RAJALAKSHMI ENGINEERING COLLEGE
AUTONOMOUS
M.E. ENGINEERING DESIGN
REGULATIONS 2019
CHOICE BASED CREDIT SYSTEM
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):

Enable the students:

I. To develop an aptitude to use engineering principles to conceptualize, create, model, test and evaluate designs within the context of local and global needs.

II. To become effective and excellent collaborators and innovators, participating in efforts to address and provide solutions to social and technical challenges.

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. Graduates will demonstrate knowledge of mathematics, science and engineering.
2. Graduates will have an ability to identify, formulate and solve engineering design problems by using computer-aided tools.
3. Graduate will have an ability to conduct experiments, analyze and interpret data in the area of design engineering though software.
4. Graduates will have an ability to design a system, component or process as per needs and specifications.
5. Graduate will demonstrate skills to use modern engineering tools, software and equipment to analyze multidisciplinary problems.
6. Graduates will demonstrate knowledge of professional and ethical responsibilities in the field of mechanical design.
7. Graduate will communicate their technical knowledge.
8. Graduate will be able to comprehend the impact of engineering solutions on the society and also will be able to face the contemporary issues.
9. Graduate will continue professional development and learning as a life-long activity.

PROGRAMME SPECIFIC OUTCOMES (PSOs):

1. Provide optimized solution to problems during design phase of product using advanced CAD /CAE / FEA tools and mathematical models.
2. Identify the space of work in different areas of research including inter disciplinary fields and provide innovative solutions using the design paradigms.
3. Become a successful professional with his/her acquired creative design skills and knowledge through which they would provide impetus to develop solutions that would lead to next generation technologies.

SEMESTER I

S.NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1	ED19101	COMPUTER APPLICATIONS IN DESIGN	PCC	5	3	0	2	4
2	ED19102	ADVANCED MECHANICS OF MATERIALS	PCC	3	3	0	0	3
3	ED19103	VIBRATION ANALYSIS AND CONTROL	PCC	3	3	0	0	3
4	ED19104	ADVANCED MECHANISMS IN DESIGN	PCC	4	3	1	0	4
5	PG19101	RESEARCH METHODOLOGY AND IPR	PCC	3	3	0	0	3
6	PE-1	PROFESSIONAL ELECTIVE-1	PEC	3	3	0	0	3
7	AC-1	AUDIT COURSE-I	AC	2	2	0	0	0
PRACTICAL								
8	ED19111	MECHANISM DESIGN LAB	PCC	3	0	0	3	1.5
9	ED19112	VIBRATION LAB	PCC	3	0	0	3	1.5
				29 Hrs				**23**

SEMESTER II

S.NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1	ED19201	FINITE ELEMENT METHODS IN MECHANICAL DESIGN	PCC	4	3	1	0	4
2	ED19202	INTEGRATED PRODUCT DESIGN AND PROCESS DEVELOPMENT	PCC	3	3	0	0	3
3	ED19203	DESIGN WITH ADVANCED MATERIALS	PCC	3	3	0	0	3
4	PE-2	PROFESSIONAL ELECTIVE-2	PEC	3	3	0	0	3
5	PE-3	PROFESSIONAL ELECTIVE-3	PEC	3	3	0	0	3

6	PE-4	PROFESSIONAL ELECTIVE-4	PEC	3	3	0	0	3
7	AC-2	AUDIT COURSE-II	AC	2	2	0	0	0
PRACTICAL								
8	ED19211	PRODUCT DESIGN AND DEVELOPMENT LAB	PCC	3	0	0	3	1.5
9	ED19212	ANALYSIS LAB	PCC	3	0	0	3	1.5
				28 Hrs				**22**

SEMESTER III

S.NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1	PE-5	PROFESSIONAL ELECTIVE-5	PEC	3	3	0	0	3
2	PE-6	PROFESSIONAL ELECTIVE-6	PEC	3	3	0	0	3
3		OPEN ELECTIVE	OEC	3	3	0	0	3
PRACTICAL								
4	ED19311	TECHNICAL SEMINAR/INTERNSHIP	EEC	2	0	0	2	1
5	ED19312	DISSERTATION-I	EEC	12	0	0	12	6
				23 Hrs				**16**

SEMESTER IV

S.NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
PRACTICAL								
1	ED19411	DISSERTATION-II	EEC	24	0	0	24	12
							TOTAL CREDITS:	**12**

TOTAL NO. OF CREDITS: 23+22+16+12 = 73

PROFESSIONAL ELECTIVES –I

S.NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1	ED19P11	CONDITION BASED MONITORING	**PEC**	3	3	0	0	3
2	ED19P12	COMPOSITE MATERIALS AND MECHANICS	**PEC**	3	3	0	0	3
3	ED19P13	DESIGN OF HYDRAULIC AND PNEUMATIC SYSTEMS	**PEC**	3	3	0	0	3
4	ED19P14	DESIGN AND ANALYSIS OF EXPERIMENTS	**PEC**	3	3	0	0	3
5.	ED19P15	ADVANCED MACHINE TOOL DESIGN	**PEC**	3	3	0	0	3

PROFESSIONAL ELECTIVES –II

S.NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1	ED19P21	DESIGN FOR MANUFACTURING AND ASSEMBLY	**PEC**	3	3	0	0	3
2	ED19P22	ADDITIVE MANUFACTURING	**PEC**	3	3	0	0	3
3.	ED19P23	DESIGN OF PRESSURE VESSEL AND PIPING	**PEC**	3	3	0	0	3

PROFESSIONAL ELECTIVES –III

S.NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1	ED19P24	OPTIMIZATION TECHNIQUES IN DESIGN	**PEC**	3	3	0	0	3
2	ED19P25	ENGINEERING FRACTURE MECHANICS	**PEC**	3	3	0	0	3
3	ED19P26	THEORY OF ELASTICITY AND PLASTICITY	**PEC**	3	3	0	0	3

PROFESSIONAL ELECTIVES –IV

S.NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1	ED19P27	CORROSION AND SURFACE ENGINEERING	**PEC**	3	3	0	0	3
2	ED19P28	QUALITY CNCEPT IN DESIGN	**PEC**	3	3	0	0	3
3	ED19P29	BEARING DESIGN AND ROTOR DYNAMICS	**PEC**	3	3	0	0	3

PROFESSIONAL ELECTIVES -V

S.NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1	ED19P31	PRODUCT LIFE CYCLE MANAGEMENT	**PEC**	3	3	0	0	3
2	ED19P32	ADVANCED FINITE ELEMENT ANALYSIS	**PEC**	3	3	0	0	3
3	ED19P33	GEAR ENGINEERING	**PEC**	3	3	0	0	3

PROFESSIONAL ELECTIVES –VI

S.NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1	ED19P34	DESIGN OF MATERIAL HANDLING EQUIPMENTS	**PEC**	3	3	0	0	3
2	ED19P35	TRIBOLOGY IN DESIGN	**PEC**	3	3	0	0	3
3	ED19P36	EXPERIMENTAL STRESS ANALYSIS	**PEC**	3	3	0	0	3
4.	ED19P37	COMPUTATIONAL FLUID DYNAMICS	**PEC**	3	3	0	0	3
5.	ED19P38	MATERIAL CHARACTERISATION TECHNIQUES	**PEC**	3	3	0	0	3

AUDIT COURSE 1 & 2:

1. AC19101 - English for Research paper writing
2. AC19201 - Constitution of India

OPEN ELECTIVE:

1. CP 19O31 - Business Analytics
2. ED19O32 - Operations Research
3. PG19O31- Cost Management of Engineering Projects.
4. PG19O32- Waste to Energy.

