3	0	0	3
4.	ED5153	Advanced Finite Element Analysis	PC	4	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.	ED5254	Vibration Analysis and Control	PC	3	3	0	0	3
8.	ED5251	Mechanisms Design and Simulation	PC	3	3	0	0	3
9.	CD5291	Computer Aided Tools for Manufacturing	PC	3	3	0	0	3
10.	ED5253	Integrated Mechanical Design	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. COMPUTER AIDED DESIGN

SEMESTER I (Elective I)

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	CC5292	Additive Manufacturing and Tooling	PE	3	3	0	0	3
2.	ED5091	Design of Material Handling Equipments	PE	3	3	0	0	3
3.	ED5072	Design of Pressure Vessel and Piping	PE	3	3	0	0	3
4.	ED5073	Information Analytics	PE	3	3	0	0	3
5.	ED5071	Optimization Techniques in Design	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.	CD5001	Experimental Methods in Stress Analysis	PE	3	3	0	0	3
2.	CD5071	Advanced Tool Design	PE	3	3	0	0	3
3.	CD5091	Industrial Robotics and Expert Systems	PE	3	3	0	0	3
4.	ED5093	Computational Fluid Dynamics	PE	3	3	0	0	3
5.	ED5252	Mechanical Behavior of Materials	PE	3	3	0	0	3
6.	ED5074	Tribology in Design	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.	CD5002	Plasticity and Metal Forming	PE	3	3	0	0	3
2.	CC5291	Design for Manufacture, Assembly and Environments	PE	3	3	0	0	3
3.	ED5191	Engineering Fracture Mechanics	PE	3	3	0	0	3
4.	ED5075	Design for Internet of Things	PE	3	3	0	0	3
5.	AS5091	Systems Engineering	PE	3	3	0	0	3
6.	ED5077	Biomechanics	PE	3	3	0	0	3
7.	ED5078	Composite Materials and Mechanics	PE	3	3	0	0	3

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	CD5211	Design Project	EEC	4	0	0	4	2
2.	CD5311	Project Work Phase I	EEC	12	0	0	12	6
3.	CD5411	Project Work Phase II	EEC	24	0	0	24	12

MA5156   **APPLIED MATHEMATICS FOR ENGINEERS**   **L T P C**
                                                                        4 0 0 4

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 Poison'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, 2nd Edition, McGraw Hill, 2011.
3. James, G., "Advanced Modern Engineering Mathematics ", 3rd 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, 8th 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.

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

ED5151   **COMPUTER APPLICATIONS IN DESIGN**

L	T	P	C
3	0	0	3

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

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

ED5152   **QUALITY CONCEPTS IN DESIGN**

L	T	P	C
3	0	0	3

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

ED5153   **ADVANCED FINITE ELEMENT ANALYSIS**   **L T P C**
                                                                                  3 0 0 3
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 & Implict Methods- Lanchzos, Reduced method for large size system equations.

UNIT IV   FLUID MECHANICS AND HEAT TRANSFER   9
Governing Equations of Fluid Mechanics – Solid structure interaction - Inviscid and Incompressible Flow – Potential Formulations – Slow Non-Newtonian Flow – Metal and Polymer Forming – Navier Stokes Equation – Steady and Transient Solution.

UNIT V   ERROR ESTIMATES AND ADAPTIVE REFINEMENT   9
Error norms and Convergence rates – h-refinement with adaptivity – Adaptive refinement.

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

                                                                          TOTAL: 45 PERIODS
REFERENCES:
1. Bathe K.J., "Finite Element Procedures in Engineering Analysis", Prentice Hall, 1990.
2. Cook R.D., "Concepts and Applications of Finite Element Analysis", John Wiley and Sons Inc., Newyork, 1989.
3. Zienkiewicz, O.C. and Taylor, R.L., "The Finite Element Method", Fourth Edition, Volumes 1 &2, McGraw Hill International Edition, Physics Services, 1991.

