CURRICULUM AND SYLLABUS

(REGULATIONS 2019)

FOR

POST GRADUATE PROGRAMME

M.E – ENGINEERING DESIGN

CHOICE BASED CREDIT SYSTEM

(Applicable to the students admitted from the Academic Year 2019-20 onwards)

EASWARI ENGINEERING COLLEGE

(AUTONOMOUS INSTITUTION)

Bharathi Salai, Ramapuram, Chennai – 600 089

SEMESTER I								
S.No	Course Code	Course Title	Category	Hours / Week				Credits
				L	T	P	R	
Theory								
1	192MAB105T	Applied Mathematics for Engineers	BS	3	2	-	-	4
2	192MEC101T	Engineering Fracture Mechanics	PC	3	-	-	-	3
3	192MEC102T	Computer Applications in Design	PC	3	-	-	-	3
4	192MEC103T	Advanced Finite Element Analysis	PC	3	-	-	-	3
5		Professional Elective-I	PE	3	-	-	-	3
Practical								
6	192MEC111L	CAD and Analysis Laboratory	PC	-	-	3	1	2
Employability Enhancement / Career Advancement Course								
7	192MEA111L	Term Paper Writing and Seminar	A	-	-	4	-	2
8	192MEA112I	Industry Supported Employability Enhancement Course (Optional) *	A	-	-	-	-	ONE/ TWO
9	192MEA113T	Online Course (Optional) *	A	-	-	-	-	THREE
Total				**15**	**2**	**7**	**1**	**20**

SEMESTER II								
S.No	Course Code	Course Title	Category	Hours / Week				Credits
				L	T	P	R	
Theory								
1	192MEC201T	Mechanisms Design and Simulation	PC	3	-	-	-	3
2	192MEC202T	Mechanical Behavior of Materials	PC	3	-	-	-	3
3	192MEC203T	Vibration Analysis and Control	PC	3	-	-	-	3
4		Professional Elective –II	PE	3	-	-	-	3
5		Open Elective	OE	3	-	-	-	3
Practical								
6	192MEC211L	Vibration Laboratory	PC	-	-	3	1	2
Mandatory Course								
7		Research Methodology and IPR/ Foreign Language (Opt. any one)	MC	2	-	-	-	TWO
Employability Enhancement / Career Advancement Course								
8	192MEP211L	Design Project	A	-	-	-	4	2
9	192MEA211I	Internship / Industrial Training	A	-	-	-	-	1

10	192MEA212I	Industry Supported Employability Enhancement Course (Optional) *	A	-	-	-	-	ONE/ TWO
11	192MEA213T	Online Course (Optional) *	A	-	-	-	-	THREE
Total				**15**	**0**	**3**	**5**	**20**

SEMESTER III								
S.No	**Course Code**	**Course Title**	**Category**	**Hours / Week**				**Credits**
				L	**T**	**P**	**R**	
Theory								
1		Professional Elective-III	PE	3	-	-	-	3
2		Professional Elective-IV	PE	3	-	-	-	3
Practical								
3	192MEP311L	Project Work / Start Up Phase I	A	-	-	-	16	8
Employability Enhancement / Career Advancement Course								
4	192MEA311I	Internship / Industrial Training	A	-	-	-	-	1
Total				**6**	**0**	**0**	**16**	**15**

SEMESTER IV								
S.No	**Course Code**	**Course Title**	**Category**	**Hours / Week**				**Credits**
				L	**T**	**P**	**R**	
Practical								
1	192MEP411L	Project Work / Start Up Phase II	A	-	-	-	28	14
Total				**0**	**0**	**0**	**28**	**14**

SUBJECT AREA	**SEMESTER**				**CREDITS**
	I	II	III	IV	
Foundation Course (BS)	4	-	-	-	4
Professional Core (PC)	11	11	-	-	22
Professional Elective (PE)	3	3	6	-	12
Open Elective (OE)	-	3	-	-	3
Employability Enhancement Courses(A)	2	3	9	14	28
TOTAL CREDITS	**20**	**20**	**15**	**14**	**69**

Note : * Refer R-19 for Earning Credits.