SEMESTER- I

Subject Code	Subject Name (Lab oriented Theory Courses)	Category	L	T	P	C
ED19101	COMPUTER APPLICATIONS IN DESIGN	PC	3	0	2	4

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

UNIT-I	**INTRODUCTION TO COMPUTER GRAPHICS FUNDAMENTALS**	**9**
Output primitives (points, lines, curves etc.,), 2-D & 3-D transformation (Translation, scaling, 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 modeling.		
UNIT-IV	**VISUAL REALISM**	**9**
Hidden – Line – Surface – solid removal algorithms shading – coloring. Introduction to parametric and variational geometry based software's and their principles creation of prismatic and lofted parts using these packages.		
UNIT-V	**ASSEMBLY OF PARTS AND PRODUCT DATA EXCHANGE**	**9**
Assembly modeling - interferences of positions and orientation - tolerances analysis – mass property calculations - mechanism simulation.Graphics and computing standards– Open GL Data Exchange standards – IGES, STEP etc– Communication standards.		
	Contact Hours : 45	

Laboratory session			
1	Writing interactive programs generate graphics and to solve design problems - using any languages like Auto LISP/ C / FORTRAN etc. Each assessment should contain a component of Laboratory session.		
	Contact Hours	**:**	**30**
	Total Contact Hours	**:**	**75**

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	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO 1	-	1	-	-	-	-	-	-	1	-	1	-
CO 2	1	2	-	1	2	-	-	-	1	-	1	-
CO 3	-	2	2	2	2	-	-	-	1	-	1	-
CO 4	2	2	1	-	1	-	-	-	1	-	1	-
CO 5	2	1	1	-	1	-	-	-	1	-	-	-

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

Subject Code	Subject Name (Theory course)	Category	L	T	P	C
ED19102	**ADVANCED MECHANICS OF MATERIALS**	PC	3	0	0	3

Objectives:

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

UNIT-I	**ELASTICITY**	9
Stress-Strain relations and general equations of elasticity in Cartesian, Polar and curvilinear coordinates, differential equations of equilibrium-compatibility-boundary conditions-representation of three-dimensional stress of a tension generalized hook's law - St. Venant's principle – plane stress - Airy's stress function. Energy methods.		
UNIT-II	**SHEAR CENTER AND UNSYMMETRICAL BENDING**	10
Location of shear center for various thin sections - shear flows. Stresses and Deflections in beams subjected to unsymmetrical loading-kern of a section.		
UNIT-III	**STRESSES IN FLAT PLATES AND CURVED MEMBERS**	10
Circumference and radial stresses – deflections - curved beam with restrained ends - closed ring subjected to concentrated load and uniform load - chain links and crane hooks. Solution of rectangular plates – pure bending of plates – deflection – uniformly distributed load – various end conditions. Indeterminate structures		
UNIT-IV	**TORSION OF NON-CIRCULAR SECTIONS**	7
Torsion of rectangular cross section - St.Venants theory - elastic membrane analogy - Prandtl's stress function - torsional stress in hollow thin walled tubes.		
UNIT-V	**STRESSES IN ROTATING MEMBERS AND CONTACT STRESSES**	9
Radial and tangential stresses in solid disc and ring of uniform thickness and varying thickness allowable speeds. Methods of computing contact stress-deflection of bodies in point and line contact applications.		
	Total Contact Hours : 45	

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

- Formulate and solve problems under elasticity state.
- Determine the shear centre and stresses 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

3	Robert D. Cook, Warren C. Young, "Advanced Mechanics of Materials", Mc- millan pub. Co., 1985.
4	Srinath. L.S., "Advanced Mechanics of solids", Tata McGraw Hill, 1992.
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	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO 1	2	-	-	2	-	-	-	-	-	-	1	1
CO 2	2	-	-	2	-	-	-	-	-	-	1	1
CO 3	2	-	-	2	-	-	-	-	-	-	1	1
CO 4	2	-	-	2	-	-	-	-	-	-	1	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
ED19103	**VIBRATION ANALYSIS AND CONTROL**	PC	3	0	0	3

Objectives:	
•	To understand the Fundamentals of Vibration and its practical applications
•	To understand the working principle and operations of various vibration measuring instruments
•	To understand the various Vibration control strategies.

UNIT-I	**FUNDAMENTALS OF VIBRATION**	10
Introduction -Sources Of Vibration-Mathematical Models- Displacement, velocity and Acceleration- Review Of Single Degree Freedom Systems -Vibration isolation Vibrometers and accelerometers - Response To Arbitrary and non-harmonic Excitations – Transient Vibration – Impulse loads- Critical Speed Of Shaft-Rotor systems.		
UNIT-II	**TWO DEGREE FREEDOM SYSTEM**	7
Introduction-Free Vibration Of Undamped And Damped - Forced Vibration With Harmonic Excitation System – Coordinate Couplings And Principal Coordinates		
UNIT-III	**MULTI-DEGREE FREEDOM SYSTEM AND CONTINUOUS SYSTEM**	9
Multi Degree Freedom System –Influence Coefficients and stiffness coefficients- Flexibility Matrix and Stiffness Matrix – Eigen Values and Eigen Vectors-Matrix Iteration Method –Approximate Methods: Dunkerley, Rayleigh's, and Holzer Method -Geared Systems-Eigen Values & Eigen vectors for large system of equations using sub space, Lanczos method - Continuous System: Vibration of String, Shafts and Beams		
UNIT-IV	**VIBRATION CONTROL**	9
Specification of Vibration Limits –Vibration severity standards- Vibration as condition Monitoring tool-Vibration Isolation methods- -Dynamic Vibration Absorber, Torsional and Pendulum Type Absorber- Damped Vibration absorbers-Static and Dynamic Balancing-Balancing machines-Field balancing – Vibration Control by Design Modification- - Active Vibration Control		
UNIT-V	**EXPERIMENTAL METHODS IN VIBRATION ANALYSIS**	10
Vibration Analysis Overview - Experimental Methods in Vibration Analysis.-Vibration Measuring Instruments - Selection of Sensors- Accelerometer Mountings. -Vibration Exciters-Mechanical, Hydraulic, Electromagnetic and Electrodynamics –Frequency Measuring Instruments-. System Identification from Frequency Response -Testing for resonance and mode shapes		
	Total Contact Hours : 45	

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
•	Determine Eigen values and Eigen vectors of the given beam.
•	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**	**PO7**	**PO8**	**PO9**	**PSO1**	**PSO2**	**PSO3**
CO 1	2	2	-	3	-	-	-	1	1	-	1	1
CO 2	2	-	-	1	-	-	-	-	1	-	1	1
CO 3	2	2	-	3	1	-	-	1	1	-	1	1
CO 4	2	2	-	3	2	-	-	1	1	-	1	1
CO 5	2	2	-	3	2	-	-	1	1	-	1	1

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

Subject Code	**Subject Name (Theory course)**	**Category**	**L**	**T**	**P**	**C**
ED19104	**ADVANCED MECHANISMS IN DESIGN**	PC	3	1	0	4

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**	**12**
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- ccompliant mechanisms-Equivalent mechanisms.		
UNIT-II	**KINEMATIC ANALYSIS**	**12**
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**	**12**
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**	**12**
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**	**12**

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	**:**	**60**

Course Outcomes: On completion of this course, the students will be able to	
•	Comprehend multi-loop kinematic chains and serial & parallel robot manipulators.
•	Analyze various kinematic linkages.
•	Draw various coupler curves of kinematic linkages.
•	Synthesize four bar mechanisms.
•	Synthesize coupler curve and cam mechanism.