	L	**T**	**P**	**C**
ED5161 **CAD LABORATORY**	**0**	**0**	**4**	**2**

OBJECTIVE:
- To impart knowledge on how to prepare drawings for various mechanical components using any commercially available 3D modelling 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

	L	**T**	**P**	**C**
ED5162 **ADVANCED ANALYSIS AND SIMULATION LABORATORY**	**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.

10

ED5254   **VIBRATION ANALYSIS AND CONTROL**   L   T   P   C

                                                                      3   0   0   3

OBJECTIVES:
- 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 & Eigenvectors 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
OUTCOMES:
- 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

ED5251   **MECHANISMS DESIGN AND SIMULATION**   **L T P C**
                                                                            3 0 0 3
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 Lingages-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:
1. Amitabha Ghosh and Asok Kumar Mallik, "Theory of Mechanism and Machines", EWLP, Delhi, 1999.
2. Kenneth J, Waldron, Gary L. Kinzel, "Kinematics, Dynamics and Design of Machinery", John Wiley-sons, 1999.
3. Ramamurti, V., "Mechanics of Machines", Narosa, 2005.
4. Robert L.Norton., "Design of Machinery",Tata McGraw Hill, 2005.
5. Sandor G.N., and Erdman A.G., "Advanced Mechanism Design Analysis and Synthesis", Prentice Hall, 1984.
6. Uicker, J.J., Pennock, G. R. and Shigley, J.E., "Theory of Machines and Mechanisms", Oxford University Press, 2005.

CD5291   **COMPUTER AIDED TOOLS FOR MANUFACTURING**   L   T   P   C
                                                               3   0   0   3

OBJECTIVES:
- The purpose of this course is to make the students to get familiarized with various computer aided tools that can be implemented in various industrial applications

UNIT I   COMPUTER AIDED MANUFACTURING   9
Manufacturing Processes – Removing, Forming, Deforming and joining – Integration equipments. Integrating CAD, NC and CAM – Machine tools – Point to point and continuous path machining, NC, CNC and DNC – NC Programming – Basics, Languages, G Code, M Code, Tool path generation and verification – CAD/CAM NC Programming – Production Control – Cellular Manufacturing

UNIT II   COMPUTER AIDED PROCESS PLANNING   9
Role of process planning in CAD/CAM Integration – Computer Aided Process Planning – Development, Benefits, Model and Architecture – CAPP Approaches – Variant, Generative and Hybrid – Process and Planning systems – CAM-I, D-CLASS and CMPP – Criteria in selecting a CAPP System.

UNIT III   COMPUTER AIDED INSPECTION   9
Engineering Tolerances – Need for Tolerances – Conventional Tolerances – FITS and LIMITS – Tolerance Accumulation and Surface quality – Geometric Tolerances – Tolerances Practices in design, Drafting and manufacturing – Tolerance Analysis – Tolerance synthesis – Computer Aided Quality control – Contact Inspection Methods – Non Contact Inspection Methods - Non optical.

UNIT IV   REVERSE ENGINEERING   9
Scope and tasks of Reverse Engineering – Domain Analysis – Process Duplicating – Tools for RE – Developing Technical data – Digitizing techniques – Construction of surface model – Solid part model – Characteristic evaluation – Software's and its application – CMM and its feature capturing – surface and solid modeling.

UNIT V   DATA MANAGEMENT   9
Strategies for Reverse Engineering Data management – Software application – Finding renewable software components – Recycling real time embedded software – Design experiments to evaluate a RE tools – Rule based detection for RE user interface – RE of assembly programs

TOTAL: 45 PERIODS
OUTCOME:
- It helps the students to get familiarized with computer aided tools for various industrial applications which includes manufacturing, process planning, inspection, data management and reverse engineering.