LIST OF ELECTIVES

S.No	Course Code	Course Title	Category	Hours / Week				Credits
				L	T	P	R	
PROFESIONAL ELECTIVE - I								
1	192MEE101T	Quality Concepts in Design	PE	3	-	-	-	3
2	192MEE102T	Optimization Techniques in Design	PE	3	-	-	-	3
3	192MEE103T	Design of Pressure Vessel and Piping	PE	3	-	-	-	3
4	192MEE104T	Design of Material Handling Equipments	PE	3	-	-	-	3
5	192MEE105T	Additive Manufacturing and Tooling	PE	3	-	-	-	3
6	192MEE106T	Information Analytics	PE	3	-	-	-	3
PROFESIONAL ELECTIVE - II								
1	192MEE201T	Integrated Mechanical Design	PE	3	-	-	-	3
2	192MEE202T	Modal Analysis of Mechanical Systems	PE	3	-	-	-	3
3	192MEE203T	Advanced Metal Forming Techniques	PE	3	-	-	-	3
4	192MEE204T	Tribology in Design	PE	3	-	-	-	3
5	192MEE205T	Surface Engineering	PE	3	-	-	-	3
6	192MEE206T	Advanced Mechanics of Materials	PE	3	-	-	-	3
PROFESIONAL ELECTIVE - III								
1	192MEE301T	Product Lifecycle Management	PE	3	-	-	-	3
2	192MEE302T	Design for Internet of Things	PE	3	-	-	-	3
3	192MEE303T	Design of Hydraulic and Pneumatic Systems	PE	3	-	-	-	3
4	192MEE304T	Computational Fluid Dynamics	PE	3	-	-	-	3
5	192MEE305T	Biomechanics	PE	3	-	-	-	3
PROFESIONAL ELECTIVE - IV								
1	192MEE306T	Design for Manufacture,Assembly and Environments	PE	3	-	-	-	3
2	192MEE307T	Product Design for Sustainability	PE	3	-	-	-	3
3	192MEE308T	Bearing Design and Rotor Dynamics	PE	3	-	-	-	3
4	192MEE309T	Composite Materials and Mechanics	PE	3	-	-	-	3
5	192MEE310T	Plates and Shells	PE	3	-	-	-	3

OPEN ELECTIVE

S.No	Course Code	Course Title	Category	Hours / Week				Credits
				L	T	P	R	
1	192GEO201T	Business Analytics@	OE	3	-	-	-	3
2	192GEO202T	Composite Materials*	OE	3	-	-	-	3
3	192GEO203T	Cost Management of Engineering Projects**	OE	3	-	-	-	3
4	192GEO204T	Industrial Safety**	OE	3	-	-	-	3
5	192GEO205T	Internet of Things #	OE	3	-	-	-	3
6	192GEO206T	Machine Learning#	OE	3	-	-	-	3
7	192GEO207T	Operations Research ***	OE	3	-	-	-	3
8	192GEO208T	Waste to Energy $	OE	3	-	-	-	3

@ Offered by MBA

* Offered by Civil Engineering and Mechanical Engineering .

** Offered by Civil Engineering , Mechanical Engineering and MBA.

Offered by Computer Science Engineering and Information Technology

$ Offered by Electrical and Electronics Engineering and Mechanical Engineering.

SEMESTER-I

		L	T	P	R	C
192MAB105T	**APPLIED MATHEMATICS FOR ENGINEERS**	**3**	**2**	**0**	**0**	**4**

OBJECTIVES :

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

UNIT-I MATRIX THEORY 12

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

UNIT II CALCULUS OF VARIATIONS 12

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

UNIT III PROBABILITY AND RANDOM VARIABLES 12

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

UNIT IV LAPLACE TRANSFORM TECHNIQUES FOR PARTIAL DIFFERENTIAL EQUATIONS 12

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

UNIT V FOURIER TRANSFORM TECHNIQUES FOR PARTIAL DIFFERENTIAL EQUATIONS 12

Fourier transform : Definitions - Properties – Transform of elementary functions - Dirac delta function – Convolution theorem – Parseval's identity – Solutions to partial differential equations : Heat equation - Wave equation - Laplace and Poison's equations.

TOTAL : 60 Periods

OUTCOMES:

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

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

REFERENCES:

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

		L	T	P	R	C
192MEC101T	**ENGINEERING FRACTURE MECHANICS**	**3**	**0**	**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

TOTAL:45

OUTCOMES:

1. Students will be able to understand the basics of solid mechanics to analyse fractured fields.
2. Students will get familiarized with the design of components that contain crack under static load condition.
3. Students will get familiarized with the design of components that contain crack and its growth under fatigue load condition.
4. Students have the ability to apply various models and laws to determine the safe load for cracked components.
5. Students will be able to determine the safe design and failure of various components which have cracked fields.