Reference Books(s) / Web links:	
1	Robert L.Norton., "Design of Machinery",Tata McGraw Hill, 2011.
2	Sandor G.N., and Erdman A.G., "Advanced Mechanism Design Analysis and Synthesis", Prentice Hall, 1984.
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**	**PO7**	**PO8**	**PO9**	**PSO1**	**PSO2**	**PSO3**
CO 1	2	-	-	1	-	-	-	-	1	1	1	1
CO 2	2	-	-		-	-	-	-		1	1	1
CO 3	2	-	-		-	-	-	-		1	1	1
CO 4	2	-	-		-	-	-	-		1	1	1
CO 5	2	-	-		-	-	-	-		1	1	1

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

Subject Code	**Subject Name (Theory course)**	**Category**	**L**	**T**	**P**	**C**
PG19101	**Research Methodology and IPR**	PC	3	0	0	3

Objectives:	
●	To inculcate the importance of research methodology and Intellectual Property Rights. The main objective of the IPR is to make the students aware of their rights for the protection of their invention done in their project work.
●	To get registration of patents in our country and foreign countries of invention, designs and thesis or theory written. To get knowledge of patents, copy right, trademarks and designs

UNIT-I	**FUNDAMENTALS**	9
Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations		

UNIT-II	**REVIEW OF LITERATURE AND TECHNICAL WRITING**	9
Effective literature studies approaches, analysis Plagiarism, Research ethics, Effective technical writing, how to write report, Paper Developing a Research Proposal.		
UNIT-III	**INTELLECTUAL PROPERTY RIGHTS**	9
Nature of Intellectual Property: Patents, Designs, Trade and Copyright, copyright registration in India Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under Patent Cooperation Treaty.		
UNIT-IV	**PATENT RIGHTS AND RECENT DEVELOPMENTS IN IPR**	9
Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies,		
UNIT-V	**INDUSTRIAL DESIGNS AND GEOGRAPHICAL INDICATIONS**	9
Industrial designs and IC Layout design, Registrations of designs, conditions and procedures of industrial designs-Cancellation of Registration, International convention of design- types and functions. Semiconductor Integrated circuits and layout design Act- Geographical indications-potential benefits of Geographical Indications		
	Total Contact Hours : 45	

Course Outcomes: On completion of this course, the students will be able to	
●	Apply knowledge on research problem formulation and analyze research related information
●	Apply IPR concept to important place in growth of individuals & nation.
●	Describe the importance of copyright and industrial designs.
●	Apply patent right to new products developed.
●	Describe the procedure and the tools to get patent copy right for their innovative work.

Reference Books(s) / Web links:	
1	Neeraj Pandey and Khushdeep Dharni, Intellectual Property Rights, First edition, PHI learning Pvt. Ltd., Delhi, 2014
2	Uma Sekaran and Roger Bougie, Research methods for Business, 5th Edition, Wiley India, New Delhi, 2012.
3	Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students"' ,2nd edition, Juta Academic, 2001 "
4	Ramakrishna B & Anilkumar H S, Fundamentals of Intellectual Property Rights, Ist edition, Notion Press, 2017,
5	William G Zikmund, Barry J Babin, Jon C.Carr, Atanu Adhikari,Mitch Griffin, Business
	Research methods, A South Asian Perspective, 8th Edition, Cengage Learning, New Delhi, 2012.

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PSO1**	**PSO2**	**PSO3**
CO 1	2	2	-	-	2	3	-	-	2	-	-	-
CO 2	2	2	-	-	2	3	-	-	2	-	-	-
CO 3	-	-	-	-	2	3	-	-	-	-	-	-
CO 4	-	-	-	-	2	3	-	-	-	-	-	-
CO 5	-	-	-	-	2	3	-	-	-	-	-	-

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

Subject Code	Subject Name (Laboratory Course)	Category	L	T	P	C
ED19111	MECHANISM DESIGN LAB	PC	0	0	3	1.5

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		
	Total Contact Hours	**:**	**45**

Course Outcomes: On completion of this course, the students will be able to	
•	Determine the displacement, velocity and acceleration.
•	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	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO 1	2	3	3	3	3	-	2	-	2	3	-	1
CO 2	2	3	3	3	3	-	2	-	2	3	-	1
CO 3	2	3	3	3	3	-	2	-	2	3	-	1
CO 4	2	3	3	3	3	-	2	-	2	3	-	1
CO 5	2	3	3	3	3	-	2	-	2	3	-	1

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

Subject Code	Subject Name (Laboratory Course)	Category	L	T	P	C
ED19112	VIBRATION LAB	PC	0	0	3	1.5

Objectives:	
●	To impart knowledge to the students for determining the natural frequency of various systems

List of Experiments				
1.	To determine the radius of gyration of given bar using bi-fillar suspension			
2.	To verify the dunker lay's rule.			
3.	To determine the natural frequency of undamped torsional vibration of a single rotor shaft system.			
4.	To determine the natural frequency of undamped torsional vibration of two rotor shaft system			
5.	To determine the frequency of undamped free vibration of an equivalent spring mass system			
6.	To determine the frequency of the beam using free vibration setup.			
7.	To determine the frequency of the composite beam using free vibration setup.			
8.	To determine the critical speed of the shaft.			
9.	To determine the natural frequency of SDOF undamped and damped system using coding.			
		Total Contact Hours	**:**	**45**

Course Outcomes: On completion of this course, the students will be able to	
●	Determine the natural frequency of torsional vibrations
●	Determine the natural frequency of spring mass system
●	Determine the natural frequency of beams.
●	Determine the radius of gyration of bi filar suspension.
●	Use the free vibration setup to determine the frequency and mode shapes.

Web links for virtual lab (if any)	
1	http://mdmv-nitk.vlabs.ac.in/
2	http://vlab.amrita.edu/?sub=62&brch=175&sim=1077&cnt=2
3	http://vaoep.vlabs.ac.in/List%20of%20experiments.html?domain=Mechanical%20Engineering

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO 1	2	-	-	-	1	-	1	-	1	-	1	-
CO 2	2	-	-	-	1	-	1	-	1	-	1	-
CO 3	2	-	-	-	1	-	1	-	1	-	1	-
CO 4	2	-	-	-	1	-	1	-	1	-	1	-
CO 5	2	-	3	-	1	-	1	-	1	-	1	-

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

SEMESTER II

Subject Code	Subject Name (Theory course)	Category	L	T	P	C
ED19201	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 - Applications to Heat Transfer problems.		
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	**DYNAMIC ANALYSIS**	**12**
Dynamic Analysis – Equations of Motion – Mass & damping matrices – Free Vibration analysis – Natural frequencies of Longitudinal and Transverse vibration – Introduction to transient field problems – h & p elements.		
UNIT-V	**SOLUTION TECHNIQUES**	**12**
Inversion Method, LU decomposition, Cholesky Decomposition, Banded Solver method, Skyline procedure method, Band width reduction Techniques, Frontal width Methods, Free meshing and Mapped Meshing.		
	Total Contact Hours : 60	

Course Outcomes: On completion of this course, the students will be able to	
●	Mathematically model physical systems and solve using numerical techniques.
●	Select appropriate element and boundary conditions for various 1D Boundary value problems.
●	Apply appropriate element and boundary conditions for various 2D Boundary value problems.
●	Apply various solution techniques to solve Boundary value problems and Eigen value problems
●	Able to solve dynamic and 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/

PO/PSO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO9	PSO1	PSO2	PSO3
CO 1	3	-	1	2	2	1	-	-	3	1	1	1
CO 2	3	-	2	2	2	1	-	-	3	1	1	1
CO 3	3	-	2	2	2	1	-	-	3	1	1	1
CO 4	3	-	2	2	2	1	-	-	3	1	1	1
CO 5	3	-	2	2	2	1	-	-	3	1	1	1
Average	**3**	-	**1.8**	**2**	**2**	**1**	-	-	**3**	**1**	**1**	1

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

Subject Code	Subject Name (Theory course)	Category	L	T	P	C
ED19202	**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	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO 1	2	-	-	1	-	-	-	-	1	-	-	1
CO 2	2	-	-	1	-	-	-	-	1	-	-	1
CO 3	2	-	-	1	-	-	-	1	1	1	-	1
CO 4	2	-	-	1	-	-	-	-	1	1	-	1
CO 5	2	-	-	1	-	-	-	2	1	-	-	1

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

Subject Code	Subject Name (Theory course)	Category	L	T	P	C
ED19203	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 modeling 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 behavior of laminates.		
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.		
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.		
	Total Contact Hours : 45	

Course Outcomes: On completion of this course, the students will be able to	
•	Describe the properties of various 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	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO 1	1	-	-	-	-	-	-	-	1	-	1	1
CO 2	1	-	-	-	-	-	-	-	1	-	1	1
CO 3	1	-	-	-	-	-	-	-	1	-	1	1

CO 4	1	-	-	-	-	-	-	-	1	-	1	1
CO 5	1	-	-	-	-	-	-	-	1	-	1	1

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

Subject Code	Subject Name (Laboratory Course)	Category	L	T	P	C
ED19211	**PRODUCT DESIGN AND DEVELOPMENT LAB**	**PC**	**0**	**0**	**3**	**1.5**