REFERENCES
1. Catherine A. Ingle, "Reverse Engineering", Tata McGraw Hill Publication, 1994
2. David D. Bedworth, Mark R. Henderson, Philp M. Wolfe, "Computer Integrated Design and manufacturing", McGraw Hill International series, 1991
3. Donald R. Honra, "Co-ordinate measurement and reverse Engineering, American Gear Manufacturers Association.
4. Ibrahim Zeid and R. Sivasubramanian, "CAD/CAM Theory and Practice", Revised First special Indian Edition, Tata McGraw Hill Publication, 2007
5. Ibrahim Zeid, "Mastering CAD/CAM", special Indian Edition, Tata McGraw Hill Publication, 2007
6. Linda Wills, "Reverse Engineering" Kluwer Academic Press, 1996

ED5253   **INTEGRATED MECHANICAL DESIGN**   L   T   P   C

                        (Use of Approved Data Book Is Permitted)   3   0   0   3

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

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

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.

CD5211   **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

PD5091   **PRODUCT LIFECYCLE MANAGEMENT**   **L T P C**

                                                                               3 0 0 3

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 (3rd 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 (2nd Edition).
6. Michael Grieves, "Product Life Cycle Management", Tata McGraw Hill, 2006.

CD5311	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.

CD5411	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.

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.

ED5091   **DESIGN OF MATERIAL HANDLING EQUIPMENTS**   L   T   P   C

(Use of Approved Data Book Is Permitted)   3   0   0   3

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

UNIT I   MATERIALS HANDLING EQUIPMENT   5
Types, selection and applications

UNIT II   DESIGN OF HOISTS   10
Design of hoisting elements: Welded and roller chains - Hemp and wire ropes - Design of ropes, pulleys, pulley systems, sprockets and drums, Load handling attachments. Design of forged hooks and eye hooks – crane grabs - lifting magnets - Grabbing attachments - Design of arresting gear - Brakes: shoe, band and cone types.

UNIT III   DRIVES OF HOISTING GEAR   10
Hand and power drives - Traveling gear - Rail traveling mechanism - cantilever and monorail cranes - slewing, jib and luffing gear - cogwheel drive - selecting the motor ratings.

UNIT IV   CONVEYORS   10
Types - description - design and applications of Belt conveyors, apron conveyors and escalators Pneumatic conveyors, Screw conveyors and vibratory conveyors.

UNIT V   ELEVATORS   10
Bucket elevators: design - loading and bucket arrangements - Cage elevators - shaft way, guides, counter weights, hoisting machine, safety devices - Design of fork lift trucks.

TOTAL: 45 PERIODS

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 NarayanaI yengar, "Machine Design Data Hand Book", Vol. 1 & 2, SumaPublishers, 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.

ED5072　　　　**DESIGN OF PRESSURE VESSEL AND PIPING**　　　L　T　P　C

　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　3　0　0　3

OBJECTIVE
- The main objective is to present the industrial related problems, procedures and design principles for pressure vessels and enhance the understanding of design procedure of pressure vessel and Design of piping layout.

UNIT I　　　INTRODUCTION　　　　　　　　　　　　　　　　　　　　　3
Methods for determining stresses – Terminology and Ligament Efficiency – Applications.

UNIT II　　　STRESSES IN PRESSURE VESSELS　　　　　　　　　　15
Introduction – Stresses in a circular ring, cylinder – Membrane stress Analysis of Vessel Shell components – Cylindrical shells, spherical Heads, conical heads – Thermal Stresses – Discontinuity stresses in pressure vessels.

UNIT III　　　DESIGN OF VESSELS　　　　　　　　　　　　　　　　15
Design of Tall cylindrical self supporting process columns – Supports for short, vertical and horizontal vessels – stress concentration – at a variable Thickness transition section in a cylindrical vessel, about a circular hole, elliptical openings. Theory of Reinforcement – pressure vessel Design. Introduction to ASME pressure vessel codes

UNIT IV　　　BUCKLING OF VESSELS　　　　　　　　　　　　　　　8
Buckling phenomenon – Elastic Buckling of circular ring and cylinders under external pressure – collapse of thick walled cylinders or tubes under external pressure – Effect of supports on Elastic Buckling of Cylinders – Buckling under combined External pressure and axial loading.

UNIT V　　　PIPING　　　　　　　　　　　　　　　　　　　　　　　4
Introduction – Flow diagram – piping layout and piping stress Analysis.

