Rajalakshmi Engineering College, Thandalam

(An Autonomous Institution and Affiliated to Anna University, Chennai)

Department of Mechanical Engineering

Regulation 2023

M.E. – Engineering Design

Curriculum & Syllabus

RAJALAKSHMI ENGINEERING COLLEGE

(An Autonomous Institution and Affiliated to Anna University, Chennai)

M.E. ENGINEERING DESIGN

REGULATIONS 2023

CHOICE BASED CREDIT SYSTEM (CBCS)

CURRICULUM AND SYLLABUS

DEPARTMENT VISION

To provide a world class Mechanical Engineering education through innovation and excellence in Teaching and Research.

DEPARTMENT MISSION

- To impart high quality technical education and develop Mechanical Engineers with all round knowledge of multi-disciplinary branches of engineering and technology.
- To foster skill sets required to be a global professional in the areas of industry, research and technology management.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):

I. To comprehend the principles and methodologies employed in engineering to ideate, construct, simulate, validate, and assess designs, considering both local and global requirements.

II. To understand and explore the behaviour of existing and new materials suitable for design needs.

III. To develop innovative technologies and find solutions to contemporary issues in Engineering Design using fundamental principles in combination with modern engineering tools and methods.

IV. To pursue advanced education, research and development and other creative/ innovative efforts in their professional career.

PROGRAMME OUTCOMES (POs):

On successful completion of the Engineering Design programme,

1. An ability to independently carry out research /investigation and development work to solve practical problems.
2. An ability to write and present a substantial technical report/document.
3. Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.
4. Students should possess the capacity to recognize the significance of the creative process in design and exhibit proficiency in identifying, formulating, designing, and resolving engineering problems within a system.
5. Students should be able to use the techniques, and modern engineering tools necessary for engineering problems.
6. Responsibility of understanding ethically and professionally and develop confidence for self-education and ability for life-long learning.

PEO/PO Mapping:

PEO	PO					
	1	2	3	4	5	6
I	√	√	√	√		
II	√	√	√			√
III	√	√	√	√	√	
IV	√	√	√	√		√

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SEMESTER I

S.NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1	ED23111	Advanced Mechanics of Materials	PC	4	3	1	0	4
2	ED23112	Advanced Mechanisms in Design	PC	3	3	0	0	3
3	ED23113	Design with advanced materials	PC	3	3	0	0	3
4	ED23131	Vibration Analysis and Control	PC	5	3	0	**2**	4
5	PG23111	Research Methodology and IPR	PC	3	3	0	0	3
6	PE-1	Professional Elective-1	PE	3	3	0	0	3
7	AC-1	Audit Course-I	AC	2	2	0	0	0
PRACTICAL								
8	ED23121	Mechanism Design Laboratory	PC	4	0	0	4	2
							TOTAL :	**22**

SEMESTER II

S.NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1	ED23211	Finite Element Methods in Mechanical Design	PC	4	3	1	0	4
2	ED23212	Integrated Product Design and Process Development	PC	3	3	0	0	3
3	ED23213	Engineering Fracture Mechanics	PC	3	3	0	0	3
4	PE-2	Professional Elective-2	PE	3	3	0	0	3
5	PE-3	Professional Elective-3	PE	3	3	0	0	3
6	PE-4	Professional Elective-4	PE	3	3	0	0	3
7	AC-2	Audit Course-II	AC	2	2	0	0	0
PRACTICAL								
8	ED23221	Product Design and Development Laboratory	PC	2	0	0	2	1
9	ED23222	Analysis Laboratory	PC	4	0	0	4	2
							TOTAL :	**22**

SEMESTER III

S.NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1	PE-5	Professional Elective-5	PE	3	3	0	0	3
2	PE-6	Professional Elective-6	PE	3	3	0	0	3
3		Open Elective	OE	3	3	0	0	3
PRACTICAL								
4	ED23321	Research Article Writing	PC	2	0	0	2	1
5	ED23322	Internship	EEC	2	0	0	2	1
6	ED23323	Dissertation-I	EEC	12	0	0	12	6
							TOTAL :	**17**

SEMESTER IV

S.NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
PRACTICAL								
1	ED23421	Dissertation-II	EEC	24	0	0	24	12
							TOTAL :	**12**

TOTAL NO. OF CREDITS: 22+22+17+12 = 73

PROFESSIONAL ELECTIVES –I

S.NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1	ED23P11	Condition Based Monitoring	**PE**	3	3	0	0	3
2	ED23P12	Composite Materials And Mechanics	**PE**	3	3	0	0	3
3	ED23P13	Design of Hydraulic And Pneumatic Systems	**PE**	3	3	0	0	3
4	ED23P14	Design and Analysis Of Experiments	**PE**	3	3	0	0	3
5.	ED23P15	Advanced Machine Tool Design	**PE**	3	3	0	0	3

PROFESSIONAL ELECTIVES –II

S.NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1	ED23P21	Design For Manufacturing and Assembly	**PE**	3	3	0	0	3
2	ED23P22	Additive Manufacturing	**PE**	3	3	0	0	3
3.	ED23P23	Design of Pressure Vessel and Piping	**PE**	3	3	0	0	3

PROFESSIONAL ELECTIVES –III

S.NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1	ED23P24	Optimization Techniques in Design	**PE**	3	3	0	0	3
2	ED23P25	Computer Graphics for Design Engineers	**PE**	3	3	0	0	3
3	ED23P26	Design for X	**PE**	3	3	0	0	3

PROFESSIONAL ELECTIVES –IV

S.NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1	ED23P27	Corrosion and Surface Engineering	**PE**	3	3	0	0	3
2	ED23P28	Quality Concept in Design	**PE**	3	3	0	0	3
3	ED23P29	Bearing Design and Rotor Dynamics	**PE**	3	3	0	0	3

PROFESSIONAL ELECTIVES –V

S.NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1	ED23P31	Product Life Cycle Management	**PE**	3	3	0	0	3
2	ED23P32	Advanced Finite Element Analysis	**PE**	3	3	0	0	3
3	ED23P33	Artificial Intelligence and Machine Learning in Design	**PE**	3	3	0	0	3
4.	ED23P34	Failure Analysis and Prevention	**PE**	3	3	0	0	3

PROFESSIONAL ELECTIVES –VI

S.NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1	ED23P35	Material Handling Systems Design	**PE**	3	3	0	0	3
2	ED23P36	Tribology in Design	**PE**	3	3	0	0	3
3	ED23P37	Mechanical Measurements and Analysis	**PE**	3	3	0	0	3
4.	ED23P38	Computational Fluid Dynamics	**PE**	3	3	0	0	3
5.	ED23P39	Material Characterisation Techniques	**PE**	3	3	0	0	3

Open Electives

1. Business Analytics
2. Operations Research
3. Cost Management of Engineering Projects
4. Composite Materials
5. Waste to Energy

Audit course 1 & 2

1. English for Research Paper Writing
2. Disaster Management
3. Sanskrit for Technical Knowledge
4. Value Education
5. Constitution of India
6. Pedagogy Studies
7. Stress Management by Yoga
8. Personality Development through Life Enlightenment Skills

SEMESTER- I

Subject Code	Subject Name (Theory course)	Category	L	T	P	C
ED23111	ADVANCED MECHANICS OF MATERIALS	PC	3	1	0	4

Objectives:

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

UNIT-I	**ELASTICITY**	**9 + 3**
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. Mohr's Circle in 3D.		
UNIT-II	**SHEAR CENTER AND UNSYMMETRICAL BENDING**	**9 + 3**
Location of shear center for various thin sections - shear flows. Stresses and Deflections in beams subjected to unsymmetrical loading-kern of a section. Shear Center of Composite Beams Formed from Stringers and Thin Webs.		
UNIT-III	**STRESSES IN FLAT PLATES AND CURVED MEMBERS**	**9 + 3**
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. Indeterminate structures		
UNIT-IV	**TORSION OF NON-CIRCULAR SECTIONS**	**9 + 3**
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 + 3**
Radial and tangential stresses in solid disc and ring of uniform thickness and varying thickness allowable speeds. Methods of computing contact stress-method of computing-deflection of bodies in point and line contact with load – normal and tangent to contact area.		
	Total Contact Hours : 60	

Course Outcomes: On completion of this course, the students will be able to

- Apply the concepts of theory of elasticity in three-dimensional stress system.
- Determine the shear centre, stresses and deflection of various cross section due to unsymmetrical loading.
- Analyse the stresses in flat plate and curved members.
- Analyse and predict stresses in the member due to torsional load.
- Determine the stresses in rotating components and compute stresses in contact problems.

Reference Books(s) / Web links:

1. Arthur P Boresi, Richard J. Schmidt, "Advanced mechanics of materials", John Wiley, 2002.
2. Timoshenko and Goodier, "Theory of Elasticity", McGraw Hill.1951
4. Srinath. L.S., "Advanced Mechanics of solids", Tata McGraw Hill, 2010.
5. G H Ryder Strength of Materials Macmillan, India Ltd, 2007.
6. Allan F. Bower, "Applied Mechanics of Solids", CRC press – Special Indian Edition -2012,
7. K. Baskar and T.K. Varadan, "Theory of Isotropic/Orthotropic Elasticity", Ane Books Pvt. Ltd., New Delhi, 2009

	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	3	1	1	3	2	1
CO 2	3	1	1	3	2	1
CO 3	3	1	1	3	2	1
CO 4	3	1	1	3	2	1
CO 5	3	1	1	3	2	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Subject Code	Subject Name (Theory course)	Category	L	T	P	C
ED23112	ADVANCED MECHANISMS IN DESIGN	PC	3	0	0	3

Objectives:	
•	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-Hartenberg Parameters – Forward and inverse kinematics of robot manipulators.		
UNIT-III	**PATH CURVATURE THEORY, COUPLER CURVE**	**9**
Fixed and moving centrodes, inflection points and inflection circle. Euler Savary equation, graphical constructions – cubic of stationary curvature. Four bar coupler curve- cusp, crunode coupler driven six-bar mechanisms-straight line mechanisms.		
UNIT-IV	**SYNTHESIS OF FOUR BAR MECHANISMS**	**9**
Type synthesis – Number synthesis – Associated Linkage Concept. Dimensional synthesis – function generation, path generation, motion generation. Graphical methods-Pole technique, inversion technique-point position reduction-two, three and four position synthesis of four- bar mechanisms. Analytical methods- Freudenstein's Equation-Bloch's Synthesis.		
UNIT-V	**SYNTHESIS OF COUPLER CURVE BASED MECHANISMS & CAM MECHANISMS**	**9**
Cognate Linkages-parallel motion Linkages. Design of six bar mechanisms-single dwell-double dwell - double stroke. Geared five bar mechanism-multi-dwell. Cam Mechanisms- determination of optimum size of cams. Mechanism defects.		
	Total Contact Hours : 45	

Course Outcomes: On completion of this course, the students will be able to	
•	Apply concepts of gross motion capability and develop multi loop kinematic chains and equivalent mechanisms.
•	Evaluate velocity and acceleration of complex mechanisms.
•	Draw inflection points and inflection circle of various kinematic linkages.
•	Synthesize four bar mechanisms using various techniques.
•	Design of six bar coupler driven mechanisms and cam mechanism.

Reference Books(s) / Web links:	
1	Robert L.Norton., "Design of Machinery", Tata McGraw Hill, 2011.
2	Eric Constans and Karl B. Dyer, "Introduction to Mechanism Design With Computer Applications", CRC Press, 2019.
3	Uicker, J.J., Pennock, G. R. and Shigley, J.E., "Theory of Machines and Mechanisms", Oxford University Press, 2014.
4	Amitabha Ghosh and Asok Kumar Mallik, "Theory of Mechanism and Machines", EWLP, Delhi,1999
5	Kenneth J, Waldron, Gary L. Kinzel, "Kinematics, Dynamics and Design of Machinery", John Wiley-sons, 2014.
6	Ramamurti, V., "Mechanics of Machines", Narosa, 2009
7.	http://vlabs.iitkgp.ernet.in/mr/
8.	http://mm-nitk.vlabs.ac.in/#

	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	2	1	3	3	1
CO 2	2	3	1	3	2	1
CO 3	2	2	1	3	2	1
CO 4	2	2	1	3	2	1
CO 5	2	3	1	3	3	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Subject Code	Subject Name (Theory course)	Category	L	T	P	C
ED23113	**DESIGN WITH ADVANCED MATERIALS**	**PC**	**3**	**0**	**0**	**3**

Objectives:	
•	Understanding selection of materials for various engineering applications, high temperature materials (super-alloys), engineering plastics, elastomers, ceramics, and coatings.

UNIT-I	**Design and Materials**	**9**
Engineering Design process and the role of materials; materials classification and their properties; material property charts; selection of materials based on function, objective, constraints and free variables; examples of material selection for typical applications.		
UNIT-II	**Selection of Materials**	**9**
Computer aided materials selection. Selection of process based on material classification; pencil curve approach; material selection for multiple constraints and multiple objective cases; multiple constraints and conflicting objectives. Co-selection of material and shape; concept of macroscopic and microscopic shape factors; Four-quadrant method of material selection.		
UNIT-III	**Polymers and FRP's**	**9**
General Properties of plastics, polymers and elastomers; visco-elastic properties; short-term and long-term properties of plastics; mathematical modelling of plastic properties; Maxwell, Kelvin-Voigt Models; fatigue and fracture of plastics; selection of plastics based on mechanical properties, degradation due to environment, wear. Fundamentals of fiber-reinforced plastics; Stress, strain analysis of continuous fiber composites, rule of mixtures, general deformation behaviour of laminates. Case studies on application of FRP's life cycle.		
UNIT-IV	**High Temperature Materials**	**9**
Introduction to high temperature materials; families of super alloys and their characteristics; creep and fatigue resistance of super alloys; role of precipitates in strengthening of super alloys; repair of super alloys after creep damage; coatings for high temperature materials. Application of high temperature materials- Case study.		
UNIT-V	**Ceramics and Coating**	**9**
Fundamentals of ceramics, general properties, applications of ceramics for critical applications. Design considerations. Surface treatment of materials using coatings; type of coatings; PVD and CVD coatings. Basics of electro-plating and electro-less plating. Measurement and testing of coatings and coated samples.		
	Total Contact Hours : 45	

Course Outcomes: On completion of this course, the students will be able to	
•	Elaborate on the characteristics and attributes exhibited by different materials.
•	Select the material for the product suitably.
•	Explain the behaviour of polymers and FRP's under various conditions.
•	Describe the behaviour of materials under creep.
•	Apply the various methods of coating over the surface.

