

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	√	√	√	√		√

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
27 Hrs								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
27 Hrs								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	ED 23321	Research Article Writing	PC	2	0	0	2	1
5	ED 23322	Internship	EEC	2	0	0	2	1
6	ED 23323	Dissertation-I	EEC	12	0	0	12	6
25 Hrs								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 CREDITS:								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	Design of Material Handling Equipment's	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. Industrial Safety
3. Operations Research
4. Cost Management of Engineering Projects
5. Composite Materials
6. 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:						
<ul style="list-style-type: none"> 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)

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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/#

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	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:

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

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	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, Roorkee, 2009.
4	Sujatha, Vibrations and Acoustics, TMH,2010
5	Graham Kelly, Mechanical Vibrations Theory & Applications, CENGAGE Learning, 2012.
6	Rao V. Dukkupati, 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.		

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UNIT-IV	INTRODUCTION TO INTELLECTUAL PROPERTY , TRADE MARKS ,GRAPHICAL INDICATION AND INDUSTRIAL DESIGN	9
<p>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.</p> <p>Industrial designs and IC Layout design - Registrations of designs-Semiconductor Integrated circuits and layout design Act - Geographical indications-potential benefits of Geographical Indications.</p>		
UNIT-V	LAW OF COPYRIGHTS & PATENTS	9
<p>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.</p> <p>Law of patents: Foundation of patent law, patent searching process - ownership rights and transfer New Developments in IPR: Administration of Patent System</p>		
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)

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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/

M.E. ENGINEERING DESIGN R2023

	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

M.E. ENGINEERING DESIGN R2023

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 K_{Ic} /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.		

M.E. ENGINEERING DESIGN R2023

UNIT-II	STRESS AND DISPLACEMENT AROUND THE CRACK TIP FOR DIFFERENT MODES OF FRACTURE	9
Brittle and Ductile Fracture-Modes of Fracture-Weakness of the components due to Flaws-Need for Linear Elastic Fracture Mechanics (LEFM) – Evaluation of Structural Design-Stress and displacement around the crack tip in K-annulus for Mode-I and Mode-II plane crack problems – Stress and displacement around the crack tip in K-annulus for Mode III crack problems.		
UNIT-III	STATIONARY CRACK UNDER STATIC LOADING	9
Griffith analysis- Irwin's approximation-CTOD and stress ahead of the crack tip- Westergaard solutions: Analytical Calculations for SIF for different crack geometries-Critical crack length and fracture stress calculations. Two dimensional elastic fields – Analytical solutions for small scale yielding near a crack front – plastic zone size – Specimen size calculations: K _{1c} Testing for Fracture toughness of the Material.		
UNIT-IV	FATIGUE FAILURE AND ENVIRONMENTAL-ASSISTED FRACTURE	9
Introduction to fatigue failure-S-N Curve-Crack Initiation-Crack propagation- Effect of an Overload-Variable amplitude Fatigue load-Crack closure- Characteristics of fatigue crack-Paris Law- Fatigue Crack Growth Test to evaluate Paris constants- life calculations for a given load amplitude –effects of changing the load spectrum Environmental-assisted Fracture-Micro mechanisms-factors influencing Environmental-assisted fracture- Environment-assisted Fatigue Failure affecting fatigue performance, fatigue loading, constant and variable amplitude loading.		
UNIT-V	APPLICATIONS OF FRACTURE MECHANICS	9
J-integral, Mixed-mode fracture. Crack arrest methodologies- Case studies: Analysis on failed components and design for the extension of its life.		
Total 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 K _{1c} /SIF/critical flaws/failure stresses for different crack geometries
●	Assess the life of the cracked components under different types of repeated/variable fatigue 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/ CRC Press, 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)

M.E. ENGINEERING DESIGN R2023

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)

M.E. ENGINEERING DESIGN R2023

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 of India 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.

M.E. ENGINEERING DESIGN R2023

	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)

M.E. ENGINEERING DESIGN R2023

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 Esposito, “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)

M.E. ENGINEERING DESIGN R2023

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/

M.E. ENGINEERING DESIGN R2023

	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.

M.E. ENGINEERING DESIGN R2023

	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.

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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, Hertz 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

M.E. ENGINEERING DESIGN R2023

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 Schöffner, 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

M.E. ENGINEERING DESIGN R2023

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.		

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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)

M.E. ENGINEERING DESIGN R2023

Subject Code	Subject Name (Theory Course)	Category	L	T	P	C
ED23125	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

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	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)

M.E. ENGINEERING DESIGN R2023

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

Objectives:						
•	To emphasize 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 emphasize 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.

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	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

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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

M.E. ENGINEERING DESIGN R2023

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 Six 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 8 th 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- -		

M.E. ENGINEERING DESIGN R2023

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)