　　　　　　　　　　　　　　　　　　　　　　　　TOTAL: 45 PERIODS
OUTCOME
- It helps the student to get familiarized with the various theories and practice on pressure vessel and piping design and procedures which are necessary to solve the industrial practical problems that arise and also for the research in the field of pressure vessel design.

REFERENCES
1. Henry H. Bedner, "Pressure Vessels, Design Hand Book, CBS publishers and Distributors,1987.
2. John F. Harvey, Theory and Design of Pressure Vessels, CBS Publishers and Distributors,1987.
3. Stanley, M. Wales, "Chemical process equipment, selection and Design. Buterworths series in Chemical Engineering, 1988.
4. William. J., Bees, "Approximate Methods in the Design and Analysis of Pressure Vessels and Piping", Pre ASME Pressure Vessels and Piping Conference, 1997.

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, χ 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.

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.

UNIT II   CONSTRAINED OPTIMIZATION TECHNIQUES   10
Optimization with equality and inequality constraints - Direct methods – Indirect methods using penalty functions, Lagrange multipliers - Geometric programming

UNIT III   ADVANCED OPTIMIZATION TECHNIQUES   10
Multi stage optimization – dynamic programming; stochastic programming; Multi objective optimization, Genetic algorithms and Simulated Annealing techniques; Neural network & Fuzzy logic principles in optimization.

UNIT IV   STATIC APPLICATIONS   8
Structural applications – Design of simple truss members - Design applications – Design of simple axial, transverse loaded members for minimum cost, weight – Design of shafts and torsionally loaded members – Design of springs.

UNIT V   DYNAMIC APPLICATIONS   7
Dynamic Applications – Optimum design of single, two degree of freedom systems, vibration absorbers. Application in Mechanisms – Optimum design of simple linkage mechanisms.

TOTAL: 45 PERIODS
OUTCOME:
- It helps the students to get familiarized with the different approaches of optimizing (maximizing or minimizing) an engineering problem or a function.

REFERENCES:
1. Goldberg, D.E., "Genetic Algorithms in Search, Optimization and Machine Learning", Pearson,2008.
2. Johnson Ray, C., "Optimum design of mechanical elements", Wiley, John & Sons, 1990.
3. Kalyanmoy Deb, "Optimization for Engineering design algorithms and Examples", Prentice Hall of India Pvt. 2004.
4. Rao, Singaresu, S., "Engineering Optimization – Theory & Practice", New Age International (P)Limited, New Delhi, 2000.

CD5001   **EXPERIMENTAL METHODS IN STRESS ANALYSIS**   L   T   P   C

                                                                    3   0   0   3

OBJECTIVES:
- To impart the principles of measurement, its need, within the field of production, ibration, acoustics, fluid mechanics, fracture mechanics & NDT.

UNIT I   FORCES AND STRAIN MEASUREMENT   9
Strain gauge, principle, types, performance and uses. Photo elasticity – Principle and applications - Moire Fringe - Hydraulic jacks and pressure gauges – Electronic load cells – Proving Rings – Calibration of Testing Machines.

UNIT II   VIBRATION MEASUREMENTS   9
Characteristics of Structural Vibrations – Linear Variable Differential Transformer (LVDT) – Transducers for velocity and acceleration measurements. Vibration meter – Seismographs – Vibration Analyzer – Display and recording of signals – Cathode Ray Oscilloscope – XY Plotter – Chart Plotters – Digital data Acquisition systems.

UNIT III   ACOUSTICS AND WIND FLOW MEASURES   9
Principles of Pressure and flow measurements – pressure transducers – sound level meter – venturimeter and flow meters – wind tunnel and its use in structural analysis – structural modeling – direct and indirect model analysis

UNIT IV   DISTRESS MEASUREMENTS   9
Diagnosis of distress in structures – crack observation and measurements – corrosion of reinforcement in concrete – Half-cell, construction and use – damage assessment – controlled blasting for demolition.