REFERENCES:

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

192MEC102T	COMPUTER APPLICATIONS IN DESIGN	L	T	P	R	C
		3	0	0	0	3

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 **8**

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 **10**

Introduction to curves - Analytical curves: line, circle and conics – synthetic curves: Hermite cubic spline- Bezier curve and B-Spline curve – curve manipulations. Introduction to surfaces - Analytical surfaces: Plane surface, ruled surface , surface of revolution and tabulated cylinder – synthetic surfaces: Hermite bicubic surface- Bezier surface and B-Spline surface- surface manipulations.

UNIT III NURBS AND SOLID MODELING **9**

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

UNIT IV VISUAL REALISM **9**

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

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

Assembly modeling - interferences of positions and orientation - tolerances analysis - mass property calculations - mechanism simulation.
Graphics and computing standards– Open GL Data Exchange standards – IGES, STEP etc– Communication standards.

TOTAL:45 Periods

OUTCOMES:

1. The students will understand the fundamentals of computer graphics.
2. The students will be able to gain knowledge in curves and surfaces used in CAE problems.
3. The students will be able to model solids which are used in CAE problems in engineering.
4. The students will be familiarized with visual realism in modeling software's.

5. The students will acquire knowledge in modeling assemblies, graphics and computing standards.

REFERENCES:

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

192MEC103T	ADVANCED FINITE ELEMENT ANALYSIS	L	T	P	R	C
		3	0	0	0	3

OBJECTIVES :

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

UNIT-I BENDING OF PLATES AND SHELLS 9

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

UNIT II NON-LINEAR PROBLEMS 9

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

UNIT III DYNAMIC PROBLEM 9

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

UNIT IV FLUID MECHANICS AND HEAT TRANSFER 9

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

UNIT V ERROR ESTIMATES AND ADAPTIVE REFINEMENT 9

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

TOTAL:45 Periods

OUTCOMES:

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

REFERENCES:

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

192MEC111L	CAD and ANALYSIS LABORATORY	L	T	P	R	C
		0	0	3	1	2

OBJECTIVES :

To impart knowledge on how to prepare drawings for various mechanical components using any commercially available 3D modelling software's

PART A CAD MODELLING

- **CAD** Introduction.
- **Sketcher**
- **Solid modeling** – Extrude, Revolve, Sweep, etc and Variational sweep, Loft ,etc
- **Surface modeling** – Extrude, Sweep, Trim .etc and Mesh of curves, Free form etc
- **Feature manipulation** – Copy, Edit, Pattern, Suppress, History operations etc.
- **Assembly**-Constraints, Exploded Views, Interference check
- **Drafting** - Layouts, Standard & Sectional Views, Detailing & Plotting.
- **CAD data Exchange formats -** IGES, PDES, PARASOLID, DXF and STL

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

PART B SIMULATION & ANALYSIS

A. SIMULATION

1. MATLAB basics, Dealing with matrices, Graphing-Functions of one variable and two variables

2. Use of Mat lab to solve simple problems in vibration

3. Mechanism Simulation using Multi body Dynamic software

B. ANALYSIS

1. Force and Stress analysis using link elements in Trusses, cables etc.

2. Stress and deflection analysis in beams with different support conditions.

3. Stress analysis of flat plates and simple shells.

4. Stress analysis of axi – symmetric components.

5. Thermal stress and heat transfer analysis of plates.

6. Thermal stress analysis of cylindrical shells.

7. Vibration analysis of spring-mass systems.

8. Model analysis of Beams.

9. Harmonic, transient and spectrum analysis of simple systems.

TOTAL:45 Periods

OUTCOMES:

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

192MEA111L TERM PAPER WRITING AND TECHNICAL SEMINAR

L	T	P	R	C
0	0	4	0	2

OBJECTIVE:

- In this course, students will develop their scientific and technical reading and writing skills that they need to understand and construct research articles.

SYLLABUS:

A term paper requires a student to obtain information from a variety of sources (i.e., Journals, dictionaries, reference books, case studies) and then place it in logically developed ideas.

The work involves the following steps:

1. Selecting a subject, narrowing the subject into a topic
2. Stating an objective.
3. Collecting the relevant bibliography (at least 15 journal papers)
4. Preparing a working outline.
5. Studying the papers and understanding the author's contributions and critically analysing each paper.
6. Preparing a working outline
7. Linking the papers and preparing a draft of the paper.
8. Preparing conclusions based on the reading of all the papers.
9. Writing the Final Paper and giving final Presentation

Please keep a file where the work carried out by you is maintained. Activities to be carried Out.