Reference Books(s) / Web links:	
1	Ashby, M.F., "Materials Selection in Design", Butterworth-Heinemann, 4/e, 2010.
2	Crawford, R. J., "Plastics Engineering", Butterworth-Heinemann, 3/e, 2002.
3	Donachie, M. J. and Donachie, S. J., "Super alloys: A technical guide", ASM International, 2002.
4	Carter, C.B., and Grant, N. M., "Ceramic Materials: Science and Engineering", Springer, 2007.
5	Bralla, J. C., "Design for Manufacturability Handbook", McGraw-Hill Professional; 2/e, 1998.

	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	1	1	1	1	1
CO 2	2	1	1	1	1	1
CO 3	2	1	1	1	1	1
CO 4	2	1	1	1	1	1
CO 5	2	1	1	1	1	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Subject Code	Subject Name (Lab integrated course)	Category	L	T	P	C
ED23131	**VIBRATION ANALYSIS AND CONTROL**	**PC**	**3**	**0**	**2**	**4**

Objectives:	
•	To understand the Fundamentals of Vibration and its practical applications
	To calculate the natural frequencies and mode shapes of the single,two and multi degree freedom systems.
•	To understand the working principle and operations of various vibration measuring instruments
•	To understand the various Vibration control strategies.

UNIT-I	**FUNDAMENTALS OF VIBRATION and MEASURING INSTRUMENTS**	**10**
Introduction -Sources of Vibration-Mathematical Models- Displacement, velocity and Acceleration- Review of Single Degree Freedom Systems - - Response to Arbitrary and non- harmonic Excitations – Transient Vibration – Impulse loads- Critical Speed of Shaft-Rotor systems. Selection of Sensors, Vibrometers and accelerometers, Vibration Exciters-Mechanical, Hydraulic, Electromagnetic and Electrodynamics –Frequency Measuring Instruments.		
UNIT-II	**TWO DEGREE FREEDOM SYSTEM**	**8**
Introduction-Free Vibration Of Undamped and Damped - Forced Vibration With Harmonic Excitation System – Coordinate Couplings and Principal Coordinates. Estimation of natural frequency and mode shape of a two DoF system using software.		
UNIT-III	**MULTI-DEGREE FREEDOM SYSTEM AND CONTINUOUS SYSTEM**	**10**
Multi Degree Freedom System –Influence Coefficients and stiffness coefficients- Flexibility Matrix and Stiffness Matrix – Eigen Values and Eigen Vectors-Matrix Iteration Method –Approximate Methods: Dunkerley, Rayleigh's, and Holzer Method -Geared Systems-Eigen Values & Eigen vectors for large system of equations using sub space, Lanczos method - Continuous System: Vibration of String, Shafts and Beams. Estimation of natural frequency and mode shape of multi degree freedom system using software.		
UNIT-IV	**VIBRATION and NOISE CONTROL**	**9**
Specification of Vibration Limits – Vibration severity standards- Vibration as condition Monitoring Tool-Vibration Isolation methods - Dynamic Vibration Absorber - Static and Dynamic Balancing machines – Field balancing - Major sources of noise – Noise survey techniques – Measurement technique for vehicular noise – Road vehicle noise standards – Industrial noise sources – Control Strategies – Noise control at the source and along the path – use of acoustic barriers – Noise control at the receiver.		
UNIT-V	**EXPERIMENTAL METHODS IN VIBRATION ANALYSIS**	**8**
Vibration Analysis Overview - Experimental Methods in Vibration Analysis.-Vibration Measuring Instruments - - Accelerometer Mountings. - -. System Identification from Frequency Response -Testing for resonance and mode shapes.		
	Total Contact Hours : 45	

List of Experiments	
1.	To verify the dunker lay's rule.
2.	To determine the natural frequency of undamped torsional vibration of a single rotor shaft system.
3.	To determine the natural frequency of undamped torsional vibration of two rotor shaft system
4.	To determine the frequency of undamped free vibration of an equivalent spring mass system
5.	To determine the frequency of the beam using free vibration setup.
6.	To determine the critical speed of the shaft.
7.	To simulate the natural frequency of SDOF undamped and damped system using coding.
	Total Contact Hours : 30

Course Outcomes: On completion of this course, the students will be able to	
•	Describe the basics of vibration and its importance in engineering field.
•	Use various vibration measuring instruments, vibration control and analysis techniques.
•	Solve vibration problems with two degree of freedom and comprehend it with experiments
•	Determine Eigen values and Eigen vectors of the given beam and comprehend it with experiments.
•	Make vibration measurement and vibration analysis using different methods.
Reference Books(s) / Web links:	
1	Rao, S.S.," Mechanical Vibrations," Prentice Hall, 2011
2	Ramamurti. V, "Mechanical Vibration Practice and Noise Control, Alpha Science International, 2012
3	Grover G K, Mechanical Vibrations, Nemchand Publishers, Roorki, 2009.
4	Sujatha, Vibrations and Acoustics, TMH,2010
5	Graham Kelly, Mechanical Vibrations Theory & Applications, CENGAGE Learning, 2012.
6	Rao V. Dukkipati, J. Srinivas, Textbook of Mechanical Vibrations, Prentice-Hall of India Pvt.Ltd,2010
5.	http://mdmv-nitk.vlabs.ac.in/

	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	3	3	1	1	1	1
CO 2	3	3	1	1	3	1
CO 3	3	3	1	1	3	1
CO 4	3	3	1	1	1	1
CO 5	3	3	1	1	1	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Subject Code	Subject Name (Theory course)	Category	L	T	P	C
PG23111	**RESEARCH METHODOLOGY AND IPR**	**PC**	**3**	**0**	**0**	**3**

Objectives:	
●	At the end of this course the students will be able to understand the research problem formulation and analyse the research related information by following research ethics.
●	Inculcating the understanding of today's computer, information technology and also understand tomorrows world of ideas and creativity.
●	Emphasizing the role of IPR in individual and nations growth.

UNIT-I	**INTRODUCTION TO RESEARCH METHODOLOGY**	**9**
Objectives and Motivation of Research - Types of Research - Defining and Formulating the Research Problem - Errors in selecting a research problem - Features of research design, Different Research Designs- Criteria of good research - Problems encountered by researchers in India - Benefits to the society in general.		
UNIT-II	**DATA ANALYSIS AND HYPOTHESIS TESTING**	**9**
Data collection: Primary data - Secondary data - Data organization - Sample design - Estimation of population - Parametric vs. non parametric methods - Measures of central tendency and dispersion. ANOVA; Principles of least squares-Regression and correlation; Normal Distribution, Properties of Normal Distribution; Testing of Hypothesis – Hypothesis Testing Procedure, Types of errors, t-Distribution - Chi-Square Test as a Test of Goodness of Fit - Use of statistical software's.		
UNIT-III	**LITERATURE REVIEW AND RESEARCH REPORT WRITING**	**9**
Effective literature studies approaches- Importance of literature survey - Sources of information– analysis – Plagiarism - Research ethics. Interpretation and Report Writing - Techniques and Precautions; Report Writing – Significance - Different Steps – Layout - Types of reports, Mechanics of Writing a Research Report - Precautions in Writing Reports; Format of the research report.		

UNIT-IV	INTRODUCTION TO INTELLECTUAL PROPERTY , TRADE MARKS ,GRAPHICAL INDICATION AND INDUSTRIAL DESIGN	9
Importance of intellectual property rights; types of intellectual property-international organizations; Purpose and function of trademarks - acquisition of trade mark rights - protectable matter - selecting and evaluating trade mark - trade mark registration processes. Industrial designs and IC Layout design - Registrations of designs-Semiconductor Integrated circuits and layout design Act - Geographical indications-potential benefits of Geographical Indications.		
UNIT-V	**LAW OF COPYRIGHTS & PATENTS**	**9**
Fundamental of copy right law - originality of material - rights of reproduction - rights to perform the work publicly - copy right ownership issues - copy right registration -notice of copy right, international copy right law. Law of patents: Foundation of patent law, patent searching process - ownership rights and transfer New Developments in IPR: Administration of Patent System		
	Total Contact Hours : 45	

Course Outcomes: On completion of this course, the students will be able to	
●	Understand the research problem and research process
●	To formulate the hypothesis, data collection and processing, analyzing the data using statistical methods
●	Interpret the observations and communicating the novel findings through a research report.
●	Apply the conceptual knowledge of intellectual property rights for filing patents and trade mark registration process.
●	Understand the adequate knowledge on copyright and patent law and rights.

Reference Books(s) / Web links:	
1	C.R. Kothari, Research Methodology: Methods and Techniques, 2nd revised edition, New Age International Publishers, New Delhi, 2004.
2	Deborah, E. Bouchoux, Intellectual property right, 5th edition, Cengage learning, 2017.
3	R. Panneerselvam, Research Methodology, PHI learning Pvt. Ltd., 2009.
4	Prabuddha Ganguli, Intellectual property right - Unleashing the knowledge economy, Tata McGraw Hill Publishing Company Ltd, 2001.
5	Donald R. Cooper and Ramela S. Schindler, Business Research Methods, Tata McGraw- Hill Publishing Company Limited, New Delhi, 2000
6	Uma Sekaran, Research Methods for Business, John Wiley and Sons Inc., New York, 2000.
7	Ranjit Kumar, Research Methodology, Sage Publications, London, New Delhi, 1999.
8	T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand, 2008

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO 1	2	2	-	-	-	1
CO 2	2	2	2	-	2	-
CO 3	-	2	2	-	2	1
CO 4	-	-	2	-	-	2
CO 5	-	-	-	-	-	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Subject Code	Subject Name (Laboratory Course)	Category	L	T	P	C
ED23121	MECHANISM DESIGN LABORATORY	PC	0	0	4	2

Objectives:	
•	To make the students familiar with the design of various mechanism through software.

List of Experiments				
1	Simulation of Falling Stone – Find the displacement, velocity, and acceleration			
2	Simulation of Inclined Plane			
3	Simulation of Lift Mechanism			
4	Simulation of One-degree-of-freedom Pendulum			
5	Simulation of Projectile Motion			
6	Simulation of Spring Damper system			
7	Simulation of Suspension System			
8	Simulation of Four bar mechanism			
9	Simulation of Cam-Follower Mechanism			
10	Simulation of Crank Slider Mechanism			
11	Simulation of Valve train Mechanism			
12	Simulation of Cam-rocker-valve Mechanism			
13.	Project Work			
		Total Contact Hours	:	60

Course Outcomes: On completion of this course, the students will be able to	
•	Determine the displacement, velocity and acceleration of mechanisms.
•	Simulate the mechanism and find its degree of freedom.
•	Analyse the output of a mechanism
•	Design and model any real-world mechanism
•	Simulate and analyse the real-world mechanism

Web links for virtual lab (if any)	
1	https://www.psmotion.com/mechanism-design-software
2	http://blog.rectorsquid.com/linkage-mechanism-designer-and-simulator/
3	https://www.mscsoftware.com/sites/default/files/Book_Adams-Tutorial-ex17-w.pdf

	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	3	1	1	3	2
CO 2	2	3	1	1	3	2
CO 3	2	3	1	1	3	2
CO 4	2	3	1	1	3	2
CO 5	2	3	1	1	3	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

SEMESTER II

Subject Code	Subject Name (Theory course)	Category	L	T	P	C
ED23211	FINITE ELEMENT METHODS IN MECHANICAL DESIGN	PC	3	1	0	4

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

UNIT-I	**FINITE ELEMENT ANALYSIS OF ONE-DIMENSIONAL PROBLEMS**	**12**
Historical Background -Basic Concept of FEM – Finite Element Modelling – Element Equations – Linear and Quadratic Shape functions – Bar, Beam Elements – Bars and beams of arbitrary orientation . One dimension Heat transfer application.		
UNIT-II	**FINITE ELEMENT ANALYSIS OF TWO-DIMENSIONAL PROBLEMS**	**12**
Basic Boundary Value Problems in two-dimension – Triangular, quadrilateral, higher order elements – Element Matrices and Vectors – Application to scalar variable problem - Introduction to Theory of Elasticity – Plane Stress – Plane Strain and Axisymmetric Formulation – Principle of virtual work – Element matrices using energy approach – Examples related to two-dimensional problems.		
UNIT-III	**ISO-PARAMETRIC FORMULATION**	**12**
Natural Co-ordinate Systems – Lagrangian Interpolation Polynomials – Isoparametric Elements – Formulation – Numerical Integration – Gauss quadrature – one-, two- and three-dimensional triangular elements formulation – rectangular elements – Serendipity elements – Illustrative Examples.		
UNIT-IV	**EIGEN VALUE PROBLEMS**	**12**
Dynamic Analysis – Equations of Motion – Consistent and lumped mass matrices – Free Vibration analysis – Natural frequencies of Longitudinal, Transverse and torsional vibration – Solution of Eigenvalue problems - Introduction to transient field problems.		
UNIT-V	**NON-LINEAR ANALYSIS**	**12**
Introduction to Non-linear problems - some solution techniques- computational procedure material non-linearity- Plasticity and viscoplasticity, stress stiffening, contact interfaces- problems of gaps and contact - geometric non-linearity - modeling considerations - Free and Mapped meshing -Mesh quality- Error estimate		
	Total Contact Hours : 60	

Course Outcomes: On completion of this course, the students will be able to	
●	Develop mathematical models for one dimensional problems and their numerical solutions.
●	Determine field variables for two dimensional scalar and vector variable problems.
●	Apply Isoparametric transformation and numerical integration for evaluation of element matrices.
●	Solve Eigen value problems by using appropriate technique.
●	Understand and formulate solution techniques to solve non-linear problems.