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

List of Experiments			
	Each student is required to select any new component or an integrated mechanical system that involves various sub components, which are to be designed as per design standards and further required to be analyzed for optimum dimensions with respect to the strength and stiffness.		
	Total Contact Hours	**:**	**45**

Course Outcomes: On completion of this course, the students will be able to	
●	Use design standards for different applications.
●	Make detailed design calculations.
●	Analyze and design any mechanical component or system.
●	Carry out optimum design of a given component based on strength and rigidity.
●	Select a suitable material for his design.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO 1	2	3	3	3	-	-	3	2	2	3	1	2
CO 2	2	3	3	3	-	-	3	2	2	3	1	2
CO 3	2	3	3	3	-	-	3	2	2	3	1	2
CO 4	2	3	3	3	3	-	3	2	2	3	1	2
CO 5	2	3	3	3	3	-	3	2	2	3	1	2

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

Subject Code	Subject Name (Laboratory Course)	Category	L	T	P	C
ED19212	**ANALYSIS LAB**	**PC**	**0**	**0**	**3**	**1.5**

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	**:**	**45**	

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**	**PO7**	**PO8**	**PO9**	**PSO1**	**PSO2**	**PSO3**
CO 1	1	2	3	1	1	-	-	-	1	-	-	1
CO 2	1	2	3	1	1	-	-	-	1	-	-	1
CO 3	1	2	3	1	1	-	-	-	1	1	-	1
CO 4	1	2	3	1	1	-	-	-	1	1	-	1
CO 5	1	2	3	1	1	-	-	1	1	1	-	1

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

Subject Code	**Subject Name (Theory course)**	**Category**	**L**	**T**	**P**	**C**
ED19P11	**CONDITION BASED MONITORING**	**PE**	**3**	**0**	**0**	**3**

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

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 – Haarwavelets, 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. Tool 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**	**PO7**	**PO8**	**PO9**	**PSO1**	**PSO2**	**PSO3**
CO 1	1	-	-	-	-	-	-	-	-	-	-	1
CO 2	1	-	-	-	-	-	-	-	-	-	-	1
CO 3	1	-	-	-	-	-	-	-	-	-	-	1
CO 4	1	-	-	-	-	-	-	-	-	-	-	1
CO 5	1	-	-	-	-	-	-	-	-	-	-	1

Subject Code	Subject Name (Theory course)	Category	L	T	P	C
ED19P12	COMPOSITE MATERIALS AND MECHANICS	PE	3	0	0	3

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

UNIT-I	INTRODUCTION TO COMPOSITE MATERIALS	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)-handlay-up, spray technique, filament winding, Pultrusion, Resin Transfer Moulding (RTM)-, bag moulding, injection moulding, Sandwich Mould Composites (SMC) - Manufacturing of Metal Matrix Composites (MMCs) – Solid state, liquid state, vapour state processing, Manufacturing of Ceramic Matrix Composites (CMCs) –hot pressing-reaction bonding process-infiltration technique, direct oxidation-interfaces.		
UNIT-III	**INTRODUCTION, LAMINA CONSTITUTIVE EQUATIONS**	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.		
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		
UNIT-V	**THERMAL ANALYSIS**	9
Thermal effect of composite plates- Modified Hookes law, Transformation of thermal expansion coefficients from material axes to x and y-directions. Consideration of thermal effects in semi - infinite plates. Analysis of the thermal effects on the semi-infinite plate. Effect of symmetricity of semi-infinite plate. Boundary condition, problems on thermal analysis.		
	Total Contact Hours : 45	

Course Outcomes: On completion of this course, the students will be able to	
•	Explain the types of composite.
•	Adopt the various manufacturing methods of composite.
•	Predict lamina properties of different composites.
•	Evaluate laminate properties using various theories.
•	Estimate thermal properties of the 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	Issac M. Daniel and Ori Ishai, "Engineering Mechanics of Composite Materials", Oxford University Press-2006, First Indian Edition - 2007

4	Mallick, P.K., "Fiber Reinforced Composites: Materials, Manufacturing and Design", Third Edition, CRC Press, 2007.
5	Halpin, J.C., "Primer on Composite Materials, Analysis",Second Edition, CRC Press., 1992.
6	Agarwal, B.D., and Broutman L.J., "Analysis and Performance of Fiber Composites", Fourth Edition, Wiley, New York, 2017.
7	Mallick, P.K. and Newman, S., (edition), "Composite Materials Technology: Processes and Properties", Hansen Publisher, Munish, 1990.
8	Madhujit Mukhopadhyay, "Mechanics of Composite Materials and Structures", University Press (India) Pvt. Ltd., Hyderabad, 2004 (Reprinted 2008)
9	Chung, Deborah D.L., "Composite Materials: Science and Applications", Ane Books Pvt. Ltd./Springer, New Delhi, 1st Indian Reprint, 2009.
10	https://nptel.ac.in/courses/112104229/2
11	https://nptel.ac.in/courses/112104249/
12	https://online.stanford.edu/courses/aa256-mechanics-composites
13	https://www.edx.org/course/composite-materials-overview-for-engineers

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO 1	2	-	-	-	-	-	-	-	-	-	-	-
CO 2	2	-	-	-	-	-	-	-	-	-	1	-
CO 3	2	-	-	3	-	-	-	-	-	1	1	-
CO 4	2	-	-	3	-	-	-	-	-	1	1	-
CO 5	2	-	-	3	-	-	-	-	-	1	1	-

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

Subject Code	Subject Name (Theory course)	Category	L	T	P	C
ED19P13	**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.		
UNIT-IV	**PNEUMATIC SYSTEMS AND CIRCUITS**	10
Pneumatic fundamentals - control elements, position and pressure sensing, Pneumatic equipments- selection of components - design calculations - logic circuits - switching circuits - fringe conditions modules and these integration - sequential circuits - cascade methods – mapping methods - step counter method - compound circuit design - combination circuit design- Karnaugh - Veitch map.		
UNIT-V	**ELECTROMAGNETIC & ELECTRONIC CONTROL OF HYDRAULIC & PNEUMATIC CIRCUIT**	10

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

Reference Books(s) / Web links:	
1	Antony Espossito, "Fluid Power with Applications", Pearson Education Limited, 2014.
2	Dudleyt, A. Pease and John J. Pippenger, "Basic fluid power", Prentice Hall, 1987.
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**	**PO7**	**PO8**	**PO9**	**PSO1**	**PSO2**	**PSO3**
CO 1	1	-	-	1	-	-	-	-	1	-	-	2
CO 2	1	-	-	1	-	-	-	-	1	-	-	2
CO 3	1	-	-	1	-	-	-	-	1	-	-	2
CO 4	1	-	-	1	-	-	-	-	1	-	-	2
CO 5	1	-	-	1	-	-	-	-	1	-	-	2

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

Subject Code	**Subject Name (Theory course)**	**Category**	**L**	**T**	**P**	**C**
ED19P14	**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**	**PO7**	**PO8**	**PO9**	**PSO1**	**PSO2**	**PSO3**
CO 1	2	-	-	-	1	-	-	-	1	3	1	-
CO 2	2	-	-	-	1	-	-	-	1	3	1	-
CO 3	2	-	-	-	1	-	-	-	1	3	1	-
CO 4	2	-	-	-	1	-	-	-	1	3	1	-
CO 5	2	-	-	-	1	-	-	-	1	3	1	-

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

Subject Code	**Subject Name (Theory course)**	**Category**	**L**	**T**	**P**	**C**
ED19P15	**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**	**PO7**	**PO8**	**PO9**	**PSO1**	**PSO2**	**PSO3**
CO 1	1	-	-	2	-	-	1	1	1	1	-	2
CO 2	1	-	-	3	-	-	1	1	1	1	-	2
CO 3	1	-	-	3	-	-	1	1	1	1	-	2
CO 4	1	-	-	-	-	-	1	1	1	-	-	2
CO 5	1	-	-	-	-	-	1	1	1	-	-	2