Activity	**Instructions**	**Submission week**	**Evaluation**
Selection of area of interest and Topic Stating an Objective	You are requested to select an area of interest, topic and state an objective	2nd week	3 % Based on clarity of thought, current relevance and clarity in writing
Collecting Information about your area & topic	1. List 1 Special Interest Groups or professional society 2. List 2 journals 3. List 2 conferences, symposia or workshops 4. List 1 thesis title 5. List 3 web presences (mailing lists, forums, news sites) 6. List 3 authors who publish regularly in your area 7. Attach a call for papers (CFP) from your area.	3rd week	3% (the selected information must be area specific and of international and national standard)
Collection of Journal papers in the topic in the context	• You have to provide a complete list of references you will be using- Based on your objective -Search various digital libraries and Google Scholar • When picking papers to read - try to:	4th week	6% (the list of standard papers and reason for selection)

of the objective – collect 20 & then filter	• Pick papers that are related to each other in some ways and/or that are in the same field so that you can write a meaningful survey out of them, • Favour papers from well-known journals and conferences, • Favour "first" or "foundational" papers in the field (as indicated in other people"s survey paper), Favour more recent papers, • Pick a recent survey of the field so you can quickly gain an overview, • Find relationships with respect to each other and to your topic area (classification scheme/categorization) • Mark in the hard copy of papers whether complete work or section/sections of the paper are being considered		
Reading and notes for first 5 papers	Reading Paper Process •For each paper form a Table answering the following questions: • What is the main topic of the article? • What was/were the main issue(s) the author said they want to discuss? •Why did the author claim it was important? •How does the work build on other's work, in the author's opinion? •What simplifying assumptions does the author claim to be making? • What did the author do? • How did the author claim they were going to evaluate their work and compare it to others? •What did the author say were the limitations of their research? • What did the author say were the important directions for future research? Conclude with limitations/issues not addressed by the paper (from the perspective of your survey)	5th week	8% (the table given should indicate your understanding of the paper and the evaluation is based on your conclusions about each paper)

Reading and notes for next5 papers	Repeat Reading Paper Process	6th week	8% (the table given should indicate your understanding of the paper and the evaluation is based on your conclusions about each paper)
Reading and notes for final 5 papers	Repeat Reading Paper Process	7th week	8% (the table given should indicate your understanding of the paper and the evaluation is based on your conclusions about each paper)
Draft outline 1 and Linking papers	Prepare a draft Outline, your survey goals, along with a classification / categorization diagram	8th week	8% (this component will be evaluated based on the linking and classification among the papers)
Abstract	Prepare a draft abstract and give a presentation	9th week	6% (Clarity, purpose and conclusion) 6% Presentation & Viva Voce
Introduction Background	Write an introduction and background sections	10th week	5% (clarity)
Sections of the paper	Write the sections of your paper based on the classification / categorization diagram in keeping with the goals of your survey	11th week	10% (this component will be evaluated based on the linking and classification among the papers)
Your conclusions	Write your conclusions and future work	12th week	5% (conclusions – clarity and your ideas)
Final Draft	Complete the final draft of your paper	13th week	10% (formatting, English, Clarity and linking) 4% Plagiarism Check Report

Seminar	A brief 15 slides on your paper	14th & 15th week	10% (based on presentation and Viva-voce)

Total: 60 Hours

OUTCOME:

- The students will be trained to face an audience and to tackle any problem during group discussion in the Interviews.

SEMESTER-II

		L	T	P	R	C
192MEC201T	**MECHANISMS DESIGN AND SIMULATION**	**3**	**0**	**0**	**0**	**3**

OBJECTIVES :

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

UNIT-I INTRODUCTION 9

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

UNIT II KINEMATIC ANALYSIS 9

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

UNIT III PATH CURVATURE THEORY, COUPLER CURVE 9

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

UNIT IV SYNTHESIS OF FOUR BAR MECHANISMS 9

Type synthesis – Number synthesis – Associated Linkage Concept. Dimensional synthesis – function generation, path generation, motion generation. Graphical methods-Pole technique, inversion technique-

point position reduction-two, three and four position synthesis of four- bar mechanisms. Analytical methods- Freudenstein's Equation-Bloch's Synthesis.

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

Cognate Lingages-parallel motion Linkages. Design of six bar mechanisms-single dwell-double dwell-double stroke. Geared five bar mechanism-multi-dwell. Cam Mechanisms- determination of optimum size of cams. Mechanism defects.

Study and use of Mechanism using Simulation Soft-ware packages. Students should design and fabricate a mechanism model as term project.