Reference Books(s) / Web links:	
1	Klaus - Jurgen Bathe, Finite Element Procedures, PHI, 1996.
2	Rao,S.S., "The Finite Element Method in Engineering", Butterworth-Heinemann (An imprint of Elsevier), reprint 2012, Published by Elsevier India Pvt. Ltd., New Delhi,
3	Reddy, J.N., "Introduction to Non-Linear Finite Element Analysis", Oxford University Press, 2014
4	Zienkiewicz.O.C, Taylor.R.L,& Zhu,J.Z "The Finite Element Method: Its Basis & Fundamentals", Butterworth-Heinemann (An imprint of Elsevier), 2013, India
5	Cook, R.D., Malkus, D. S., Plesha,M.E., and Witt,R.J " Concepts and Applications of Finite Element Analysis", Wiley Student Edition, 4th Edition, First Reprint 2007, Authorized reprint by Wiley India(P) Ltd., New Delhi,
6.	https://nptel.ac.in/courses/112106135/
7.	https://www.digimat.in/nptel/courses/video/112104193/

	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	3	-	2	2	-	2
CO 2	3	-	2	2	1	2
CO 3	3	-	2	2	1	2
CO 4	3	-	2	2	1	2
CO 5	3	-	2	2	1	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Subject Code	Subject Name (Theory course)	Category	L	T	P	C
ED23212	**INTEGRATED PRODUCT DESIGN AND PROCESS DEVELOPMENT**	**PC**	**3**	**0**	**0**	**3**

Objectives:	
	1. To Understand the principles of generic development process; product planning; customer need analysis for new product design and development. 2. To enhance the understanding of setting product specifications and generate, select, screen, and test concepts for new product design and development. 3. To apply the principles of product architecture and the importance of industrial design principles and DFM principles for new product development. 4. To expose the different Prototyping techniques, Design of Experiment principles to develop a robust design and importance to patent a developed new product. 5. Applying the concepts of economics principles; project management practices in development of new product.

UNIT-I	**INTRODUCTION TO PRODUCT DESIGN AND IDENTIFICATION OF CUSTOMER NEED**	**9**
Need for IPPD - Strategic importance of Product development –Duration and Cost of Product Development – Challenges in Product Development - Product Development Processes and Organizations – Activities in Identifying Customer Needs.		
UNIT-II	**PRODUCT SPECIFICATIONS, CONCEPT GENERATION, SELECTION AND TESTING**	**9**
Plan and establish Target and Final product specifications – Activities of Concept Generation - Task - Concept Selection methodology – Concept Screening and Scoring - Concept Testing Methodologies.		
UNIT-III	**PRODUCT ARCHITECTURE , INDUSTRIAL DESIGN AND DESIGN FOR MANUFACTURE**	**9**
Product Architecture – Implications and establishing the architecture – Delayed Differentiation – Platform Planning - Need and impact of industrial design - Industrial design process - management of the industrial design process - assessing the quality of industrial design – DFM Definition - Estimation of Manufacturing cost- Reducing the component costs, costs of supporting function and assembly costs – Impact of DFM decision on other factors.		
UNIT-IV	**PROTOTYPING, ROBUST DESIGN AND INTELLECTUAL PROPERTY**	**9**
Prototype basics - Principles of prototyping - Planning for prototypes - Robust design – Seven step process of Robust Design through Design of Experiments- Need and Importance of Intellectual Property – Seven step process of preparing a patent document.		
UNIT-V	**PRODUCT DEVELOPMENT ECONOMICS AND MANAGING PROJECTS**	**9**
Economic Analysis – Elements of Economic Analysis - Understanding and representing tasks baseline project planning - accelerating the project - project execution – post mortem project evaluation.		
	Total Contact Hours : 45	

Course Outcomes: On completion of this course, the students will be able to	
●	Apply the principles of generic development process; product planning; customer need analysis for new product design and development.
●	Set product specifications and generate, select, screen, test concepts for new product design and development.
●	Apply the principles of product architecture, industrial design and design for manufacturing principles in new product development.
●	Apply and adopt Prototyping techniques and Design of Experiment principles to develop a robust design and document a new product for patent.
●	Apply of the concepts of economics principles; project management practices in accelerating the new product development activity.

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

	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	1	-	1	2	-	1
CO 2	1	-	1	2	-	1
CO 3	1	-	1	2	2	1
CO 4	1	-	1	2	-	1
CO 5	1	2	1	2	-	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Subject Code	Subject Name (Theory course)	Category	L	T	P	C
ED23213	**ENGINEERING FRACTURE MECHANICS**	PE	3	0	0	3

Objectives:	
●	Formulation of governing equations for elastic problems
●	Stresses calculations/displacements around the crack tip for different modes of fracture.
●	Estimation of K1c/SIF/critical flaws/failure stresses for different crack geometries
●	Life assessment of the cracked components under different types of repeated/variable fatigue loads and design for its life extension.
●	Analysis of failed engineering components under different modes of fracture.

UNIT-I	ELEMENTS OF SOLID MECHANICS	9
Introduction to Failure and Fracture- Spectacular Failures-Basics Principles-Governing equations for the deformable body-Stress-Strain relations and general equations of elasticity in Cartesian and Polar Coordinates-vectors and tensors-differential equations of equilibrium-compatibility boundary conditions-representation of three-dimensional stress system -generalized hook's law – plane stress and stain problems - Airy's stress function. Methods of formulation of Governing Differential equations for plane elasticity-Naviers Equation-Biharmonic equation in Cartesian and polar coordinates.		

UNIT-II	**STRESS AND DISPLACEMENT AROUND THE CRACK TIP FOR DIFFERENT MODES OF FRACTURE**	**9**
Brittle and Ductile Fracture-Modes of Fracture-Weakness of the components due to Flaws-Need for Linear Elastic Fracture Mechanics (LEFM) – Evaluation of Structural Design-Stress and displacement around the crack tip in K-annulus for Mode-I and Mode-II plane crack problems – Stress and displacement around the crack tip in K-annulus for Mode III crack problems.		
UNIT-III	**STATIONARY CRACK UNDER STATIC LOADING**	**9**
Griffith analysis- Irwin's approximation-CTOD and stress ahead of the crack tip- Westergaard solutions: Analytical Calculations for SIF for different crack geometries-Critical crack length and fracture stress calculations. Two dimensional elastic fields – Analytical solutions for small scale yielding near a crack front –- plastic zone size – Specimen size calculations: K1c Testing for Fracture toughness of the Material.		
UNIT-IV	**FATIGUE FAILURE AND ENVIRONMENTAL-ASSISTED FRACTURE**	**9**
ntroduction to fatigue failure-S-N Curve-Crack Initiation-Crack propagation- Effect of an Overload-Variable amplitude Fatigue load-Crack closure- Characteristics of fatigue crack-Paris Law- Fatigue Crack Growth Test to evaluate Paris constants- life calculations for a given load amplitude –effects of changing the load spectrum Environmental-assisted Fracture-Micro mechanisms-factors influencing Environmental-assisted fracture-Environment-assisted Fatigue Failure affecting fatigue performance, fatigue loading, constant and variable amplitude loading.		
UNIT-V	**APPLICATIONS OF FRACTURE MECHANICS**	9
J-integral, Mixed-mode fracture. Crack arrest methodologies- Case studies: Analysis on failed components and design for the extension of its life.		
	Total Contact Hours :	**45**

Course Outcomes: On completion of this course, the students will be able to	
●	Formulate governing equation for elastic problems
●	Calculate stresses/displacements around the crack tip for different modes of fracture
●	Estimate K1c/SIF/critical flaws/failure stresses for different crack geometries
●	Assess the life of the cracked components under different types of repeated/variablefatigue loads and design for its life extension.
●	Analyze failed engineering components under different modes of fracture.
Reference Books(s) / Web links:	
1	T.L. Anderson, Fracture Mechanics "Fundamentals and Applications, 3rd Edition, Taylor and Francis Group, 2005.
2	Prashant Kumar, "Elements of Fracture Mechanics", McGraw Hill Publication, 2017.
4	Tribikram Kundu, "Fundamentals of Fracture Mechanics", Ane Books Pvt. Ltd. New Delhi/ CRCPress, 1st Indian Reprint, 2012
5.	https://nptel.ac.in/courses/112106065/
6.	K. Ramesh, e-Book on Engineering Fracture Mechanics, IIT Madras, 2007.

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO 1	2	-	2	2	-	2
CO 2	2	1	2	2	1	2
CO 3	2	1	2	2	1	2
CO 4	2	1	2	2	1	2
CO 5	2	1	2	2	1	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Subject Code	Subject Name (Laboratory Course)	Category	L	T	P	C
ED23221	PRODUCT DESIGN AND DEVELOPMENT LABORATORY	PC	0	0	2	1

Objectives:	
●	To give exposure to develop digital and physical prototype models using 3d printing a new product/ existing product.

List of Experiments			
	Each student must develop digital and physical prototype models using RP machine of a new product/ existing product with enhanced feature involving the following areas: • Automotive components • Tool and die components • Press tool components • Consumer product • Injection moulded products		
	Total Contact Hours	**:**	**30**

Course Outcomes: On completion of this course, the students will be able to	
●	Do a survey of product, function(s) and its cons
●	Provide a solution to the cons in the product.
●	
●	Appreciate the use of physical prototype models for evaluating product concept
●	Apply theoretical knowledge to design and development of physical products RP techniques

	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	2	2	2	2	2
CO 2	2	2	2	2	2	2
CO 3	2	2	2	2	2	2
CO 4	2	2	2	2	2	2
CO 5	2	2	2	2	2	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Subject Code	Subject Name (Laboratory Course)	Category	L	T	P	C
ED23222	ANALYSIS LABORATORY	PC	0	0	4	2

Objectives:	
●	At the end of this course, the students would have developed a thorough understanding of the Computer Aided Finite Element Analysis packages with an ability to effectively use the tools of the analysis for solving practical problems arising in engineering design.

List of Experiments				
1	Machine elements under Static loads			
2	Thermal Analysis of mechanical systems			
3	Modal Analysis			
4	Machine elements under Dynamic loads			
5.	Buckling Analysis			
6.	Contact Analysis			
7.	Non-linear structural analysis			
8.	Composite Materials Analysis			
		Total Contact Hours	**:**	**60**

Course Outcomes: On completion of this course, the students will be able to	
●	Preprocess the component for static force analysis.
●	Create or Import Solid/surface models
●	Mesh the component for further analysis.
●	Analyse the model for different types of loads.
●	Validate the model/mesh for correct result.

Web links for virtual lab (if any)	
1	https://sites.ualberta.ca/~wmoussa/AnsysTutorial/
2	https://www.udemy.com/ansys-tutorial/
3	Divya Zindani (Author), Apurba Kumar Roy (Author), Kaushik Kumar. Working with ANSYS: A Tutorial Approach, I.K. International Publishing House, 2017.

	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	2	2	2	3	2
CO 2	2	2	2	2	3	2
CO 3	2	2	2	2	3	2
CO 4	2	2	2	2	3	2
CO 5	2	2	2	2	3	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Subject Code	Subject Name (Theory course)	Category	L	T	P	C
ED23P11	CONDITION BASED MONITORING	PE	3	0	0	3

Objectives:	
●	To educate students with fundamental and advanced knowledge about the maintenance of system through various condition monitoring techniques.

UNIT-I	Introduction to Maintenance and Condition-Based Maintenance	9
Definition, system approach, objectives, responsibilities of maintenance department, maintenance strategies, principles of maintenance, concepts of maintainability, availability and reliability, implementation of CBM, comparison of CBM with other maintenance techniques and case studies (overview). Introduction to condition monitoring, Basic concept, techniques - visual monitoring, temperature monitoring, vibration monitoring, lubricant monitoring, crack monitoring, thickness monitoring, noise and sound monitoring.		
UNIT-II	**Signal Processing**	**9**
Basic signal processing techniques, Probability distribution and density, Fourier analysis, Hilbert Transform, Cepstrum analysis, Digital filtering, Deterministic / random signal separation, Time-frequency analysis. Wavelet Transform Introduction to Wavelets, Continuous Wavelet Transform (CWT), Discrete Wavelet Transform (DWT), Wavelet Packet Transform (WPT),types of wavelets – Haar wavelets, Shannon wavelets, Meyer wavelets, Daubechies wavelets, Coifmann wavelets and applications of wavelets.		
UNIT-III	**Vibration Monitoring**	**9**
Introduction, vibration data collection, techniques, instruments, transducers, selection, measurement location, time domain analysis, frequency domain analysis, time-frequency domain analysis and commonly witnessed machinery faults diagnosed by vibration analysis. Rotating and reciprocating machines, Vibration signals from rotating and reciprocating machines – signal classification, signals generated by rotating machines, signals generated by reciprocating machines.		
UNIT-IV	**Mechanical Fault Diagnosis**	**9**
Wear monitoring and lubricant analysis - sources of contamination, techniques, Spectrometric Oil Analysis Procedure (SOAP) and ferrography. –Non-destructive testing techniques Measurement of surface and subsurface flaws – liquid penetrant inspection, eddy current inspection, radiographic inspection, ultrasonic inspection.		
UNIT-V	**Condition Monitoring of Rotating Elements**	**9**
Condition monitoring of rolling element bearings and gear Introduction, construction, types of faults, rolling element bearing diagnostics and gear diagnostics. Tools wear monitoring- Introduction, techniques and case studies.		
	Total Contact Hours : 45	

Course Outcomes:	
On completion of this course, the students will be able to	
●	Apply the different types of maintenance used and its significant role in condition based monitoring.
●	Implement the basic signal processing techniques
●	Apply the role of vibration monitoring, its methodology and its use in condition monitoring of rotating and reciprocating machines
●	Apply mechanical fault diagnosis and non-destructive testing techniques in monitoring and maintenance.
●	Use condition monitoring of rolling element bearing, gears and tool condition monitoring techniques in machining

Reference Books(s) / Web links:	
1	Robert Bond Randall – Vibration-Based Condition Monitoring – Industrial, Aerospace and Automotive applications, John Wiley & Sons Ltd., 2011
2	R.C.Mishra, K.Pathak – Maintenance Engineering and Management, Prentice Hall ofIndia Pvt. Ltd., 2002.
3	K. P. Soman, K. I. Ramachandran, N. G. Resmi – Insight into wavelet from theory to practice, Third Edition, Prentice Hall of India, ISBN: 978-81-203-4053-
4	John S.Mitchell, Introduction to Machinery Analysis and Monitoring, PennWell Books,1993.