UNIT V   NON DESTRUCTIVE TESTING METHODS   9
Load testing on structures, buildings, bridges and towers – Rebound Hammer – acoustic emission – ultrasonic testing principles and application – Holography – use of laser for structural testing – Brittle coating

                                                        TOTAL: 45 PERIODS
OUTCOME:
- As a design engineer at the end of course one could be confident with measurement principles in all the branches of mechanical engineering.

REFERENCES
1. D.E. Bray & R. K.Stanley, Non-destructive Evaluation, McGraw Hill Publishing Company, N.Y.1989
2. F.K Garas, J.L. Clarke and GST Armer, Structural assessment, Butterworths, London, 1987
3. JW Dalley and WF Riley, Experimental Stress Analysis, McGraw Hill Book Company, N.Y. 1991
4. L.S.Srinath et al, Experimental Stress Analysis, Tata McGraw Hill Company, New Delhi, 1984
5. R.S.Sirohi, HC Radhakrishna, Mechanical Measurements, New Age International (P) Ltd. 1997
6. Sadhu Singh – Experimental Stress Analysis, Khanna Publishers, New Delhi, 1996.

CD5071   **ADVANCED TOOL DESIGN**   L   T   P   C

                                                                         3   0   0   3

OBJECTIVES:
- The purpose of this course is to make the students to get familiarized with the design of various tools that can be implemented for different mechanical operations

UNIT I   INTRODUCTION TO TOOL DESIGN   8
Introduction –Tool Engineering – Tool Classifications– Tool Design Objectives – Tool Design in manufacturing- Challenges and requirements- Standards in tool design-Tool drawings -Surface finish – Fits and Tolerances - Tooling Materials- Ferrous and Non ferrous Tooling Materials-Carbides, Ceramics and Diamond -Non metallic tool materials-Designing with relation to heat treatment

UNIT II   DESIGN OF CUTTING TOOLS   9
Mechanics of Metal cutting –Oblique and orthogonal cutting- Chip formation and shear angle - Single-point cutting tools – Milling cutters – Hole making cutting tools- Broaching Tools - Design of Form relieved and profile relieved cutters-Design of gear and thread milling cutters

UNIT III   DESIGN OF JIGS AND FIXTURES   10
Introduction – Fixed Gages – Gage Tolerances –selection of material for Gages – Indicating Gages – Automatic gages – Principles of location – Locating methods and devices – Principles of clamping – Drill jigs – Chip formation in drilling – General considerations in the design of drill jigs – Drill bushings – Methods of construction –Thrust and Turning Moments in drilling - Drill jigs and modern manufacturing- Types of Fixtures – Vise Fixtures – Milling Fixtures – Boring Fixtures – Broaching Fixtures – Lathe Fixtures – Grinding Fixtures – Modular Fixtures – Cutting Force Calculations.

UNIT IV   DESIGN OF PRESS TOOL DIES   10
Types of Dies –Method of Die operation–Clearance and cutting force calculations- Blanking and Piercing die design – Pilots – Strippers and pressure pads- Presswork materials – Strip layout – Short-run tooling for Piercing – Bending dies – Forming dies – Drawing dies-Design and drafting.

UNIT V   TOOL DESIGN FOR CNC MACHINE TOOLS   8
Introduction –Tooling requirements for Numerical control systems – Fixture design for CNC machine tools- Sub plate and tombstone fixtures-Universal fixtures– Cutting tools– Tool holding methods– Automatic tool changers and tool positioners – Tool presetting– General explanation of the Brown and Sharp machine

                                                                  TOTAL: 45 PERIODS
OUTCOME:
- It helps the students to get familiarized with advanced tool design for various mechanical operations which includes cutting, jigs and fixtures, press tool dies and modern CNC machine tools.