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

Subject Code	Subject Name (Theory course)	Category	L	T	P	C
ED19P21	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	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO 1	2	-	-	2	-	-	-	-	1	1	1	1
CO 2	2	-	-	2	-	-	-	-	1	1	1	1
CO 3	2	-	-	2	-	-	-	-	1	1	1	1
CO 4	2	-	-	-	-	-	-	-	1	1	1	1
CO 5	2	-	-	-	-	3	-	2	1	-	-	1

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

Subject Code	Subject Name (Theory course)	Category	L	T	P	C
ED19P22	**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**	9
Need - Development of AM systems – AM process chain - Impact of AM on Product Development - Virtual Prototyping- Rapid Tooling – RP to AM -Classification of AM processes-Benefits 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.		
UNIT-III	**LIQUID AND SOLID BASED ADDITIVE MANUFACTURING SYSTEMS**	9
Stereolithography Apparatus (SLA): Principle, pre-build process, part-building and post-build processes, photo polymerization of SL resins, part quality and process planning, recoating issues, materials, advantages, limitations and applications. Solid Ground Curing (SGC): working principle, process, strengths, weaknesses and applications. Fused deposition 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		
UNIT-IV	**POWDER BASED ADDITIVE MANUFACTURING SYSTEMS**	9
Selective Laser Sintering (SLS): Principle, process, Indirect and direct SLS- powder structures, materials, post processing, surface deviation and accuracy, Applications. Laser Engineered Net Shaping (LENS): Processes, materials, products, advantages, limitations and applications– Case Studies.		
UNIT-V	**TOOLING**	9
Classification, Soft tooling, Production tooling, Bridge tooling, direct and indirect tooling, Fabrication processes, Applications Case studies automotive, aerospace and electronics industries		
	Total 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	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO 1	2	-	-	-	-	-	-	-	1	-	-	-
CO 2	2	2	-	2	2	-	-	-	1	2	2	2
CO 3	2	2	-	2	2	-	-	-	1	2	2	2
CO 4	2	2	-	2	2	-	-	-	1	2	2	2
CO 5	2	2	-	2	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
ED19P23	**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**	3
Methods for determining stresses – Terminology and Ligament Efficiency – Applications		
UNIT-II	**STRESSES IN PRESSURE VESSELS**	15
Introduction – Stresses in a circular ring, cylinder – Membrane stress Analysis of Vessel Shell components – Cylindrical shells, spherical Heads, conical heads – Thermal Stresses – Discontinuity stresses in pressure vessels.		
UNIT-III	**DESIGN OF VESSELS**	15
Design of Tall cylindrical self supporting process columns – Supports for short, vertical and horizontal vessels – stress concentration – at a variable Thickness transition section in a cylindrical vessel, about a circular hole, elliptical openings. Theory of Reinforcement – pressure vessel Design. Introduction to ASME pressure vessel codes		
UNIT-IV	**BUCKLING OF VESSELS**	8
Buckling phenomenon – Elastic Buckling of circular ring and cylinders under external pressure – collapse of thick walled cylinders or tubes under external pressure – Effect of supports on Elastic Buckling of Cylinders – Buckling under combined External pressure and axial loading.		
UNIT-V	**PIPING**	4
Introduction – Flow diagram – piping layout and piping stress Analysis		
	Total 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**	**PO7**	**PO8**	**PO9**	**PSO1**	**PSO2**	**PSO3**
CO 1	3	-	-	-	-	-	-	-	-	-	-	-
CO 2	3	-	-	3	-	-	-	1	1	2	1	-
CO 3	3	-	-	3	-	-	-	1	1	2	1	-
CO 4	3	-	-	3	-	-	-	1	1	2	1	-
CO 5	3	-	-	3	-	-	-	1	1	2	1	-

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

Subject Code	**Subject Name (Theory course)**	**Category**	**L**	**T**	**P**	**C**
ED19P24	**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**	**PO7**	**PO8**	**PO9**	**PSO1**	**PSO2**	**PSO3**
CO 1	2	-	-	1	1	-	-	-	1	2	2	1
CO 2	2	-	-	1	1	-	-	-	1	2	2	1
CO 3	2	-	-	1	1	-	-	-	1	2	2	1
CO 4	2	-	-	1	1	-	-	-	1	2	2	1
CO 5	2	-	-	1	1	-	-	-	1	2	2	1

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

ED19P25	ENGINEERING FRACTURE MECHANICS	PE	3	0	0	3

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

UNIT-I	ELEMENTS OF SOLID MECHANICS	9
The geometry of stress and strain, elastic deformation, plastic and elasto-plastic deformation – limit analysis – Airy's function – field equation for stress intensity factor.		
UNIT-II	**STATIONARY CRACK UNDER STATIC LOADING**	9
Two dimensional elastic fields – Analytical solutions yielding near a crack front – Irwin's approximation - plastic zone size – Dugdaale model – determination of J integral and its relation to crack opening displacement.		
UNIT-III	**ENERGY BALANCE AND CRACK GROWTH**	9
Griffith analysis – stable and unstable crack growth –Dynamic energy balance – crack arrest mechanism –K1c test methods - R curves - determination of collapse load.		
UNIT-IV	**FATIGUE CRACK GROWTH CURVE**	9
Empirical relation describing crack growth law – life calculations for a given load amplitude – effects of changing the load spectrum -- rain flow method– external factors affecting the K1c values.- leak before break analysis.		
UNIT-V	**APPLICATIONS OF FRACTURE MECHANICS**	9
Crack Initiation under large scale yielding – thickness as a design parameter – mixed mode fractures - crack instability in thermal and residual stress fields - numerical methods.Prediction of crack growth using software.		
	Total Contact Hours : 45	

Course Outcomes: On completion of this course, the students will be able to	
●	Comprehend the basics elements related to solid mechanics.
●	Design components that contain crack under static load condition.
●	Estimate the energy required for a crack to grow under cyclic load.
●	Apply the crack growth law and predict residual life.
●	Describe the mechanism of crack under thermal load and its initiation.

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.
3	John M.Barson and Stanely T.Rolfe Fatigue and fracture control in structures Prentice hall Inc. Englewood cliffs. 1987
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	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO 1	2	-	-	-	-	-	-	-	1	1	1	-
CO 2	2	-	-	-	-	-	-	-	1	1	1	-
CO 3	2	-	-	-	-	-	-	-	1	1	1	-
CO 4	2	-	-	-	-	-	-	-	1	1	1	-

CO 5	2	-	-	-	-	-	-	-	1	1	1	-

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

Subject Code	Subject Name (Theory course)	Category	L	T	P	C
ED19P26	**THEORY OF ELASTICITY AND PLASTICITY**	**PE**	**3**	**0**	**0**	**3**

Objectives:	
•	To make the students familiar with the elastic and plastic state behavior of the materials.
•	To compute the stresses and strains in elastic and plastic state.

UNIT-I	**ANALYSIS OF STRESS AND STRAIN**	9
Stress at a point, stress tensor, stress transformations, principal stresses, octahedral stress, equations of equilibrium, strain tensor, principal strains, strain-displacement relations, compatibility conditions, strain gages and rosettes		
UNIT-II	**CONSTITUTIVE EQUATIONS**:	9
General theory, generalized Hooke's law, equations of elasticity, formulation of the general elasticity problem, boundary conditions, two-dimensional problems in rectangular and polar co-ordinates, Airy's stress function.		
UNIT-III	**CONTACT STRESSES**	9
Introduction, geometry of contact surfaces, notation and meaning of terms, expressions for principal stresses, method of computing contact stresses – Hertzian, JKR, DMT models.		
UNIT-IV	**PLASTICITY**	9
Plastic flow and its microscopic and macroscopic descriptions, stress-strain curves of real materials, definition of yield criterion, concept of a yield surface in principal stress space, Yield criteria - Tresca - von Mises.		
UNIT-V	**PLASTIC STRAIN ANALYSIS**	9
Prandtl-Reuss and Levy-Mises equations, deformation in plane stress-yielding of thin sheet in biaxial and uniaxial tension. Plane strain deformation-stress tensor, hydrostatic and deviatoric components, plastic potential, plastic instability, effect of strain rates and temperature effects on flow stress. Introduction to slip line theory.		
	Total Contact Hours : 45	

Course Outcomes: On completion of this course, the students will be able to	
•	Analyse the stresses in components.
•	Derive constitutive equation in 2D.
•	Compute the contact stresses in a body.
•	Describe the behavior of materials under plastic state.
•	Compute the strains in a body under plastic state

Reference Books(s) / Web links:	
1	Timoshenko S P and Goodier J N, "Theory of Elasticity", McGraw Hill International Editions, 2017.
2	Chakrabarthy J, "Theory of Plasticity", McGraw Hill Co, 1987
3	Durelli A J, Phillips E A and Tsao C H, "Introduction to the Theoretical and Experimental Analysis of Stress and Strain", McGraw Hill, New York, 1958.
4	H.Jane Helena, Theory of Elasticity and Plasticity, PHI, 2017.
5	Irving H.Shames and James,M.Pitarresi, Introduction to Solid Mechanics,Prentice Hall of India Pvt. Ltd., New Delhi -2002.