	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	2	2	-	1	1
CO 2	2	2	2	-	1	1
CO 3	2	2	2	-	1	1
CO 4	2	2	2	-	1	1
CO 5	2	2	2	-	1	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Subject Code	Subject Name (Theory course)	Category	L	T	P	C
ED23P12	**COMPOSITE MATERIALS AND MECHANICS**	**PE**	**3**	**0**	**0**	**3**

Objectives:	
•	To understand the fundamentals of composite material strength and its mechanical behaviour
•	Understanding the analysis of fiber reinforced Laminate design for different combinations of plies with different orientations of the fiber.
•	Thermo-mechanical behaviour 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**	**9**
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, Testing standards in composites.		
UNIT-II	**MANUFACTURING OF COMPOSITES**	**9**
Manufacturing of Polymer Matrix Composites (PMCs)-hand lay-up, spray technique, filament winding, pultrusion, Resin Transfer Moulding (RTM)-, bag moulding, injection moulding, Sandwich Mould Composites (SMC) - Manufacturing of Metal Matrix Composites (MMCs) – Solid state, liquid state, vapour state processing, Manufacturing of Ceramic Matrix Composites (CMCs) –hot pressing-reaction bonding process-infiltration technique, direct oxidation- interfaces.		
UNIT-III	**LAMINA CONSTITUTIVE EQUATIONS**	**9**
Lamina Constitutive Equations: Lamina Assumptions – Macroscopic Viewpoint. Generalized Hooke's Law. Reduction to Homogeneous Orthotropic Lamina – Isotropic limit case, Orthotropic Stiffness matrix (Qij), Definition of stress and Moment Resultants. Strain Displacement relations. Basic Assumptions of Laminated anisotropic plates. Laminate Constitutive Equations – Coupling Interactions, Balanced Laminates, Symmetric Laminates, Angle Ply Laminates, Cross Ply Laminates. Laminate Structural Moduli. Evaluation of Lamina Properties from Laminate Tests. Quasi-Isotropic Laminates. Determination of Lamina stresses within Laminates. Estimation of laminate stress ,strain etc using software tool.		
UNIT-IV	**LAMINA STRENGTH ANALYSIS AND ANALYSIS OF LAMINATED FLAT PLATES**	**9**
Introduction - Maximum Stress and Strain Criteria. Von-Misses Yield criterion for Isotropic Materials. Generalized Hill's Criterion for Anisotropic materials. Tsai-Hill's Failure Criterion for Composites. Tensor Polynomial (Tsai-Wu) Failure criterion. Prediction of laminate Failure Equilibrium Equations of Motion. Energy Formulations. Static Bending Analysis. Buckling Analysis. Free Vibrations – Natural Frequencies. Estimation of laminate stress ,strain under buckling load, etc using software tool.		
UNIT-V	**THERMAL ANALYSIS**	**9**
Residual stress in FRP composites- Coefficient of thermal expansion (C.T.E)- Modification of Hooke's law – Modification of laminate constitutive equation. Orthotropic lamina – C.T.E- stress-Moment resultant due to cooling of lamina – Calculation of thermo-mechanical stress in lamina.		
	Total Contact Hours : 45	

Course Outcomes: On completion of this course, the students will be able to	
•	Describe and understand various types of composites.
•	Adopt various manufacturing methods based on type of composite.
•	Predict lamina properties of different composites.
•	Evaluate laminate properties using various theories.
•	Analyse and evaluate thermo-mechanical behaviour of FRP composite

Reference Books(s) / Web links:	
1	Gibson, R.F., Principles of Composite Material Mechanics, Fourth Edition - CRC press ,2016
2	Hyer, M.W., "Stress Analysis of Fiber – Reinforced Composite Materials",DES tech Publication Inc, 2009
3	Mallick, P.K., "Fiber Reinforced Composites: Materials, Manufacturing and Design", Third Edition, CRC Press, 2007.
4	Agarwal, B.D., and Broutman L.J., "Analysis and Performance of Fiber Composites", Fourth Edition, Wiley, New York, 2017.
5	Madhujit Mukhopadhyay, "Mechanics of Composite Materials and Structures", University Press (India) Pvt. Ltd., Hyderabad, 2005 (Reprinted 2008)
6	Ever J. Barbero, Finite Element Analysis of Composite Materials Using ANSYS, CRC Press, 2013.
7	https://nptel.ac.in/courses/112104229/2
8	https://nptel.ac.in/courses/112104249/
9	https://www.mathworks.com/matlabcentral/fileexchange/48522-abd-matrix-of-composite-laminate-theory

	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	1	-	2	1	2	2
CO 2	2	-	2	1	2	2
CO 3	2	-	2	1	2	2
CO 4	2	-	2	1	2	2
CO 5	2	-	2	1	2	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Subject Code	Subject Name (Theory course)	Category	L	T	P	C
ED23P13	DESIGN OF HYDRAULIC AND PNEUMATIC SYSTEMS	PE	3	0	0	3

Objectives:		
●	To impart students on the science, use and application of hydraulics and pneumatics as fluid power in Industry. Also, to impart knowledge on the methodology of basic and advanced design of pneumatics and hydraulics systems.	
UNIT-I	**OIL HYDRAULIC SYSTEMS AND HYDRAULIC ACTUATORS**	**7**
Hydraulic Power Generators – Selection and specification of pumps, pump characteristics. Linear and Rotary Actuators – selection, specification and characteristics, Hydrostatic drives, types, selection.		
UNIT-II	**CONTROL AND REGULATION ELEMENTS**	**10**
Pressure - direction and flow control valves - relief valves, non-return and safety valves – actuation systems, Proportional Electro hydraulic servo valves.		
UNIT-III	**HYDRAULIC CIRCUITS**	**8**
Reciprocation, quick return, sequencing, synchronizing circuits - accumulator circuits – industrial circuits - press circuits - hydraulic milling machine - grinding, planning, copying, - forklift, earth mover circuits design methodology- design and selection of components - safety and emergency mandrels – Cascade method. Simulation of hydraulic circuits using software tools.		
UNIT-IV	**PNEUMATIC SYSTEMS AND CIRCUITS**	**10**
Pneumatic fundamentals - control elements, position and pressure sensing, Pneumatic equipments- selection of components - design calculations - logic circuits - switching circuits - fringe conditions modules and these integration - sequential circuits - cascade methods – mapping methods - step counter method - compound circuit design - combination circuit design- Karnaugh - Veitch map. Simulation of pneumatic circuits using software tools.		
UNIT-V	**ELECTROMAGNETIC & ELECTRONIC CONTROL OF HYDRAULIC & PNEUMATIC CIRCUIT**	**10**
Electrical control of pneumatic circuits – use of relays, counters, timers, ladder diagrams, use of microprocessor in circuit design – use of PLC in hydraulic and pneumatic circuits – Fault finding– application -fault finding - hydro pneumatic circuits - use of microprocessors for sequencing - PLC, Low cost automation - Robotic circuits.		
	Total Contact Hours : 45	
Course Outcomes: On completion of this course, the students will be able to		
●	Select the pump and drives based on the design constraint.	
●	Use the control and regulation elements.	
●	Design and analyse the circuits for the hydraulic systems	
●	Design and analyse the circuit for the pneumatic systems.	
●	Design and analyse the control circuit using electrical and electronic components for hydraulic & pneumatic system.	

Reference Books(s) / Web links:	
1	Antony Espossito, “Fluid Power with Applications”, Pearson Education Limited, 2014.
3	Andrew Parr, “Hydraulic and Pneumatics”, Butterworth Heinmann, 2011.
4.	K.Shanmuga Sundaram, “Hydraulic and Pneumatic Controls: Understanding made Easy" S.Chand & Co Book publishers, New Delhi, 2006 (Reprint 2009)
5	https://nptel.ac.in/courses/112106175/

	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	1	-	2	1	-	1
CO 2	2	-	2	1	-	1
CO 3	2	-	2	1	2	1
CO 4	2	-	2	1	2	1
CO 5	2	-	2	1	-	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Subject Code	Subject Name (Theory course)	Category	L	T	P	C
ED23P14	DESIGN AND ANALYSIS OF EXPERIMENTS	PE	3	0	0	3

Objectives:	
•	To introduce the various methods of analysing the data and evaluate the outcome.

UNIT-I	INTRODUCTION AND STATISTICAL CONCEPTS	8
Strategy of Experimentation, Typical applications of Experimental design, Basic Principles, Guidelines for Designing Experiments. Concepts of random variable, probability, density function cumulative distribution function. Sample and population, Measure of Central tendency; Mean median and mode, Measures of Variability, Concept of confidence level. Statistical Distributions: Normal, Log Normal & Weibull distributions. Hypothesis testing, Probability plots, choice of sample size. Illustration through Numerical examples.		
UNIT-II	**EXPERIMENTAL DESIGN**	**8**
Classical Experiments: Factorial Experiments: Terminology: factors, levels, interactions, treatment combination, randomization, Two-level experimental designs for two factors and three factors. Three-level experimental designs for two factors and three factors, Factor effects, Factor interactions, Fractional factorial design, Saturated Designs, Central composite designs. Illustration through Numerical examples.		
UNIT-III	**ANALYSIS AND INTERPRETATION METHODS**	**8**
Measures of variability, Ranking method, Column effect method & Plotting method, Analysis of variance (ANOVA) in Factorial Experiments: YATE's algorithm for ANOVA, Regression analysis, Mathematical models from experimental data. Illustration through Numerical examples.		
UNIT-IV	**QUALITY BY EXPERIMENTAL DESIGNS**	**9**
Quality, Western and Taguchi's quality philosophy, elements of cost, Noise factors causes of variation. Quadratic loss function & variations of quadratic loss function. Robust Design: Steps in Robust Design: Parameter design and Tolerance Design. Reliability Improvement through experiments, Illustration through Numerical examples.		
UNIT-V	**EVALUATION METHODS OF TAGUCHI**	**12**
Types of Orthogonal Arrays, selection of standard orthogonal arrays, Linear graphs and Interaction assignment, Dummy level Technique, Compound factor method, Modification of linear graphs. Illustration through Numerical examples. Evaluation of sensitivity to noise. Signal to Noise ratios for static problems: Smaller-the-better type, Nominal-the – better-type, Larger-the-better type. Signal to Noise ratios for Dynamic problems. Illustration through Numerical examples.		
	Total Contact Hours : 45	

Course Outcomes: On completion of this course, the students will be able to	
•	Apply various statistical methods for finding solution
•	Analyze various factorial methods to find solution.
•	Use various Analysis and Interpretation Methods
•	Use various quality function to design
•	Use various Taguchi Methods to find solution.

Reference Books(s) / Web links:	
1	Douglas C Montgomery, Design and analysis of experiments, Wiley Publication, 9th Edition, 2017.
2	K. Krishnaiah (Author), P. Shahabudeen, Applied Design of Experiments and Taguchi Methods, Prentice Hall of India, 2012.
3	Jiju Antony, Design of Experiments for Engineers and Scientists, Elsevier Insights
4	https://nptel.ac.in/courses/110105087/
5	https://nptel.ac.in/courses/111104078/

	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	-	1	1	-	1
CO 2	2	-	1	1	-	1
CO 3	2	-	1	1	2	1
CO 4	2	-	1	1	2	1
CO 5	2	-	1	1	2	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Subject Code	Subject Name (Theory course)	Category	L	T	P	C
ED23P15	**ADVANCED MACHINE TOOL DESIGN**	**PE**	**3**	**0**	**0**	**3**

Objectives:	
•	Study of various machine internal parts, design and Automation of machine parts.

UNIT-I	**FUNDAMENTALS AND KINEMATICS OF MACHINE TOOL**	**10**
General classification of machine tools, working and auxiliary motions, Hydraulics transmission and its elements, Mechanical transmission and its elements, General requirement of machine tools. Kinematics of Machine Tools – Stepped and step less drive, Basic considerations in the design of drives, Variable speed range in machine tools, Graphical representation of speed, structure diagram, selection of optimum ray diagram, Design of speed and feed gear boxes, step-less regulation of speed and feed rates.		
UNIT-II	**MACHINE TOOL STRUCTURES AND GUIDEWAYS**	**12**
Design criteria, materials, static and dynamic stiffness, Basic dynamic stiffness, Basic design procedure, design of beds and columns, Model technique in design of machine tool structures. Guideways :Classification of guideways, material and Lubrication, design criteria and calculations for guideways, designs of guides under hydrostatic lubrication, Aerostatic slide ways, Antifriction guideways, Combination guideways, classification of power screws, Design principles of power screws, Recirculating power screws assemblies, Elimination of backlash.		
UNIT-III	**MACHINE TOOL SPINDLES**	**6**
Materials of spindles, Effect of machine tool compliance on machining accuracy, Design principles of spindles, Antifriction and sliding bearings.		
UNIT-IV	**CONTROLLING SYSTEMS IN MACHINE TOOLS**	**9**
Classification, Control systems for changing speeds and feeds, Ergonomic considerations applied to design of control members, principles of automatic and adaptive control.		
UNIT-V	**VIBRATION IN MACHINE TOOLS**	**8**
Forced Vibration, self-excited vibration, stick-slip vibration and its minimization, vibration isolation		
	Total Contact Hours : 45	

COURSE OUTCOMES: On completion of this course, the students will be able to	
•	Identify various parts in machine tool and comprehend the Kinematics of machine tool.
•	Design machine tool structures and guideways.
•	Apply various design aspects of spindles and bearings.
•	Apply various methods of controlling systems.
•	Reduce vibration and chatter in machine tools.
Reference Books(s) / Web links:	
1	N. K. Mehta, Machine Tool Design and Numerical Control, 3rd Edition, Tata Mcgraw Hill, India,2012.
2	Machine Tool Design Handbook, Central Machine Tool Institute, 2017.
3	Principles of Machine Tools, G. C. Sen, Bhattacharya, New Central Book Agency,2006.