REFERENCES
1. Cyrll Donaldson, George H.LeCain, V.C. Goold, "Tool Design", Tata McGraw Hill Publishing Company Ltd., 2000.
2. E.G. Hoffman," Jig and Fixture Design", Thomson Asia Pvt Ltd, Singapore, 2004
3. Haslehurst M., "Manufacturing Technology", The ELBS, 1978
4. Prakash Hiralal Joshi, "Tooling data", Wheeler Publishing, 2000
5. Venkataraman K., "Design of Jigs, Fixtures and Press tools", TMH, 2005

CD5091   INDUSTRIAL ROBOTICS AND EXPERT SYSTEMS   L   T   P   C

**   3   0   0   3**

OBJECTIVES:
- To teach students the basics of robotics, construction features, sensor applications, robot cell design, robot programming and application of artificial intelligence and expert systems in robotics.

UNIT I   INTRODUCTION AND ROBOT KINEMATICS   10
Definition need and scope of Industrial robots – Robot anatomy – Work volume – Precision movement – End effectors – Sensors. Robot Kinematics – Direct and inverse kinematics – Robot trajectories – Control of robot manipulators – Robot dynamics – Methods for orientation and location of objects.

UNIT II   ROBOT DRIVES AND CONTROL   9
Controlling the Robot motion – Position and velocity sensing devices – Design of drive systems – Hydraulic and Pneumatic drives – Linear and rotary actuators and control valves – Electro hydraulic servo valves, electric drives – Motors – Designing of end effectors – Vacuum, magnetic and air operated grippers.

UNIT III   ROBOT SENSORS   9
Transducers and Sensors – Tactile sensor – Proximity and range sensors – Sensing joint forces – Robotic vision system – Image Representation - Image Grabbing –Image processing and analysis – Edge Enhancement – Contrast Stretching – Band Rationing - Image segmentation – Pattern recognition – Training of vision system.

UNIT IV   ROBOT CELL DESIGN AND APPLICATION   9
Robot work cell design and control – Safety in Robotics – Robot cell layouts – Multiple Robots and machine interference – Robot cycle time analysis. Industrial application of robots.

**UNIT V   ROBOT PROGRAMMING, ARTIFICIAL INTELLIGENCE AND EXPERT
                  SYSTEMS   8**
Methods of Robot Programming – Characteristics of task level languages lead through programming methods – Motion interpolation. Artificial intelligence – Basics – Goals of artificial intelligence – AI techniques – problem representation in AI – Problem reduction and solution techniques - Application of AI and KBES in Robots.

TOTAL: 45 PERIODS

OUTCOME:
- The student will be able to design robots and robotic work cells and write program for controlling the robots.
- The student will be able to apply artificial intelligence and expert systems in robotics.

REFERENCES:
1. Deb, S.R."Robotics Technology and Flexible Automation", Tata McGraw-Hill, 1994.
2. K.S.Fu, R.C. Gonzalez and C.S.G. Lee, "Robotics Control, Sensing, Vision and Intelligence", McGraw Hill, 1987.
3. Kozyrey, Yu. "Industrial Robots", MIR Publishers Moscow, 1985.
4. Mikell, P. Groover, Mitchell Weis, Roger, N. Nagel, Nicholas G. Odrey," Industrial Robotics Technology, Programming and Applications", McGraw-Hill, Int. 1986.
5. Richard. D, Klafter, Thomas, A, Chmielewski, Michael Negin, "Robotics Engineering – An Integrated Approach", Prentice-Hall of India Pvt. Ltd., 1984.
6. Timothy Jordanides et al ,"Expert Systems and Robotics ", Springer –Verlag, New York, May 1991.
7. YoramKoren," Robotics for Engineers' McGraw-Hill, 1987.

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 Strokes 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 & $k – \varepsilon$, $k – \omega$ 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. JiyuanTu, 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 PublishingCorporation, 1980.
6. Versteeg and Malalasekera, N, "An Introduction to computational Fluid Dynamics The Finite Volume Method," Pearson Education, Ltd., Second Edition, 2014.