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PSO1**	**PSO2**	**PSO3**
CO 1	3	-	-	2	-	-	-	-	1	1	2	1
CO 2	3	-	-	-	-	-	-	-	1	1	2	2
CO 3	3	-	-	3	-	-	-	-	1	1	2	2

CO 4	3	-	-	3	-	-	-	-	1	1	2	2
CO 5	3	-	-	3	-	-	-	-	1	1	2	2

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

Subject Code	Subject Name (Theory course)	Category	L	T	P	C
ED19P27	**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 nonmetallic 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	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO 1	1	-	-	-	-	-	-	1	-	-	1	-
CO 2	1	-	-	-	-	-	-	1	-	-	1	1
CO 3	1	-	-	-	-	-	-	1	-	-	1	1
CO 4	1	-	-	-	-	-	-	1	-	-	1	1
CO 5	1	-	-	-	-	-	-	1	-	-	1	1

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

Subject Code	Subject Name (Theory course)	Category	L	T	P	C
ED19P28	**QUALITY CONCEPTS IN DESIGN**	**PE**	**3**	**0**	**0**	**3**

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

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

Course Outcomes: On completion of this course, the students will be able to	
●	Comprehend the design fundamentals and material selection.

●	Explain the various quality levels in design
●	Apply FMEA and Sic sigma concepts
●	Apply various DOE approaches to a given problem.
●	Use different statistical plots for a given problem..

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" 3rd edition, , Pearson Education Asia, 2013.
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**	**PO7**	**PO8**	**PO9**	**PSO1**	**PSO2**	**PSO3**
CO 1	1	-	-	-	-	-	-	1	-	-	1	1
CO 2	1	-	-	-	-	-	-	1	-	-	1	1
CO 3	1	-	-	-	-	-	-	1	-	-	1	1
CO 4	1	-	-	-	-	-	-	1	-	-	1	1
CO 5	1	-	-	-	-	-	-	1	-	-	1	1

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

Subject Code	**Subject Name (Theory course)**	**Category**	**L**	**T**	**P**	**C**
ED19P29	**BEARING DESIGN AND ROTOR DYNAMICS**	**PE**	**3**	**0**	**0**	**3**

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

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

Contact Stresses in Rolling bearings- Centrifugal stresses-Elasto hydrodynamic lubrication- Fatigue life calculations- Bearing operating temperature- Lubrication- Selection of lubricants- Internal clearance – Shaft and housing fit- - Mounting arrangements-Materials for rolling bearings- Manufacturing methods- Ceramic bearings-Rolling bearing cages-bearing seals selection		
UNIT-IV	**DYNAMICS OF HYDRODYNAMIC BEARINGS**	10
Hydrodynamic Lubrication equation for dynamic loadings-Squeeze film effects in journal bearings and thrust bearings -Rotating loads , alternating and impulse loads in journal bearings – Journal centre Trajectory- Analysis of short bearings under dynamic conditions- Finite difference solution for dynamic conditions		
UNIT-V	**ROTOR DYNAMICS**	9
Rotor vibration and Rotor critical speeds- support stiffness on critical speeds- Stiffness and damping coefficients of journal bearings-computation and measurements of journal bearing coefficients -Mechanics of Hydro dynamic Instability- Half frequency whirl and Resonance whip- Design configurations of stable journal bearings		
	Total Contact Hours : 45	

Course Outcomes: On completion of this course, the students will be able to	
●	Comprehend the various types of bearings.
●	Make design and analyse the bearing as per the requirement.
●	Select and design the roller bearing as per the requirement.
●	Explain the behavior of bearings under dynamic condition.
●	Comprehend the various measuring techniques used to predict the bearing behavior.

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**	**PO7**	**PO8**	**PO9**	**PSO1**	**PSO2**	**PSO3**
CO 1	2	-	-	1	1	-	-	-	-	-	-	-
CO 2	2	1	-	3	1	-	1	-	1	1	-	1
CO 3	2	1	-	3	1	-	1	-	1	1	-	1
CO 4	2	1	-	3	1	-	1	-	1	1	-	1
CO 5	2	1	-	3	1	-	1	-	1	1	-	1

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

SEMESTER III

Subject Code	Subject Name (Theory course)	Category	L	T	P	C
ED19P31	PRODUCT LIFECYCLE MANAGEMENT	PEC	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& 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	AnttiSaaksvuori and AnselmiImmonen, “Product Lifecycle Management”, Springer Publisher, 2008 (3rd Edition)
2	IvicaCrnkovic, Ulf Asklund and AnnitaPerssonDahlqvist, “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.

CO-PO Mapping

	PO	**PSO**

	1	2	3	4	5	6	7	8	9	PSO 1	PSO 2	PSO 3
CO 1	3	0	0	-	-	-	--	1	1	1	1	-
CO 2	3	0	0	-	-	-	--	1	1	1	1	-
CO 3	3	2	2	-	-	-	--	1	1	1	1	-
CO 4	3	0	0	-	-	-	--	1	1	1	1	-
CO 5	3	2	2	-	-	-	--	1	1	1	1	-
Average	3	2	2	-	-	-	--	1	1	1	1	-

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

Subject Code	Subject Name (Theory course)	Category	L	T	P	C
ED19P32	**ADVANCED FINITE ELEMENT ANALYSIS**	**PE**	**3**	**0**	**0**	**3**

Objectives:	
●	The objective of this course is to learn advanced topics in FEM so that this tool can be used for analysis, design, and optimization of engineering systems.
●	Various nonlinearities in structural problems will be studied in the mathematical and numerical aspects.

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 & Implicit Methods- Lanchzos, Reduced method for large size system equations.		
UNIT-IV	**FLUID MECHANICS AND HEAT TRANSFER**	9
Governing Equations of Fluid Mechanics – Solid structure interaction - Inviscid and Incompressible Flow – Potential Formulations – Slow Non-Newtonian Flow – Metal and Polymer Forming – Navier Stokes Equation – Steady and Transient Solution.		
UNIT-V	**ERROR ESTIMATES AND ADAPTIVE REFINEMENT**	7
Error norms and Convergence rates – h-refinement with adaptivity – Adaptive refinement.		
	Total Contact Hours : 45	

Course Outcomes: On completion of this course, the students will be able to	
●	Demonstrate Plate bending element, shell element, axisymmetric element etc.
●	Solve non-linear problems using FEA.
●	Solve problems involving dynamics using FEA.
●	Apply FEA for analysis of given problem.
●	Determine solution error and do its estimation.