	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	1	-	1	2	-	1
CO 2	1	-	1	2	-	1
CO 3	1	-	1	2	-	1
CO 4	1	-	1	1	-	1
CO 5	1	-	1	2	-	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Subject Code	Subject Name (Theory course)	Category	L	T	P	C
ED23P21	**DESIGN FOR MANUFACTURE ASSEMBLY AND ENVIRONMENTS**	**PE**	**3**	**0**	**0**	**3**

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

UNIT-I	**INTRODUCTION**	**9**
Introduction - Economics of process selection - General design principles for manufacturability; Geometric Dimensioning & Tolerance (GD&T) – Form tolerancing: straightness, flatness, circularity, cylindricity – Profile tolerancing: profile of a line, and surface – Orientation tolerancing: angularity, perpendicularity, parallelism – Location tolerancing: position, concentricity, symmetry – run out tolerancing: circular and total – Supplementary symbols.		
UNIT-II	**DESIGN OF CAST AND WELD COMPONENTS**	**9**
Design considerations for: Sand cast – Die cast – Permanent mold parts. Arc welding – Design considerations for: Cost reduction – Minimizing distortion – Weld strength – Weldment. Resistance welding – Design considerations for: Spot – Seam – Projection – Flash &Upset weldment.		
UNIT-III	**DESIGN FOR MANUFACTURING PROCESS**	**9**
Review and selection of Manufacturing Processes, Design consideration for Metal extruded parts – Impact/Cold extruded parts – Stamped parts – Forged parts, Turned parts – Drilled parts – Milled, planned, shaped and slotted parts– Ground parts.		
UNIT-IV	**DESIGN FOR ASSEMBLY**	**9**
Introduction to Assembly: The assembly process, Characteristics and applications, Example of common assembly, Economic significance of assembly, General taxonomies of assembly operation and systems, Assembling a product, Design for Assembly: Introduction, Design consideration, Design for Fasteners: Introduction, Design recommendation for fasteners. Computer Application for DFA.		
UNIT-V	**DESIGN FOR 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 Contact Hours : 45	

Course Outcomes: On completion of this course, the students will be able to	
•	Select relevant process; apply the general design principles for manufacturability; GD&T
•	Apply design considerations while designing the cast and welded components
•	Apply design considerations while designing the formed and machined components
•	Apply design considerations for assembled systems.
•	Apply design considerations for environmental issues.

Reference Books(s) / Web links:	
1	Boothroyd, G, 1980 Design for Assembly Automation and Product Design. New York, Marcel Dekker.
2	Bralla, Design for Manufacture handbook, McGraw hill, 1999.
3	Boothroyd, G, Heartz and Nike, Product Design for Manufacture, CRC press, 2010.
4	Dickson, John. R, and Corroda Poly, Engineering Design and Design for Manufacture and Structural Approach, Field Stone Publisher, USA, 1995.
5.	Fixel, J. Design for the Environment McGraw Hill., 1996.
6.	Graedel T. Allen By. B, Design for the Environment Angle Wood Cliff, Prentice Hall. Reason Pub., 1996.
7.	Kevin Otto and Kristin Wood, Product Design. Pearson Publication, (Fourth Impression) 2009.
8.	Harry Peck, "Designing for Manufacture", Pitman Publications, 1983
9.	https://nptel.ac.in/courses/112106249/

	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	-	2	2	-	1
CO 2	2	-	2	2	-	1
CO 3	2	-	2	2	-	1
CO 4	2	-	2	2	-	1
CO 5	2	-	2	2	-	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Subject Code	Subject Name (Theory course)	Category	L	T	P	C
ED23P22	**ADDITIVE MANUFACTURING**	**PE**	**3**	**0**	**0**	**3**

Objectives:	
•	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**	**7**
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 and 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-modelling techniques: Wire frame, surface and solid modelling – data formats - Data interfacing, Part orientation and support generation, Support structure design, Model Slicing, Tool path generation-Software for AM- Case studies. Hands on scanning of a machine component.		
UNIT-III	**LIQUID AND SOLID BASED ADDITIVE MANUFACTURING SYSTEMS**	**10**
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 Modelling (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. Prototype development of product using any one of the AM method.		
UNIT-IV	**POWDER BASED ADDITIVE MANUFACTURING SYSTEMS**	**10**
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. Prototype development of product using any one of the AM method.		
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 Contact Hours : 45	

Course Outcomes: On completion of this course, the students will be able to	
•	Recall history, concepts and terminology of additive manufacturing
•	Apply the reverse engineering concepts for design development
•	Use the variety of additive manufacturing techniques
•	Design and develop newer tooling models
•	Analyse the cases relevant to mass customization and some of the important research challenges associated with AM and its data processing tools
Reference Books(s) / Web links:	
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	Ben Redwood, Brian Garret, Filemon Schöffer, and Tony Fadel, "The 3D Printing Handbook: Technologies, Design and Applications", 3D Hubs B.V., Netherland, 2017.ISBN-13: 978-9082748505.

	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	-	-	2	-	-	1
CO 2	1	-	2	1	2	1
CO 3	1	-	2	1	2	1
CO 4	1	-	2	1	2	1
CO 5	1	-	2	1	2	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Subject Code	Subject Name (Theory course)	Category	L	T	P	C
ED23P23	**DESIGN OF PRESSURE VESSEL AND PIPING**	**PE**	**3**	**0**	**0**	**3**

Objectives:	
•	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**	**5**
Methods for determining stresses – Terminology and Ligament Efficiency – Applications		
UNIT-II	**STRESSES IN PRESSURE VESSELS**	**12**
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**	**12**
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**	**8**
Introduction – Flow diagram – piping layout and piping stress Analysis.		
	Total Contact Hours : 45	

Course Outcomes: On completion of this course, the students will be able to	
•	Describe various theories and practice on pressure vessel and piping design and procedures.
•	Comprehend the different types of stresses and their effects in pressure vessel.
•	Design pressure vessels using ASME codes.
•	Solve the industrial practical problems that arise on pressure vessel and piping design.
•	Draw the piping layout and calculate the stresses acting on it.

Reference Books(s) / Web links:	
1	John F. Harvey, "Theory and Design of Pressure Vessels", CBS Publishers and Distributors, 2001.
2	Henry H. Bedner, "Pressure Vessels, Design Hand Book, CBS publishers and Distributors,1990.
3	William. J., Bees, "Approximate Methods in the Design and Analysis of Pressure Vessels and Piping", Pre ASME Pressure Vessels and Piping Conference, 1997.
4	Stanley, M. Wales, "Chemical process equipment, selection and Design. Butterworth's series in Chemical Engineering, 1988.
5	Dennis R. Moss (Author), Michael M. Basic , Pressure Vessel Design Manual, Butterworth-Heinemann; 4 edition ,2013.
6	Somnath Chattopadhyay, Pressure Vessels: Design and Practice, CRC Press ,2004
7.	https://pveng.com/home/asme-code-design/
8.	https://www.engineersedge.com/pressure_vessels_menu.shtml
9.	https://nptel.ac.in/courses/103103027/

	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	-	-	-	-	-	1
CO 2	2	-	1	-	-	1
CO 3	2	-	2	2	-	1
CO 4	2	-	2	2	-	1
CO 5	-	-	2	-	-	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Subject Code	Subject Name (Theory course)	Category	L	T	P	C
ED23P24	OPTIMIZATION TECHNIQUES IN DESIGN	PE	3	0	0	3

Objectives:	
●	To impart knowledge on various categories of existing engineering problems and solutions to such problems through different optimization techniques and approaches.
●	To learn about optimization techniques in static and dynamic applications

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 Contact Hours : 45	

Course Outcomes: On completion of this course, the students will be able to	
●	Comprehend different approaches of optimizing.
●	Use various unconstrained optimization techniques.
●	Apply various constrained optimization techniques.
●	Apply advanced optimization techniques to specific problems.
●	Analyse optimisation techniques in static and dynamic applications.

Reference Books(s) / Web links:	
1	Rao, Singaresu, S., “Engineering Optimization – Theory & Practice”, New Age International (P) Limited, New Delhi, 2013.
2	Johnson Ray, C., “Optimum design of mechanical elements”, Wiley, John & Sons, 1990.
3	Kalyanamoy Deb, “Optimization for Engineering design algorithms and Examples”, Prentice Hall of India Pvt. 2012.
4	Goldberg, D.E., “Genetic algorithms in search, optimization and machine”, Barnen, Addison- Wesley, New York, 2002.

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO 1	2	-	2	2	-	2
CO 2	2	-	2	2	-	2
CO 3	2	-	2	2	-	2
CO 4	2	-	2	2	-	2
CO 5	2	-	2	2	-	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Subject Code	Subject Name (Theory Course)	Category	L	T	P	C
ED23P25	COMPUTER GRAPHICS FOR DESIGN ENGINEER	PC	3	0	0	3

Objectives:	
●	To understand fundamental concepts of computer graphics and its tools in a generic framework.
●	To impart the parametric fundamentals to create and manipulate geometric models using curves, surfaces and solids
●	To impart the parametric fundamentals to create and manipulate geometric models using NURBS and solids
●	To provide clear understanding of CAD systems for 3D modeling and viewing.
●	To create strong skills of assembly modeling and prepare the student to be an effective user of a standards in CAD system

UNIT-I	INTRODUCTION TO COMPUTER GRAPHICS FUNDAMENTALS	9
Output primitives (points, lines, curves etc.,), 2-D & 3-D transformation (Translation, scaling, rotators) 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, bi-cubic 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 modelling.		
UNIT-IV	**VISUAL REALISM**	**9**
Hidden – Line – Surface – solid removal algorithms shading – colouring. 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 modelling - 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 Contact Hours : 45	

Course Outcomes: On completion of this course, the students will be able to	
•	Describe the principles of translation, rotation and scaling.
•	Create various curves in surface modeling.
•	Use various solid modeling techniques.
•	Apply visualization methods to visualize the objects and edit it.
•	Apply the various data exchange formats.

Reference Books(s) / Web links:	
1	William M Neumann and Robert F.Sproull. "Principles of Computer Graphics", Mc Graw Hill Book Co. Singapore, 2001.
2	Donald Hearn and M. Pauline Baker. "Computer Graphics", Prentice Hall, Inc., 2012.
3	Ibrahim Zeid . Mastering CAD/CAM – McGraw Hill, International Edition, 2007.
4	Foley, Wan Dam, Feiner and Hughes – Computer graphics principles & practices, Pearson Education – 2003.
5	David F. Rogers, James Alan Adams "Mathematical elements for computer graphics" second edition, Tata McGraw-Hill edition.2003

	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	1	1	3	2	1
CO 2	2	1	1	3	2	1
CO 3	2	1	1	3	2	1
CO 4	2	1	1	3	2	1
CO 5	2	1	1	3	2	1

Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Subject Code	Subject Name (Theory course)	Category	L	T	P	C
ED23P26	DESIGN FOR X	PE	3	0	0	3

Objectives:	
•	To emphasis the importance and the basics of GDT in design.
•	To provide knowledge on machining consideration during component design.
	To introduce the basics of design consideration during assemble.
	To familiarize the importance of reliability and maintainability of product in design.
	To emphasis the importance of sustainability during design.

UNIT-I	INTRODCUTION	9
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. Factors influencing form design- Working principle, Material, Manufacture, Design- Possible solutions - Materials choice –Influence of materials on form design - form design of welded members, forgings and castings		
UNIT-II	**COMPONENT DESIGN - MACHINING CONSIDERATION**	**9**
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.		
UNIT-III	**DESIGN FOR ASSEMBLY**	**9**
Design for assembly – General assembly recommendations – Minimizing the no. of parts – Design considerations for: Rivets – Screw fasteners – Gasket & Seals – Press fits – Snap fits – Design for assembly – Product design for manual assembly - Product design for automatic assembly – Robotic assembly-Automatic assembly – Computer Application for DFMA -Case studies.		
UNIT-IV	**DESIGN FOR RELIABILITY AND MAINTAINABILITY**	**9**
Reliability design process, system effectiveness, economic analysis and life cycle cost, reliability allocation, design methods, parts and material selection, derating, stress-strength and analysis, failure analysis, identification determination of causes, assessments of effects, computation of criticality index, corrective action, system safety – analysis of down-time – the repair time distribution, stochastic point processes system repair time, reliability under preventive maintenance state dependent system with repair. MTTR – mean system down time, repair vs replacement, replacement models, proactive, preventive, predictive maintenance maintainability and availability, optimization techniques for system reliability with redundancy heuristic methods applied to optimal system reliability.		
UNIT-V	**SUSTAINABLE DESIGN**	**9**
Industrial ecology, multiple life cycle design, principles of design, green engineering, cradle to cradle design, The Natural Step, biomimicry, design for reuse, dematerialization, modularization, Design to minimize material usage – Design for disassembly – Design for recyclability – design for flexibility, design for disassembly, design for inverse manufacturing, design for the environment, – Design for energy efficiency – Design to regulations and standards etc		
	Total Contact Hours : 45	

Course Outcomes: On completion of this course, the students will be able to	
•	Select relevant process; apply the general design principles for manufacturability; GD&T
•	Apply design considerations while designing the formed and machined components
•	To design the component by considering the assembly requirement.
•	To design a product with reliability and maintainability.
•	To design a sustainable product.