ED5252	**MECHANICAL BEHAVIOR OF MATERIALS**	L	T	P	C
		3	0	0	3

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_2O_3,SiC, Si_3N_4 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:
1. Ashby M.F., materials selection in Mechanical Design 2nd Edition, Butter worth1999.
2. Charles, J.A., Crane, F.A.A. and Fumess, J.A.G., Selection and use of engineering materials, (34d edition), Butterworth-Heiremann, 1997.
3. Flinn, R.A., and Trojan, P.K., Engineering Materials and their Applications, (4th Edition) Jaico, 1999.
4. George E.Dieter, Mechanical Metallurgy, McGraw Hill, 1988
5. Metals Hand book, Vol.10, Failure Analysis and Prevention, (10th Edition),Jaico, 1999.
6. Thomas H. Courtney, Mechanical Behavior of Materials, (2nd edition), McGraw Hill, 2000

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 andoutside contact zones-Film thickness and friction calculation- Rolling bearings- Stresses and deflections-Traction drives
                                                      TOTAL: 45 PERIODS
OUTCOMES:
- 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 PvtLtd , New Delhi, 2005
6. Williams J.A. "Engineering Tribology", Oxford Univ. Press, 1994.

CD5002   **PLASTICITY AND METAL FORMING**   L   T   P   C

                                                                                  3   0   0   3

OBJECTIVES:
- To impart knowledge on theory of plasticity, analysis of various metal forming processes that arise in engineering applications.

UNIT I   THEORY OF PLASTICITY   9
Theory of plastic deformation - Engineering stress and strain relationship – Stress tensor - Strain tensor - Yield criteria's - Plastic stress strain relationship – Plastic work - Equilibrium conditions - Incremental plastic strain

UNIT II   CONSTITUTIVE RELATIONSHIPS AND INSTABILITY   7
Uniaxial tension test - Mechanical properties - Work hardening, Compression test, bulge test, plane strain compression stress, plastic instability in uniaxial tension stress, plastic instability in biaxial tension stress

UNIT III   ANALYSIS OF METAL FORMING PROBLEMS   12
Slab analysis - Slip line method, upper bound solutions, statistically admissible stress field, numerical methods, contact problems, effect of friction, thermo elastic Elasto plasticity, elastovisco plasticity - Thermo mechanical coupling – Analysis of forging, rolling, extrusion and wire drawing processes - Experimental techniques of the evaluation of metal forming

UNIT IV   ANALYSIS OF SHEET METAL FORMING   8
Bending theory - Cold rolling theory - Hill's anisotropic theory, Hill's general yield theory - Sheet metal forming - Elements used - Mesh generation and formulation Equilibrium equations - Consistent full set algorithm - Numerical solutions procedures - examples of simulation of simple parts - Bench mark tests – Forming limit diagrams

UNIT V   ADVANCES IN METAL FORMING   9
Orbital forging, Isothermal forging, Warm forging, Hot and Cold isotropic pressing, high speed extrusion, rubber pad forming, micro blanking –Superplastic forming - Overview of Powder Metal techniques - Powder rolling - Tooling and process parameters

                                                          TOTAL: 45 PERIODS
OUTCOME:
- It helps the students to get familiarized with the various metal forming processes and its analysis which are necessary to solve the engineering problems numerically.

REFERENCES
1. Hosford. W. F and Caddell. RM., Metal Forming Mechanics and Metallurgy, Prentice Hall Eaglewood Cliffs, 1993.
2. Narayanaswamy. R, Theory of Metal Forming Plasticity, Narosa Publishers, 1999.
3. Shiro Kobayashi, Altan. T, Metal Forming and Finite Element Method, Oxford University Press, 1989.
4. Slater. R A. C., Engineering Plasticity - Theory & Applications to Metal Forming, John Wiely and Sons, 1987.
5. Surender Kumar, " Technology of Metal Forming Processes", Prentice Hall of India, New Delhi, 2008
6. Wagoner. R H., and Chenot. J.J., Metal Forming analysis,Cambridge University Press, 2002.

CC5291DESIGN FOR MANUFACTURE, ASSEMBLY AND ENVIRONMENTS   L   T   P   C

                                                                3   0   0   3

OBJECTIVE:
- 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, MarcelDekker.
2. Boothroyd, G, Heartz 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. ReasonPub., 1996.
7. Harry Peck , Designing for manufacture, Pitman– 1973
8. Kevin Otto and Kristin Wood, Product Design. Pearson Publication, (Fourth Impression) 2009.