Reference Books(s) / Web links:	
1	J. N. Reddy , Introduction to nonlinear finite element analysis,Oxford Press, 2004.
2	Nam-Ho Kim, Introduction to Nonlinear Finite Element Analysis, Springer, New York, 2015.
3	R.D. Cook, D.S. Makus and M.F.Plesha, 'Concept and Applications of Finite Element Analysis', John Wiley and Sons, 1981.
4	S. Krishnamoorthy, 'Finite Element Analysis, Theory and Programming', Tata McGraw-Hill, Publishing Company Ltd., New Delhi, 1987.
5	Y. Nakasone, S. Yoshimoto, T. A. Stolarski, 'Engineering Analysis With ANSYS Software', Elsevier, Burlington, 2006
6	Thomas J. R. Hughes, 'The Finite Element Method- Linear Static and Dynamic Finite Element Analysis', Dover Publication, Inc., New York, 2000.
7	http://www2.mae.ufl.edu/nkim/INFEM/

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO 1	2	1	-	-	1	-	-	1	1	2	1	3
CO 2	2	1	-	-	1	-	-	1	1	2	1	3
CO 3	2	1	-	-	1	-	-	1	1	2	1	3
CO 4	2	1	-	-	1	-	-	1	1	2	1	3
CO 5	2	1	-	-	1	-	-	1	1	2	1	3

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

Subject Code	Subject Name (Theory course)	Category	L	T	P	C
ED19P33	GEAR ENGINEERING	PE	3	0	0	3

Objectives: The main learning objective of this course is to prepare the students to:	
•	Understand the fundamentals of gears and spur gear design.
•	Learn the design of helical gears and bevel gears.
•	Learn the design of worm gears, epicyclic gear train and automobile gear box.
•	Understand the various gear failures.
•	Understand the concept of optimum gear design.

UNIT-I	FUNDAMENTALS OF GEARS AND SPUR GEAR DESIGN	9
Introduction: Principles of gear tooth action, Generation of Cycloid and Involute gears, Involutometry, gear manufacturing processes and inspection, gear tooth failure modes, stresses, selection of right kind of gears. **Spur Gears:** Tooth loads, Principles of Geometry, Design considerations and methodology, Complete design of spur gear teeth considering Lewis beam strength, Buckingham's dynamic load and wear load, Design of gear shaft and bearings.		
UNIT-II	HELICAL GEARS AND BEVEL GEAR DESIGN	10

Helical Gears: Tooth loads, Principles of Geometry, Design considerations and methodology, Complete design of helical gear teeth considering Lewis beam strength, Buckingham's dynamic load and wear load, Design of gear shaft and bearings. **Bevel Gears:** Tooth loads, Principles of Geometry, Design considerations and methodology, Complete design of bevel gear teeth considering Lewis beam strength, Buckingham's dynamic load and wear load, Design of gear shaft and bearings.		
UNIT- III	**DESIGN OF WORM GEARS AND GEAR TRAINS**	**9**
Tooth loads, Principles of Geometry, Design considerations and methodology, Complete design of worm gear teeth considering Lewis beam strength, Buckingham's dynamic load and wear load, Heat dissipation considerations. Design of gear shaft and bearings. **Gear trains:** Simple, compound and epicyclic gear trains, Ray diagrams, Design of a gear box of an automobile, Design of gear trains from the propeller shafts of airplanes for auxiliary systems.		
UNIT-IV	**GEAR FAILURE ANALYSIS**	**8**
Analysis of gear tooth failures, Nomenclature of gear tooth wear and failure, tooth breakage, pitting, scoring, wear, overloading, gear-casing problems, lubrication failures.		
UNIT-V	**OPTIMAL GEAR DESIGN**	**9**
Optimization of gear design parameters, Weight minimization, Constraints in gear train design-space, interference, strength, dynamic considerations, rigidity, etc. Compact design of gear trains, multi objective optimization of gear trains. Application of Traditional and non-traditional optimization techniques. Introduction to Gear design using software.		
	Total Contact Hours : 45	

Course Outcomes: Upon successful completion of the course, the student will be able to	
•	Comprehend fundamentals of gears and design spur gear.
•	Design helical gears and bevel gears.
•	Design worm gears, epicyclic gear train and automobile gearbox.
•	Analyze the various gear failures.
•	Carry out optimum design of gears considering weight, strength.

REFERENCES / Weblinks:	
1	Maleev and Hartman, Machine Design, C.B.S. Publishers, India, 2015
2	Henry E.Merrit,Gear engineering ,Wheeler publishing,Allahabad,1992.
3	Practical Gear design by Darle W. Dudley, McGraw-Hill Book Company Ltd, 1991.
4	Earle Buckingham, Analytical mechanics of gears, Dover publications, New York, 2002.
5	G.M.Maitha, Hand book of gear design, TATA McGraw Hill publishing company Ltd., New Delhi,1994.
6	https://www.emachineshop.com/gear-design-software/

CO-PO –PSO Mapping

	PO									PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**PSO1**	**PSO2**	**PSO3**
CO 1	3	-	1	2	-	-	1	-	2	-	-	-
CO 2	3	-	1	2	-	-	1	-	2	-	1	1
CO 3	3	-	1	2	-	-	1	-	2	-	1	1

CO 4	3	-	1	2	-	-	1	-	2	-	1	1
CO 5	3	-	1	2	-	-	1	-	2	-	1	1
Average	3	-	1	2	-	-	1	-	2	-	1	1

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

Subject Code	Subject Name (Theory course)	Category	L	T	P	C
ED19P34	**DESIGN OF MATERIAL HANDLING EQUIPMENTS (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 Parts.

Course Outcomes: On completion of this course, the students will be able to	
1	Alexandrov, M., Materials Handling Equipments, MIR Publishers, 1981.
2	Boltzharol, A., Materials Handling Handbook, The Ronald Press Company, 1958
3	Norton. L Robert. "Machine Design – An Integrated Approach" Pearson Education, 2nd Edition, 2005.
4	Rudenko, N., Materials handling equipment, ELnvee Publishers, 1970.
5	Spivakovsy, A.O. and Dyachkov, V.K., Conveying Machines, Volumes I and II, MIR Publishers, 1985.

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

CO-PO –PSO Mapping

	PO									**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**PSO1**	**PSO2**	**PSO3**
CO 1	3	-	1	2	-	-	1	-	2	-	-	-
CO 2	3	-	1	2	-	-	1	-	2	-	-	1
CO 3	3	-	1	2	-	-	1	-	2	-	-	1
CO 4	3	-	1	2	-	-	1	-	2	-	-	1
CO 5	3	-	1	2	-	-	1	-	2	-	-	1
Average	3	-	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**

ED19P35	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**
Topography of Surfaces – Surface features-Properties and measurement – Surface interaction – Adhesive Theory of Sliding Friction –Rolling Friction-Friction properties of metallic and non-metallic materials – friction in extreme conditions –Thermal considerations in sliding contact.		
UNIT-II	**WEAR AND SURFACE TREATMENT**	**8**
Types of wear – Mechanism of various types of wear – Laws of wear –Theoretical wear models-Wear of Metals and Non metals – Surface treatments – Surface modifications – surface coatings methods- Surface Topography measurements –Laser methods – instrumentation – International standards in friction and wear measurements.		
UNIT- III	**LUBRICANTS AND LUBRICATION REGIMES**	**8**
Lubricants and their physical properties- Viscosity and other properties of oils –Additives-and selection of Lubricants- Lubricants standards ISO,SAE,AGMA, BIS standards – Lubrication Regimes –Solid Lubrication-Dry and marginally lubricated contacts- Boundary Lubrication-Hydrodynamic lubrication — Elasto and plasto hydrodynamic - Magneto hydrodynamic lubrication – Hydro static lubrication – Gas lubrication.		
UNIT-IV	**THEORY OF HYDRODYNAMIC AND HYDROSTATIC LUBRICATION**	**12**
Reynolds Equation,-Assumptions and limitations-One and two dimensional Reynolds Equation-Reynolds and Sommerfeld boundary conditions- Pressure wave, flow, load capacity and friction calculations in Hydrodynamic bearings-Long and short bearings-Pad bearings and Journal bearings-Squeeze film effects-Thermal considerations-Hydrostatic lubrication of Pad bearing-Pressure , flow , load and friction calculations-Stiffness considerations- Various types of flow restrictors in hydrostatic bearings.		
UNIT-V	**HIGH PRESSURE CONTACTS AND ELASTO HYDRODYNAMIC LUBRICATION**	**10**
Rolling contacts of Elastic solids- contact stresses – Hertzian stress equation- Spherical and cylindrical contacts-Contact Fatigue life- Oil film effects- Elasto Hydrodynamic lubrication Theory- Soft and hard EHL-Reynolds equation for elasto hydrodynamic lubrication- - Film shape within and outside contact zones-Film thickness and friction calculation- Rolling bearings- Stresses and deflections-Traction drives		
	Total Contact Hours : 45	

REFERENCES/WEB LINKS	
1	Rabinowicz.E, “Friction and Wear of materials”, John Willey &Sons, UK, 1995
2	2. Cameron, A. “Basic Lubrication Theory”, Ellis Herward Ltd., UK, 1981
3	3. Halling, J. (Editor) – “Principles of Tribology “, Macmillian – 1984.
4	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	G.W.Stachowiak & A.W .Batchelor , Engineering Tribology, Butterworth - Heinemann, UK, 2005.
7	https://nptel.ac.in/courses/112/102/112102015/#

Course Outcomes: Upon successful completion of the course, the student will be able to	
•	Select material / surface properties based on the tribological requirements
•	Use methodology for deciding lubricants and lubrication regimes for different operating conditions
•	Select different lubricant for different types of application
•	Analyse the different types of bearings for given load / speed conditions.
•	Solve equation for lubrication contact with different components.