Reference Books(s) / Web links:	
1	Boothroyd, G, Design for Assembly Automation and Product Design. New York, Marcel Dekker. 1980
2	Bralla, Design for Manufacture handbook, McGraw hill, 1999.
3	David J. Smith, “Reliability and Maintainability in Perspective”, McMillan,2nd Edition, 1985..
4	HFixel, J. Design for the Environment McGraw Hill., 1996.

	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	3	1	1	2	3	2
CO 2	1	1	1	2	3	2
CO 3	1	1	1	2	3	2
CO 4	2	1	1	2	3	2
CO 5	3	1	1	2	3	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Subject Code	Subject Name (Theory course)	Category	L	T	P	C
ED23P27	**CORROSION AND SURFACE ENGINEERING**	**PE**	**3**	**0**	**0**	**3**

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

UNIT-I	**CORROSION**	10
Introduction – Principle of corrosion – Classification of corrosion – Types of corrosion – Factors influencing corrosion – Testing of corrosion – In-service monitoring, Simulated service, Laboratory testing – Evaluation of corrosion – Prevention of Corrosion – Material selection, Alteration of environment, Design, Cathodic and Anodic Protection, Corrosion inhibitors		
UNIT-II	**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-III	**WEAR**	6
Introduction – Abrasive wear, Erosive, Cavitation, Adhesion, Fatigue wear and Fretting Wear- Laws of wear – Theoretical wear models – Wear of metals and non-metals – International standards in friction and wear measurements		
UNIT-IV	**SURFACE TREATMENTS**	12
Introduction – Surface properties, Superficial layer – Changing surface metallurgy – Wear resistant coatings and Surface treatments – Techniques – PVD – CVD – Physical CVD – Ion implantation – Surface welding – Thermal spraying – Laser surface hardening and alloying, Applications of coatings and surface treatments in wear and friction control – Characteristics of Wear resistant coatings – New trends in coating technology – DLC – CNC – Thick coatings – Nano-engineered coatings – Other coatings, Corrosion resistant coatings		
UNIT-V	**ENGINEERING MATERIALS**	9
Introduction – Advanced alloys – Super alloys, Titanium alloys, Magnesium alloys, Aluminium alloys, and Nickel based alloys – Ceramics – Polymers – Biomaterials – Applications – Bio Tribology Nano Tribology		
	Total Contact Hours : 45	

Course Outcomes: On completion of this course, the students will be able to	
●	Describe the fundamentals of corrosion process.
●	Comprehend the various theories on friction
●	Describe the various methods of wear in materials.
●	Apply surface modification methods which are necessary to solve the industrial practical problems.
●	Determine the properties of advanced materials.

Reference Books(s) / Web links:	
1	W.Stachowiak & A.W .Batchelor , “Engineering Tribology”, Butterworth-Heinemann, UK,2005
2	Rabinowicz.E, “Friction and Wear of materials”, John Willey &Sons,UK,1995.
3	Halling, J. (Editor) – “Principles of Tribology “, Macmillian – 1984

4	Williams J.A. "Engineering Tribology", Oxford Univ. Press, 1994
5	S.K.Basu, S.N.Sengupta & B.B.Ahuja ,"Fundamentals of Tribology", Prentice –Hall of India Pvt Ltd , New Delhi, 2005
6	Fontana G., "Corrosion Engineering", McGraw Hill, 1985
7.	https://nptel.ac.in/courses/112107248/

	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	-	2	2	-	2
CO 2	2	1	2	2	-	2
CO 3	2	1	2	2	-	2
CO 4	2	1	2	2	-	2
CO 5	2	1	2	2	-	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Subject Code	Subject Name (Theory course)	Category	L	T	P	C
ED23P28	**QUALITY CONCEPTS IN DESIGN**	**PE**	**3**	**0**	**0**	**3**

Objectives:	
●	To impart knowledge on various concepts in engineering design, material selection and manufacturing methods
●	To learn the principles of implementing quality in a product or services using different tools
●	To enhance the quality of product by use of failure mode effect analysis and implement methods to uphold the status of six sigma
●	To develop a robust product or service using various strategies of design of experiments
●	To maintain the quality of the product by use of statistical tools and enforce methods to improve the reliability of a product

UNIT-I	**DESIGN FUNDAMENTALS, METHODS, AND MATERIAL SELECTION**	**9**
Morphology of Design – The Design Process – Computer Aided Engineering – Concurrent Engineering – Competition Bench Marking – Creativity – Theory of Problem solving (TRIZ) – Value Analysis - Design for Manufacture, Design for Assembly – Design for casting, Forging, Metal Forming, Machining and Welding.		
UNIT-II	**DESIGN FOR QUALITY**	**9**
Quality Function Deployment -House of Quality-Objectives and functions-Targets-Stakeholders- Measures and Matrices-Design of Experiments –design process-Identification of control factors, noise factors, and performance metrics - developing the experimental plan- experimental design – testing noise factors- Running the experiments – Conducting the analysis-Selecting and conforming factor-Set points-reflecting and repeating.		
UNIT-III	**FAILURE MODE EFFECTS ANALYSIS AND DESIGN FOR SIX SIGMA**	9
Basic methods: Refining geometry and layout, general process of product embodiment - Embodiment checklist- Advanced methods: systems modeling, mechanical embodiment principles- MEA method- linking fault states to systems modeling - Basis of SIX SIGMA –Project selection for SIX SIGMA- SIX SIGMA problem solving- SIX SIGMA in service and small organizations - SIX SIGMA and lean production –Lean SIX SIGMA and services		
UNIT-IV	**DESIGN OF EXPERIMENTS**	9
Importance of Experiments, Experimental Strategies, Basic principles of Design, Terminology, ANOVA, Steps in Experimentation, Sample size, Single Factor experiments – Completely Randomized design, Randomized Block design, Statistical Analysis, Multifactor experiments - Two and three factor full Factorial experiments, 2K factorial Experiments, Confounding and Blocking designs, Fractional factorial design, Taguchi's approach - Steps in experimentation, Design using Orthogonal Arrays, Data Analysis, Robust Design- Control and Noise factors, S/N ratios		
UNIT-V	**STATISTICAL CONSIDERATION AND RELIABILITY**	9
Frequency distributions and Histograms- Run charts –stem and leaf plots- Pareto diagrams-Cause and Effect diagrams-Box plots- Probability distribution-Statistical Process control–Scatter diagrams –Multivariable charts –Matrix plots and 3-D plots.-Reliability-Survival and Failure-Series and parallel systems-Mean time between failure-Weibull distribution.		
	Total Contact Hours : 45	

Course Outcomes: On completion of this course, the students will be able to	
●	Comprehend the design fundamentals and material selection for quality product.
●	apply the quality concepts to develop a robust product.
●	Apply FMEA and Sic sigma concepts principles to enhance its quality.
●	Apply different experimental design methods in product development
●	Implement various statistical tools to improve its quality and reliability

Reference Books(s) / Web links:	
1	Dieter, George E., "Engineering Design - A Materials and Processing Approach", McGraw Hill, International Editions, Singapore, 2000.
2	Kevin Otto & Kristin Wood . "Product Design Techniques in Reverse Engineering and New Product Development" , Pearson Education (LPE), 2001
3	Karl t. Ulrich, Steven D. Eppinger ."Product Design And Development", ,Tata Mcgraw-Hill- 3rd Edition, 2017.
4	Amitava Mitra,"Fundamentals of Quality control and improvement", John Wiley & Sons, 2016
5	Montgomery, D.C.," Design and Analysis of experiments 8th edition, John Wiley and Sons, 2013.
6	Phillip J.Rose, Taguchi techniques for quality engineering, McGraw Hill, 2005.
7	https://www.ee.iitb.ac.in/~apte/CV_PRA_TAGUCHI.htm

	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	1	1	3	2	2	2
CO 2	1	1	3	2	2	2
CO 3	1	1	3	2	2	2
CO 4	1	1	3	2	2	2
CO 5	1	1	3	2	2	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Subject Code	Subject Name (Theory course)	Category	L	T	P	C
ED23P29	**BEARING DESIGN AND ROTOR DYNAMICS**	**PE**	**3**	**0**	**0**	**3**

Objectives:	
●	Apply and develop mathematical model of a system
●	Applying the design and suggest bearings for specific applications
●	. Applying a fatigue life calculations for various types of bearings
●	Apply and analyze bearing behaviour
●	Study the dynamics of rotors mounted on Hydrodynamic Bearings

UNIT-I	**CLASSIFICATION AND SELECTION OF BEARINGS**	**6**
Selection criteria-Dry and Boundary Lubrication Bearings-Hydrodynamic and Hydrostatic bearings- Electro Magnetic bearings-Dry bearings-Rolling Element bearings- Bearings for Precision. Applications-Foil Bearings-Special bearings-Selection of plain Bearing materials –Metallic and Non-metallic bearings.		
UNIT-II	**DESIGN OF FLUID FILM BEARINGS**	**10**
Design and performance analysis of Thrust and Journal bearings – Full, partial, fixed and pivoted journal bearings design procedure-Minimum film thickness – lubricant flow and delivery – power loss, Heat and temperature distribution calculations- Design based on Charts & Tables and Experimental curves-Design of Foil bearings-Air Bearings- Design of Hydrostatic bearings-Thrust and Journal bearings- Stiffness consideration - flow regulators and pump design.		
UNIT-III	**SELECTION AND DESIGN OF ROLLING BEARINGS**	**10**
Contact Stresses in Rolling bearings- Centrifugal stresses-Elasto hydrodynamic lubrication- Fatigue life calculations-Bearing operating temperature- Lubrication- Selection of lubricants- Internal clearance – Shaft and housing fit- -		

Mounting arrangements-Materials for rolling bearings- Manufacturing methods- Ceramic bearings-Rolling bearing cages-bearing seals selection		
UNIT-IV	**ROTOR DYNAMICS**	**9**
Rotor vibration and Rotor critical speeds- support stiffness on critical speeds- Stiffness and damping coefficients of journal bearings-computation and measurements of journal bearing coefficients -Mechanics of Hydro dynamic Instability- Half frequency whirl and Resonance whip- Design configurations of stable journal bearings.		
UNIT-V	**DYNAMICS OF ROTORS MOUNTED ON HYDRO DYNAMIC BEARINGS**	**10**
Hydrodynamic Lubrication equation for dynamic loadings-Squeeze film effects in journal bearings and thrust bearings-Rotating loads, alternating and impulse loads in journal bearings–Journal Centre Trajectory-Analysis of short bearings under dynamic conditions-Finite difference solution for dynamic conditions.		
	Total Contact Hours : 45	

Course Outcomes: On completion of this course, the students will be able to	
●	Understand application of various types of bearings and their operating principles
●	Design and suggest bearings for specific applications
●	Perform fatigue life calculations for various types of bearings,
●	Understand and analyze bearing behavior
●	Study the dynamics of rotors mounted on Hydrodynamic Bearings

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

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO 1	1	1	2	2	2	1
CO 2	1	1	2	2	2	1
CO 3	1	1	2	2	2	1
CO 4	1	1	2	2	2	1
CO 5	1	1	2	2	2	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

SEMESTER III

Course Code	Course Name (Theory course)	Category	L	T	P	C
ED23P31	PRODUCT LIFECYCLE MANAGEMENT	PE	3	0	0	3

Objectives: The main learning objective of this course is to prepare the students to:	
•	Understand the history, concepts and terminology of PLM.
•	Study the functions and features of PLM/PDM.
•	Understand different modules offered in commercial PLM/PDM tools.
•	Know the PLM/PDM approaches for industrial applications.
•	Know the PLM/PDM with legacy databases, CAx and ERP systems.

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 – Teamcenter, Windchill, ENOVIA, Aras PLM, SAP PLM, Arena, Oracle Agile PLM and Autodesk Vault.		
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 Contact Hours : 45	

Course Outcomes : On completion of this course, the students will be able to	
●	Summarize the history, concepts and terminology of PLM.
●	Apply the functions and features of PLM/PDM.
●	Apply different modules offered in commercial PLM/PDM tools.
●	Implement PLM/PDM approaches for industrial applications.
●	Integrate PLM/PDM with legacy data bases, CAx& ERP systems.

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

	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	1	-	1	1	1	1
CO 2	1	-	1	1	1	1
CO 3	1	-	1	1	1	1
CO 4	1	-	1	1	1	1
CO 5	1	-	1	1	1	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Course Name (Theory course)	Category	L	T	P	C
ED23P32	**ADVANCED FINITE ELEMENT ANALYSIS**	**PE**	**3**	**0**	**0**	**3**

Objectives:	
●	To study concept of Finite Element Analysis to solve problems involving plate and shell elements
●	To learn concept of Finite Element Analysis to solve problems involving geometric and material non linearity
●	To study solution techniques to solve dynamic problems
●	To study the concepts of Finite Element Analysis to solve fluid mechanics and heat transfer problems
●	To study error norms, convergence rates and refinement.

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**	**11**
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. Comparative study of various solution techniques using software for a simple mechanical component.		
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**	**7**
Error norms and Convergence rates – h-refinement with adaptivity – Adaptive refinement. Mesh convergence study of a mechanical part using software.		
	Total Contact Hours : 45	

Course Outcomes: On completion of this course, the students will be able to	
●	Apply concept of Finite Element Analysis to solve problems involving plate and shell elements
●	Apply concept of Finite Element Analysis to solve problems involving geometric and material non linearity.
●	Formulate solution techniques to solve dynamic problems
●	Apply concepts of Finite Element Analysis to solve fluid mechanics and heat transfer problems
●	Investigate error norms, convergence rates and refinement.
Reference Books(s) / Web links:	
1	J. N. Reddy , Introduction to nonlinear finite element analysis, Oxford Press, 2004.
2	Logan. D. L.,"A first course in Finite Element Method", Cengage Learning, 2012
3	R.D. Cook, D.S. Makus and M.F.Plesha, 'Concept and Applications of Finite Element Analysis', John Wiley and
4	S. Krishnamoorthy, 'Finite Element Analysis, Theory and Programming', Tata McGraw-Hill, Publishing
5	Y. Nakasone, S. Yoshimoto, T. A. Stolarski, 'Engineering Analysis With ANSYS Software', Elsevier, Burlington,
6	Thomas J. R. Hughes, 'The Finite Element Method- Linear Static and Dynamic Finite Element Analysis', Dover
7	http://www2.mae.ufl.edu/nkim/INFEM/

	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	1	3	2	2	1
CO 2	2	1	3	2	2	1
CO 3	2	1	3	2	2	1
CO 4	2	1	3	2	2	1
CO 5	2	1	3	2	2	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Course Name (Theory course)	Category	L	T	P	C
ED23P33	**ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING IN DESIGN**	**PE**	**3**	**0**	**0**	**3**

Objectives: The main learning objective of this course is to prepare the students to:	
•	To gain knowledge on artificial intelligence.
•	To understand the concepts of Machine Learning.
•	To appreciate supervised learning and their applications.
•	To appreciate the concepts and algorithms of unsupervised learning.
•	To understand the theoretical and practical aspects of Probabilistic Graphical Models.