ED5191   **ENGINEERING FRACTURE MECHANICS**   L   T   P   C

                                                                                       3   0   0   3

OBJECTIVES:
- 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 – Dugdaale 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 K1cvalues.- 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

OUTCOMES:
- 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 ", Fifth off 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. KareHellan, "Introduction of Fracture Mechanics", McGraw-Hill Book Company, 1985.
4. Preshant Kumar, "Elements of Fracture Mechanics", Wheeler Publishing, 1999.
5. TribikramKundu, "Fundamentals of Fracture Mechanics", Ane Books Pvt. Ltd. New Delhi/ CRCPress, 1st Indian Reprint, 2012

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", 1st 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", 1st Edition, Academic Press, 2014.
3. Vijay Madisetti and Arshdeep Bahga, "Internet of Things (A Hands-on-Approach)", 1stEdition, VPT, 2014.

AS5091   **SYSTEMS ENGINEERING**   **L T P C**
                                                                                          3 0 0 3
OBJECTIVE :
• Introduce the concepts related to system engineering, with design, analysis, game theory, decision making analysis, etc.

UNIT I   INTRODUCTION TO SYSTEM ENGINEERING   9
Overview, Systems definition and concepts, Conceptual system design, Systems thinking and Systems Engineering.

UNIT II   DESIGN AND DEVELOPMENT   9
Detail Design Requirements, The Evolution of Detail Design, Design Data, Information, and Integration, Various phases in product life cycle, Systems verification & Integration

UNIT III   DESIGN FOR OPERATIONAL FEASIBILITY   9
Design for Reliability, Maintainability, Usability, Sustainability and Affordability - Definition and Explanation, Measures, System Life Cycle cost, Analysis Methods, Practical considerations.

UNIT IV   SYSTEMS ENGINEERING MANAGEMENT   9
Systems Engineering Planning and Organization, Systems Engineering Management Plan (SEMP), Program Leadership and Direction, Risk Management, Evaluation and Feedback.

UNIT V   CASE STUDIES   9
Systems Integration -Aircraft Systems, Missile Systems, Satellite Systems-Launch Vehicle Systems and Radar, Design Drivers in the Project, Product, Operating Environment-Interfaces with the Subsystems.
                                                                              , TOTAL: 45 PERIODS
OUTCOME:
Upon completion of this course, students will understand to impart the advanced concepts of systems engineering to the engineers and to provide the necessary mathematical knowledge that are needed in understanding their significance and operation. The students will have an exposure on various topics such as conceptual system design, system design and development, design for operational feasibility, systems engineering management and will be able to deploy these skills effectively in the understanding of systems engineering.

REFERENCES:
1. Design and Development of an Aircraft Systems by Ian Moir and Allan Seabridge.
2. Gandoff, M.,(1990). Systems Analysis and Design.
3. Introduction to Systems Engineering by Andrew P.Sage and James .Armstrong.
4. Systems Engineering and Analysis by Benjamin S. Blanchard / Wolter J.Fabrycky, Prentice Hall, International Version 2010
5. Systems Engineering by Erik Aslaksen and Rod Belcher.

ED5077   **BIOMECHANICS**   L   T   P   C

                                                                 3   0   0   3

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 NavierStoke's equations, Viscoelasticity, 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

OBJECTIVES:
- 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 (Qij), Definition of stress and Moment Resultants. Strain Displacement relations. Basic Assumptions of Laminated anisotropic plates. Laminate Constitutive Equations – Coupling Interactions, Balanced Laminates, Symmetric Laminates, Angle Ply Laminates, Cross Ply Laminates. Laminate Structural Moduli. Evaluation of Lamina Properties from Laminate Tests. Quasi-Isotropic Laminates. Determination of Lamina stresses within Laminates.

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", JohnWiley 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 OriIshai, "Engineering Mechanics of Composite Materials", Oxford University Press-2006, First Indian Edition - 2007
7. Madhujit Mukho padhyay, "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", Maneel Dekker Inc, 1993.