CO - PO - PSO matrices of course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO 1	2	-	--	1	1	-	-	1	1	-	-	1
CO 2	2	-	-	1	1	-	-	1	1	-	1	1
CO 3	2	-	-	1	1	-	-	1	1	-	1	1
CO 4	2	-	-	1	1	-	-	1	1	-	1	1
CO 5	2	-	-	1	1	-	-	1	1	-	1	1
Avg.	2	-	-	1	1	-		1	1	-	1	1

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

Subject Code	Subject Name (Theory course)	Category	L	T	P	C
ED19P36	**EXPERIMENTAL STRESS ANALYSIS**	**PE**	**3**	**0**	**0**	**3**

Objectives: The main learning objective of this course is to prepare the students to:	
•	To study the various experimental techniques involved for measuring displacements, stresses, strains in structural components.

UNIT-I	**EXTENSOMETERS AND DISPLACEMENT SENSORS**	**8**
Principles of measurements, Accuracy, Sensitivity and range of measurements, Mechanical, Optical, Acoustical and Electrical extensometers and their uses, Advantages and disadvantages, Capacitance gauges, Laser displacement sensors.		
UNIT-II	**ELECTRICAL RESISTANCE STRAIN GAUGES**	**12**
Principle of operation and requirements, Types and their uses, Materials for strain gauges, Calibration and temperature compensation, cross sensitivity, Wheatstone bridge and potentiometer circuits for static and dynamic strain measurements, strain indicators, Rosette analysis, stress gauges, load cells, Data acquisition, six component balance.		
UNIT- III	**PHOTOELASTICITY**	**11**
Two dimensional photo elasticity, Photo elastic materials, Concept of light - photoelastic effects, stress optic law, Transmission photoelasticity, Jones calculus, plane and circular polariscopes, Interpretation of fringe pattern, Calibration of photoelastic materials, Compensation and separation techniques, Introduction to three dimensional photo elasticity.		
UNIT-IV	**BRITTLE COATING AND MOIRE TECHNIQUES**	**7**
Relation between stresses in coating and specimen, use of failure theories in brittle coating, Moire method of strain analysis.		

UNIT-V	NON – DESTRUCTIVE TESTING		7
Fundamentals of NDT, Acoustic Emission Technique, Radiography, Thermography, Ultrasonics, Eddy Current testing, Fluorescent Penetrant Testing.			
	Total Contact Hours	**:**	**45**

Course Outcomes: Upon successful completion of the course, the student will be able to	
•	Comprehend stress and strain measurements in loaded components.
•	Select strain gauges and photo elastic techniques of measurement.
•	Formulate and solve general three dimensional problems of stress-strain analysis especially fundamental problems of elasticity.
•	Analyze the strain gauge data under various loading condition by using gauge rosette method.
•	Experimentally evaluate the location and size of defect in solid and composite materials by using various Non-destructive Testing methods.

REFERENCES/WEB LINKS	
1	Dally, J.W., and Riley, W.F., "Experimental Stress Analysis", McGraw Hill Inc., New York 2012.
2	Srinath, L.S., Raghava, M.R., Lingaiah, K., Garagesha, G., Pant B., and Ramachandra, K., "Experimental Stress Analysis", Tata McGraw Hill, New Delhi, 2010.
3	Sadhu Singh, "Experimental Stress Analysis", Khanna Publishers, New Delhi, 2004.
4	Durelli. A.J., "Applied Stress Analysis", Prentice Hall of India Pvt Ltd., New Delhi, 2000.
5	Hetenyi, M., "Hand book of Experimental Stress Analysis", John Wiley and Sons Inc., New York, 2002.
6	Max Mark Frocht, "Photo Elasticity", John Wiley and Sons Inc., New York, 2004.
7	Pollock A.A., Acoustic Emission in Acoustics and Vibration Progress, Ed. Stephens R.W.B., Chapman and Hall,2000.
8	Ramesh, K., Digital Photoelasticity, Springer, New York, 2005.

CO - PO – PSO matrices of course

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	**PSO1**	**PSO2**	**PSO3**
CO 1	2	2	2	2	2	2	2	-	1	3	2	2
CO 2	2	2	2	2	2	2	2	-	1	3	2	2
CO 3	2	2	2	2	2	2	2	-	1	3	2	2
CO 4	2	2	2	2	2	2	2	-	1	3	2	2
CO 5	2	2	2	2	2	2	2	-	1	3	2	2

Average	2	2	2	2	2	2	2	-	1	3	2	2

Subject Code	Subject Name (Theory course)	Category	L	T	P	C
ED19P37	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	Subas and V.Patankar "Numerical heat transfer fluid flow", Hemisphere Publishing Corporation,1980.
5	Jiyuan Tu, Guan Heng Yeoh, Chaogun Liu, "Computational Fluid Dynamics A Practical Approach" Butterworth – Heinemann An Imprint of Elsevier, Madison, U.S.A., 2008.
6	John D. Anderson. JR. "Computational Fluid Dynamics The Basics with Applications" McGraw-Hill International Editions, 1995.

CO - PO – PSO matrices of course

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	**PSO1**	**PSO2**	**PSO3**
CO 1	2	2	2	2	2	2	2	-	1	2	1	1
CO 2	2	2	2	2	2	2	2	-	1	2	1	1
CO 3	2	2	2	2	2	2	2	-	1	2	1	1
CO 4	2	2	2	2	2	2	2	-	1	2	1	1
CO 5	2	2	2	2	2	2	2	-	1	2	1	1
Average	2	2	2	2	2	2	2	-	1	2	1	1

Subject Code	Subject Name (Theory course)	Category	L	T	P	C
ED19P38	**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 Gravity metric Analysis (TGA) - Dynamic Mechanical Analysis (DMA)		
UNIT-IV	**MECHANICAL TESTING – STATIC TESTS**	**9**
Hardness – Brinell, Vickers, Rockwell and Micro Hardness Test, Rebound hardness and Indentation – Tensile Test – Stress – Strain plot – Proof Stress – Torsion Test - Ductility Measurement – Impact Test – Charpy and Izod – DWTT - Fracture Toughness Test, 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: Upon successful completion of the course, the student will be able to	
•	Characterize the engineering materials.
•	Use the fundamental principle of Top-notch characterization tools.
•	Choose appropriate mechanical static testing methods.
•	Choose appropriate mechanical dynamic testing methods
•	Identify the crystal structure and analysis can be made.

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	Skoog, Holler and Nieman, Principles of Instrumental Analysis, 7thedition, Cengage Learning, 2017.
4	Suryanarayana A. V. K., Testing of metallic materialism's publications, 2007.
5	Suryanarayana C, Experimental Techniques in materials and Mechanics, CRC Press,2011.
6	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.

7	https://nptel.ac.in/courses/113106034/
8	https://nptel.ac.in/courses/115/103/115103030/

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PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	**PSO1**	**PSO2**	**PSO3**
CO 1	1	-	-	-	1	-	-	-	-	-	-	1
CO 2	1	-	-	-	1	-	-	-	-	-	-	1
CO 3	1	-	-	-	1	-	-	-	-	-	-	1
CO 4	1	-	-	-	1	-	-	-	-	-	-	1
CO 5	1	-	-	-	1	-	-	-	-	-	-	1
Average	1	-	-	-	1	-	-	-	-	-	-	1