UNIT-I	**ARTIFICIALINTELLIGENCE**	**9**
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.		
UNIT-II	**INTRODUCTION TO MACHINE LEARNING**	**9**
Machine Learning–Types of Machine Learning –Machine Learning process- preliminaries, testing Machine Learning algorithms, turning data into Probabilities, and Statistics for Machine Learning Probability theory – Probability Distributions – Decision Theory.		
UNIT- III	**SUPERVISED LEARNING**	**9**
Linear Models for Regression – Linear Models for Classification- Discriminant Functions, Probabilistic Generative Models, Probabilistic Discriminative Models – Decision Tree Learning – Bayesian Learning, Naïve Bayes – Ensemble Methods, Bagging, Boosting, Neural Networks, Multilayer Perceptron, Feed- forward Network, Error Back propagation - Support Vector Machines. Case study on mechanical component design		
UNIT-IV	**UNSUPERVISED LEARNING**	**9**
Clustering- K-means – EM Algorithm- Mixtures of Gaussians –Dimensionality Reduction, Linear Discriminant Analysis, Factor Analysis, Principal Components Analysis, Independent Components Analysis. Case study on mechanical component design.		
UNIT-V	**PROBABILISTIC GRAPHICAL MODELS**	**9**
Graphical Models – Undirected Graphical Models – Markov Random Fields – Directed Graphical Models –Bayesian Networks – Conditional Independence properties – Markov Random Fields Hidden Markov Models – Conditional Random Fields (CRFs). Popular ML methods in design of mechanical materials.		
	Total Contact Hours : 45	

Course Outcomes: Upon successful completion of the course, the student will be able to	
•	Optimize the robots using Artificial Intelligence..
•	Design a learning model appropriate to the application.
•	Implement Probabilistic Discriminative and Generative algorithms for an application of your choice and
•	Use a tool to implement typical Clustering algorithms for different types of applications.
•	Identify applications suitable for different types of Machine Learning with suitable justification.
REFERENCES / Weblinks:	
1	Vinod Chandra S. S. Artificial Intelligence and Machine Learning**,** PHI Learning, 2014
2	Ethem Alpaydin "Machine Learning – The New AI", The MIT Press, 2016..
3	Kevin P. Murphy, "Machine Learning: A Probabilistic Perspective", MIT Press, 2012.

4	G.M.Maitha, Hand book of gear design, TATA McGraw Hill publishing company Ltd., New Delhi, 1994.
5	Tom Mitchell, "Machine Learning", McGraw-Hill, 1997.
6	Artificial Intelligence Journal, Elsevier Publication, https://sciencedirect.com/journal/artificial-intelligence

	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	1	1	2	1	1
CO 2	2	1	1	2	1	1
CO 3	2	1	1	2	1	1
CO 4	2	1	1	2	1	1
CO 5	2	1	1	2	1	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Course Name (Theory course)	Category	L	T	P	C
ED23P34	**FAILURE ANALYSIS AND PREVENTION**	**PE**	**3**	**0**	**0**	**3**

Objectives: The main learning objective of this course is to prepare the students to:	
•	Fundamental Sources of Mechanical Component Failure:
•	Industrial Engineering Tools for Failure Analysis
•	General Procedure of Failure Analysis
•	Mode of Fracture and Metallographic Procedure
•	Fracture Mechanics and Fracture Toughness in Failure Analysis:

UNIT-I	**INTRODUCTION**			**9**
Need and scope of failure analysis and prevention, engineering disasters and understanding failures, Fundamental sources of failures: Deficient design I, Deficient design II, Deficient design III and upgrading of a part.				
UNIT-II	**CAUSES OF FAILURES- MANUFACTURING DEFECTS**			**9**
Imperfections in base metals, Improper Manufacturing I, Improper Manufacturing II, Improper Manufacturing III, Improper Manufacturing IV and improper service conditions.) assembly, service and maintenance				
UNIT- III	**INDUSTRIAL ENGINEERING TOOLS AND PROCEUDRE FOR FAILURE ANALYSIS**			**9**
Pareto diagram, Fishbone diagram and FMEA, Fault tree analysis and Reliability. Basic steps, Background information collection, Preliminary examination. Industrial engineering tools for failure analysis: Fishbone diagram and FMEA				
UNIT-IV	**NDT FOR FAILURE ANALYSIS**			**9**
Basics, Destructive testing, Classification of NDT, DT, selection, preservation, cleaning & sectioning of samples, Macroscopy of various fracture surfaces.				
UNIT-V	**FRACTURE ANALYSIS OF COMPONENTS**			**9**
Fracture fundamentals, types of fractures, Application of fracture mechanics, Case studies.				
		Total Contact Hours	**:**	**45**

Course Outcomes: On completion of this course, the students:	
•	Comprehensive understanding of the fundamental sources of failure in mechanical components, enabling them to identify potential weaknesses and mitigate risks effectively.
•	Will become familiar with various industrial engineering tools and techniques relevant to failure analysis, empowering them to apply these tools in real-world scenarios to diagnose and prevent failures.
•	Will learn a systematic approach to investigate failures, ensuring a thorough examination of samples and accurate identification of failure modes.
•	Will develop the skills to conduct precise macroscopic and microscopic observations of fractures, enabling them to determine the mode of fracture and employ appropriate metallographic procedures for in-depth analysis.
•	By utilizing fracture mechanics and fracture toughness principles, attendees will be able to assess the structural integrity of components, interpret failure patterns, and make informed decisions to prevent future failures.

Reference Books/Weblinks:	
1	Brett A. Miller, Roch J. Shipley, Ronald J. Parrington, and Daniel P. Dennies Failure analysis and prevention, ASM Handbook Vol:11, ASM International, 2021.
2.	Jose Luis Otegui, Failure Analysis: Fundamentals and Applications in Mechanical Components, Springer Publication, 2016.
3.	Charlie R. Brooks and Ashok Choudhury, Failure Analysis of Engineering Materials, 1st Edition, McGraw-Hill Education,2016
4	Journal of failure Analysis and Prevention, Springer Publication, https://link.springer.com/journal/11668
5	https://onlinecourses.nptel.ac.in/noc21_me14/preview

	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	-	2	2	-	2
CO 2	2	-	2	2	1	2
CO 3	2	-	2	2	1	2
CO 4	2	-	2	2	1	2
CO 5	2	1	2	2	1	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Course Name (Theory course)	Category	L	T	P	C
ED23P35	**MATERIAL HANDLING SYSTEMS DESIGN (Design Data Books are permitted in Examination)**	**PE**	**3**	**0**	**0**	**3**

Objectives: The main learning objective of this course is to prepare the students to:	
•	Fundamental concepts related to material handling.
•	Design of various hoisting gears for different material handling applications
•	Development of conveyer systems for material flow in different industrial production systems.
•	Design of elevators for various manufacturing and service applications.
•	Integrated mechanical system design for machine tools, power transmission and engine parts

UNIT-I	**INTRODUCTION AND DESIGN OF HOISTS**	**9**
Types, selection and applications, Design of hoisting elements: Welded and roller chains - Hemp and wire ropes - Design of ropes, pulleys, pulley systems, sprockets and drums, Load handling attachments. Design of forged hooks and eye hooks – crane grabs - lifting magnets -Grabbing attachments - Design of arresting gear - Brakes: shoe, band and cone types.		
UNIT-II	**DRIVES OF HOISTING GEAR**	**9**
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- III	**CONVEYORS**	**9**
Types - description - design and applications of Belt conveyors, apron conveyors and escalators Pneumatic conveyors, Screw conveyors and vibratory conveyors.		
UNIT-IV	**ELEVATORS**	**9**
Bucket elevators: design - loading and bucket arrangements - Cage elevators - shaft way, guides, counter weights, hoisting machine, safety devices - Design of fork lift trucks.		
UNIT-V	**INTEGRATED DESIGN**	**9**
Integrated Design of systems - Valve Gear Mechanisms, Portable Air Compressor, Hay-Bale lifter, Cam Testing Machine, Power Screws, Gear Box Design more than six speed.		
	Total Contact Hours : 45	

Course Outcomes: On completion of this course, the students will be able to	
•	Design hoists and brakes used in any handling applications.
•	Design drive mechanisms and hoisting gear for different handling applications.
•	Design different conveyor systems for material handling applications.
•	Design bucket, cage and fork lift elevators for to and fro transportation of .materials in vertical direction.
•	Design of integrated mechanical system for machine tools, power transmission and engine

Reference Books/Weblinks:	
1	Norton. L Robert. "Machine Design – An Integrated Approach" Pearson Education, 5th Edition, 2018.
2	Spivakovsy, A.O. and Dyachkov, V.K., Conveying Machines, Volumes I and II, MIR Publishers, 1985.
3.	Mathew M Potts, Materials-handling Equipment, a Modern Manual, Hassell Street Press,2021
4.	Michael Rivkin, Bulk Material Handling: Practical Guidance for Mechanical Engineers, Partridge Publishing Singapore, 2018

APPROVED DATA BOOKS:	
1	P.S.G. Tech., "Design Data Book", Kalaikathir Achchagam, Coimbatore, 2020
2	Lingaiah. K, "Machine Design Data Hand Book", II Edition, McGraw Hill Education, 2017.

	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	1	3	2	2	1
CO 2	2	1	3	2	2	1
CO 3	2	1	3	2	2	1
CO 4	2	1	3	2	2	1
CO 5	2	1	3	2	2	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Course Name (Theory course)	Category	L	T	P	C
ED23P36	**TRIBOLOGY IN DESIGN**	**PE**	**3**	**0**	**0**	**3**

Objectives: The main learning objective of this course is to prepare the students to:	
•	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 study different types of lubricant and its properties.
•	To understand the analytical behaviour of different types bearings and design of bearings based on analytical /theoretical approach.
•	To impart knowledge on different types of equation on lubrication.

UNIT-I	SURFACE INTERACTION AND FRICTION	7
Introduction to tribology, Surface Topography – Surface features-Properties and measurement – Surface interaction – Laws of friction- Adhesive Theory of Sliding Friction – Static friction -Rolling Friction – Friction in extreme conditions –Thermal considerations in sliding contact. **Data driven model for friction prediction.**		
UNIT-II	**WEAR AND SURFACE TREATMENT**	**8**

Types of wear mechanism – Laws of wear –Theoretical wear models- Abrasive wear – Adhesive wear – Fatigue wear – fretting wear – Cavitation wear - Wear of Metals and Non-metals – Surface treatments – Surface modifications – Laser processing – instrumentation – International standards in friction and wear measurements . **Case study on wear of various materials and their correlation with wear mechanisms. Data driven model for wear prediction.**		
UNIT- III	**LUBRICANTS AND LUBRICATION REGIMES**	**8**
Lubricants and their physical properties- Viscosity and other properties of oils –Additives-and selection of Lubricants- Lubricants standards ISO,SAE,AGMA, BIS standards – Lubrication Regimes –Solid Lubrication-Dry and marginally lubricated contacts- Boundary Lubrication-Hydrodynamic lubrication — Elasto and plasto hydrodynamic - Magneto hydrodynamic lubrication – Hydro static lubrication – Gas lubrication.		
UNIT-IV	**THEORY OF HYDRODYNAMIC AND HYDROSTATIC LUBRICATION**	**12**
Reynolds Equation,-Assumptions and limitations-One and two dimensional Reynolds Equation-Reynolds and Sommerfeld boundary conditions- Pressure wave, flow, load capacity and friction calculations in Hydrodynamic bearings-Long and short bearings-Pad bearings and Journal bearings-Squeeze film effects-Thermal considerations-Hydrostatic lubrication of Pad bearing-Pressure , flow , load and friction calculations-Stiffness considerations- Various types of flow restrictors in hydrostatic bearings.		
UNIT-V	**HIGH PRESSURE CONTACTS AND ELASTO HYDRODYNAMIC LUBRICATION**	**10**
Rolling contacts of Elastic solids- contact stresses – Hertzian stress equation- Spherical and cylindrical contacts-Contact Fatigue life- Oil film effects- Elasto Hydrodynamic lubrication Theory- Soft and hard EHL-Reynolds equation for elasto hydrodynamic lubrication- - Film shape within and outside contact zones-Film thickness and friction calculation- Rolling bearings- Stresses and deflections-Traction drives.		
	Total Contact Hours : 45	

REFERENCES/WEB LINKS	
1	Harish Hirani , Fundamentals of Engineering Tribology with Applications, Cambridge University Press; 1st edition, 2016
2	Ian Hutchings, Philip Shipway, Tribology-Friction and Wear of Engineering Materials. 2nd edition, Butterworth-Heinemann, 2017.
3	John Williams. “Engineering Tribology”, Cambridge University Press,2012.
4	S.K.Basu, S.N.Sengupta & B.B.Ahuja,” Fundamentals of Tribology”, Prentice –Hall of India Pvt Ltd, New Delhi, 2018.
5	G.W.Stachowiak and A.W .Batchelor, Engineering Tribology, Elsevier Science, 2016.
6	https://nptel.ac.in/courses/112/102/112102015/#
7	https://onlinecourses.nptel.ac.in/noc24_me75/preview
8.	Tribology Transaction, Taylor and Francis, https://www.tandfonline.com/journals/utrb20.
9.	Tribology International, Elsevier Publication, https://www.sciencedirect.com/journal/tribology-international
10.	J. of Tribology, ASME, https://asmedigitalcollection.asme.org/tribology

Course Outcomes: Upon successful completion of the course, the student will be able to	
•	Develop the knowledge on the surface features and its role on the friction behavior of metals and nonmetals
•	Understand the various types of wear mechanism and surface modification techniques
•	Familiarize the different types of lubricants and lubrication systems in the tribology
•	Methodology for deciding lubricants and lubrication regimes for different operating conditions.
•	Ability to understand the different types of high-pressure contacts and rolling bearings

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO 1	1	1	1	2	2	1
CO 2	1	1	1	2	2	1
CO 3	1	1	1	2	2	1
CO 4	1	1	1	2	2	1
CO 5	1	1	1	2	2	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Course Name (Theory course)	Category	L	T	P	C
ED23P37	MECHANICAL MEASUREMENT AND ANALYSIS	PE	3	0	0	3

Objectives:	
•	The student will understand the principle of force and strain measurement.
•	The student will understand the vibration measurement and their applications.
•	To impart knowledge on the principle behind acoustics and wind flow measurements
•	To familiarize with the distress measurements
•	To realize the non-destructive testing principle and application

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 MEASUREMENTS**	**9**
Measurement microphones: construction and mode of operation, sensitivity, linearity, frequency response, polar response, dynamic range. Sound level meter features, Measurement of sound pressure level, sound power level, sound intensity level, reverberation time. Measurement of impact noise. Principles of Pressure and flow measurements, pressure transducers – venturimeter and flow meters – wind tunnel and its use in structural analysis – structural modeling – direct and indirect model analysis		
UNIT-IV	**DISTRESS MEASUREMENTS**	**9**
Diagnosis of distress in structures–crack observation and measurements–corrosion of reinforcement in concrete – Half-cell, construction and use – damage assessment – controlled blasting for demolition.		
UNIT-V	**STRUCTURAL HEALTH MONITORING**	**9**
Load testing on structures, buildings, bridges and towers – Rebound Hammer – acoustic emission – ultrasonic testing principles and application – Holography – use of laser for structural testing.		
	Total Contact Hours : 45	

Course Outcomes: Upon successful completion of the course, the student will be able to	
•	Measure physical quantities such as forces and strains.
•	Apply different vibration measurements techniques.
•	Measure physical quantities such as pressure and flow.
•	Apply techniques involved in crack measurement.
•	Select the appropriate nondestructive testing methods for various engineering applications.

REFERENCES:	
1	S P Venkatesan, Mechanical Measurements, Springer Publication, 2022.
2	John H. Lienhard V Thomas G. Beckwith, Roy D. Marangoni, Mechanical Measurements, Revised 6e in SI Units, Pearson Publication, 2020.
3	UC Jindal, Experimental Stress Analysis, Pearson Publication, 2012.
4	Sirohi,R.S.and Radhakrishna,H.C, "Mechanical Measurements", New Age International (P) Ltd,3rd Edition, 1997.
5	Measurement Journal, https://www.sciencedirect.com/journal/measurement

	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	1	2	3	2	2	3
CO 2	1	2	3	2	2	3
CO 3	1	2	3	2	2	3
CO 4	1	2	3	2	2	3
CO 5	1	2	3	2	2	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Course Name (Theory course)	Category	L	T	P	C
ED23P38	**COMPUTATIONAL FLUID DYNAMICS**	**PE**	**3**	**0**	**0**	**3**

Objectives:	
•	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 discretization 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 governing equations for diffusion processes.
•	To develop finite volume discretized forms of the convection-diffusion processes.
•	To develop pressure based algorithms for flow processes.
•	To introduce various turbulence models, Large Eddy Simulation and Direct Numeric Simulation.

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	**TURBULENCE MODELS**	**10**
Turbulence – RANS equation - Algebraic Models, One equation model, Two equation models – k – & standard k – ϵ model, Low Reynold number models of k- ϵ, Large Eddy Simulation (LES), Direct Numerical Simulation (DNS) - Introduction. Solving simple cases using standard CFD codes.		
	Total Contact Hours : 45	

Course Outcomes: Upon successful completion of the course, the student will be able to	
•	Analyse the governing equations and boundary conditions.
•	Analyse various discretization techniques for both steady and unsteady diffusion problems.
•	Analyse the various convection-diffusion problems by Finite-Volume method.
•	Analyse the flow processes by using different pressure bound algorithms.
•	Select and use the different turbulence models according to the type of flows.

REFERENCES:	
1	Versteeg and Malalasekera, N, "An Introduction to computational Fluid Dynamics The Finite Volume Method," Pearson Education, Ltd., Second Edition, 2014.
2	Ghoshdastidar, P.S., "Computer Simulation of Flow and Heat Transfer", Tata McGraw-Hill Publishing Company Limited, New Delhi, 1998.

3	Muralidhar, K., and Sundararajan, T., "Computational Fluid Flow and Heat Transfer", Narosa Publishing House, New Delhi, 2003.
4	Jiyuan Tu, Guan Heng Yeoh, Chaogun Liu, "Computational Fluid Dynamics A Practical Approach" Butterworth – Heinemann An Imprint of Elsevier, Madison, U.S.A., 2012.
5	John D. Anderson. JR. "Computational Fluid Dynamics The Basics with Applications" McGraw- Hill International Editions, 2017
6.	International Journal of Computational Fluid Dynamics, Taylor and Francis Publication, https://www.tandfonline.com/action/journalInformation?journalCode=gcfd20
7.	Theoretical and Computational Fluid Dynamics, Springer Publication, https://link.springer.com/journal/162

	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	1	3	-	-	-
CO 2	2	1	3	-	-	-
CO 3	2	1	3	-	3	-
CO 4	2	1	3	-	3	-
CO 5	2	1	3	-	3	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Course Name (Theory course)	Category	L	T	P	C
ED23P39	**MATERIAL CHARACTERISATION TECHNIQUES**	**PE**	**3**	**0**	**0**	**3**

Objectives:	
•	To provide understanding of techniques of microstructure and crystal structure evaluation of materials
•	To introduce tools for analysis of microstructure and surface topography of materials.
•	To understand the techniques of chemical and thermal analysis of materials.
•	To gain knowledge in various static mechanical testing methods.
•	To gain knowledge in various dynamic mechanical testing methods.

UNIT-I	**MICRO AND CRYSTAL STRUCTURE ANALYSIS**	**9**
Principles of Optical Microscopy – Specimen Preparation Techniques – Polishing and Etching – polarization Techniques – Quantitative Metallography – Estimation of grain size – ASTM grain size numbers – Microstructure of Engineering Materials - Elements of Crystallography – X- ray Diffraction – Bragg's law – Techniques of X-ray Crystallography – Debye – Scherer camera – Geiger Diffractometer – analysis of Diffraction patterns – Inter planer spacing – Identification of Crystal Structure, Elements of Electron Diffraction – Estimation of residual stress and grain size.		
UNIT-II	**ELECTRON MICROSCOPY**	**9**
Interaction of Electron Beam with Materials – Transmission Electron Microscopy – Specimen Preparation – Imaging Techniques – BF and DF – SAD – Electron Probe Microanalysis – Scanning Electron Microscopy – Construction and working of SEM and FESEM Back scattered and Secondary Electron Imaging Techniques – Applications- Atomic Force Microscopy- Construction and working of AFM - Contact and Non-Contact modes Applications.		
UNIT- III	**CHEMICAL AND THERMAL ANALYSIS**	**9**
Basic Principles, Practice and Applications of X-Ray Spectrometry, Energy dispersive and Wave Dispersive X-Ray Spectrometry, Auger Spectroscopy, Secondary Ion Mass Spectroscopy, Fourier Transform Infra-Red Spectroscopy (FTIR)- Proton Induced X-Ray Emission Spectroscopy, Differential Thermal Analysis, Differential Scanning Calorimetry (DSC) And Thermo Gravimetric Analysis (TGA) - Dynamic Mechanical Analysis (DMA).		
UNIT-IV	**MECHANICAL TESTING – STATIC TESTS**	**9**
Static testing of Metals, Plastics and Composites: - Tensile, Flexural, Compression, Shear, Torsion, fracture toughness, hardness, Codes and standards for testing metallic and composite materials.		
UNIT-V	**MECHANICAL TESTING – DYNAMIC TESTS**	**9**
Fatigue – Low and High Cycle Fatigues – Rotating Beam and Plate Bending HCF tests – S-N curve – LCF tests – Crack Growth studies – Creep Tests – LM parameters – AE Tests-modal analysis - Applications of Dynamic Tests – Fatigue life estimation.		
	Total Contact Hours :	**45**

Course Outcomes: At the end of this course the students are expected to:	
•	Characterize the engineering materials crystal structure.
•	Comprehend the fundamental principle of Top-notch characterization tools.
•	Appreciate the principles of Chemical and Thermal Analysis.
•	Understand the various static mechanical testing of materials
•	Comprehend the various dynamic method of mechanical testing of materials

REFERENCES/WEB LINKS

1	Angelo P C, Material characterization, Cengage Learning India, 2016.
2	Cullity B.D., Stock S.R and Stock S., Elements of X ray Diffraction, 3rdEdition. Prentice Hall, 2018.
3	Suryanarayana A. V. K., Testing of metallic materials BS Publications, 2018.
4	Suryanarayana C, Experimental Techniques in materials and Mechanics, CRC Press, 2011.
5	Yang Leng, Materials Characterization: Introduction to Microscopic and Spectroscopic Methods, Hong Kong University Of Science And Technology, John Wiley and Sons (Asia) Pte Ltd., 2 nd Edition, 2013.
6	https://nptel.ac.in/courses/113106034/
7	https://nptel.ac.in/courses/115/103/115103030/
8	Material Characterization Journal, Elsevier Publication, https://www.sciencedirect.com/journal/materials-

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	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	1	1	2	-	2	2
CO 2	1	1	2	-	2	2
CO 3	1	1	2	-	2	2
CO 4	1	1	2	-	2	2
CO 5	1	1	2	-	2	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Course Name	Category	L	T	P	C
ED23321	RESEARCH ARTICLE WRITING	PC	0	0	2	1

- This course covers research article writing essentials across ten weeks, focusing on components like research questions, literature review, data analysis, and scholarly writing.
- Topics include search strategies, statistical analysis, ethical considerations, and citation styles.
- Students will be introduced to draft a section of a research article, engage in peer review, and submit a final manuscript.
- Evaluation comprises **Monthly review (50%),** and **Final submission (50%).** Emphasis is on clarity, coherence, adherence to academic standards, and active engagement in the scholarly process.
- By course end, students should adeptly compose and critically assess research articles, honing their academic writing skills.

Assessment:

Review	Marks
Review I	25
Review II	25
Final Review	50

ourse Code	Course Name (Laboratory Course)	Category	L	T	P	C
ED23322	INTERNSHIP	EEC	0	0	2	1

Objectives:
• To work on a specific technical topic in Engineering design related topics in order to acquire the skills of oral presentation

Description

Students are advised to go internship in a company or institute related to Design or Materials for a period of minimum of **2 (Two) weeks** with a prior approval from the Head of the Department. At the end, students have to submit a report of their internship along with the certificate of satisfactory from the industry or institute. Evaluation will be based on the technical presentation, the report and also on the interaction during the presentation to the committee constituted by HoD.

Course Outcomes: On completion of this course, the students will be able to
1. Comprehend concepts and methods adequate to understand inductive and deductive reasoning
2. Increase their general problem-solving skills
3. Develop communicative skills
4. Understand the latest techniques in their chosen area.
5. Make use of new and recent technology for creating technical reports

Scheme for Internal Evaluation

S.No.	Review	Marks
1	Report	25
2	Presentation	25

Course Code	Course Name (Laboratory Course)	Category	L	T	P	C
ED23323	DISSERTATION - I	EEC	0	0	12	6

Objectives:

- To identify industrial problem or research problem and solve them
- To develop the proper methodology of literature survey
- To develop good written and oral communication skills
- To train the students in preparing the project reports and to face reviews

Description:

Each student has to work on a specific topic approved by the Head of the Department under the supervision of a faculty member and prepare a comprehensive report after completing the work including Literature survey/Methodology and submit a project report to the satisfaction of the review committee. The progress of the project is evaluated based on a minimum of three reviews. The review committee may be constituted by the Head of the Department. The project work is evaluated based on oral presentation and the project report jointly by external and internal examiners constituted by the Head of the Department.

TOTAL: 30 PERIODS

Scheme for Internal Evaluation

S.No.	Review	Marks
1	Review - I	10
2	Review - II	20
3	Review - III	20

SEMESTER IV

Subject Code	Subject Name (Laboratory Course)	Category	L	T	P	C
ED23421	DISSERTATION - II	EEC	0	0	24	12

Objectives:

- To produce factual results of their applied research idea in the Design Engineering.
- To improve research and development activities.
- To develop technical competency to provide solutions for problems.
- To accelerate the learning process.
- To develop good communication skills

Description:

Each student has to work on a specific topic approved by the Head of the Department under the supervision of a faculty member and prepare a comprehensive report after completing the work including Literature survey/Methodology and submit a project report to the satisfaction of the review committee. The progress of the project is evaluated based on a minimum of three reviews. The review committee may be constituted by the Head of the Department. The project work is evaluated based on oral presentation and the project report jointly by external and internal examiners constituted by the Head of the Department.

TOTAL:30 PERIODS

Scheme for Internal Evaluation

S.No.	Review	Marks
1	Review - I	10
2	Review - II	20
3	Review - III	20

COURSE OUTCOMES: The students can able to

1. Apply the knowledge gained from theoretical and practical courses in solving problem
2. Demonstrate a strong working knowledge of ethics and professional responsibility.
3. Demonstrate effective organizational leadership and change skills.
4. Realize the importance of solving problems using literature review.
5. Develop skills to read, write and comprehend