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

TOTAL : 45

OUTCOMES:

1. Students can differentiate different mechanism and will be able to find the DOF for various mechanisms.
2. Students able to develop ability to find acceleration of all the linkages which is the input for the force analysis.
3. Students can have the ability to design mechanism with coupler curve.
4. Students can have the ability to find the length of four bar mechanism with only final output and known constrains
5. Students able to design advance mechanism and cam mechanism.

REFERENCES:

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

		L	T	P	R	C
192MEC202T	**MECHANICAL BEHAVIOR OF MATERIALS**	**3**	**0**	**0**	**0**	**3**

OBJECTIVES :

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

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

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

UNIT II BEHAVIOUR UNDER DYNAMIC LOADS AND DESIGN APPROACHES 10

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

UNIT III SELECTION OF MATERIALS 10

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

UNIT IV MODERN METALLIC MATERIALS 8

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

UNIT V NON METALLIC MATERIALS 7

Polymeric materials – Formation of polymer structure – Production techniques of fibers, foams, adhesives and coating – structure, properties and applications of engineering polymers – Advanced structural ceramics, WC, TIC, TaC, Al2O3, SiC, Si3N4 CBN and diamond – properties, processing and applications.

TOTAL : 45 Periods

OUTCOMES:

1. The Student will be able to understand the basic concepts of mechanical behavior of metals.
2. The Student will get familiarized about the researches in the area of material behavior under different loading and selection of materials for the design of engineering structures.
3. The Student will get familiarized about selection requirement and process of materials in various engineering applications.
4. The Student will have knowledge on advanced metallic and non metallic materials and their properties used in engineering applications

5. The Student will have knowledge on non metallic materials, their properties and the process involved in their production.

REFERENCES:

1. Ashby M.F., materials selection in Mechanical Design 2nd Edition, Butter worth 1999.

2 Charles, J.A., Crane, F.A.A. and Fumess, J.A.G., Selection and use of engineering materials, (34d edition), Butterworth-Heiremann, 1997.

3 Flinn, R.A., and Trojan, P.K., Engineering Materials and their Applications, (4th Edition) Jaico, 1999.

4 George E.Dieter, Mechanical Metallurgy, McGraw Hill, 1988

5 Metals Hand book, Vol.10, Failure Analysis and Prevention, (10th Edition), Jaico, 1999.

6 Thomas H. Courtney, Mechanical Behavior of Materials, (2nd edition), McGraw Hill, 2000

192MEC203T	VIBRATION ANALYSIS AND CONTROL	L	T	P	R	C
		3	0	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 : 45 Periods

OUTCOMES:

1. The students will be able to understand the basics of vibration and its importance in engineering field.
2. The students will have knowledge on analyzing two degree freedom system vibration problems in engineering applications.
3. The students will have knowledge on analyzing multi degree freedom system and continuous systems vibration problems in engineering applications.
4. The students will be able to understand the various vibration control strategies used in engineering applications.
5. The students will have knowledge on the working operations of various vibration measuring instruments, vibration control and analysis techniques.

REFERENCES:

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

192MEC211L	**VIBRATION LABORATORY**	**L**	**T**	**P**	**R**	**C**
		0	**0**	**3**	**1**	**2**

OBJECTIVES :

Introduce basic aspects of vibrational analysis, considering both single and multi-degree-of freedom systems. Discuss the use of exact and approximate methods in the analysis of complex systems.

LIST OF EXPERIMENTS

1. To study the forced vibration of the beam for different damping.
2. To determine the radius of gyration ‘k’ of a given compound pendulum.
3. To determine the radius of gyration of trifilar suspension.

4. To determine the radius of gyration of given bar using bi-filler suspension.
5. To verify the dunker lay's rule viz.
6. To study the pressure profile of lubricating conditions of load and speed.
7. To determine the natural frequency of undamped torsional vibration of a single rotor shaft system.
8. To determine the natural frequency of undamped torsional vibration of two rotor shaft system.
9. To determine the frequency of undamped free vibration of an equivalent spring mass system.
10. To determine the frequency of damped force vibration of a spring mass system.

TOTAL : 45 Periods

OUTCOMES:

Upon completion of the course students shall be able to:

1. Derive the equations of motion for vibratory systems.
2. Linearize nonlinear systems so as to allow a linear vibrational analysis.
3. Compute the natural frequency (or frequencies) of vibratory systems and determine the system's modal response.
4. Determine the overall response based upon the initial conditions and/or steady forcing input.
5. Design a passive vibration absorber to ameliorate vibrations in a forced system.

		L	T	P	R	C
192MEC202L	**DESIGN PROJECT**	**0**	**0**	**0**	**4**	**2**

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.

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 : 60 Periods

OUTCOMES:

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

RESEARCH METHODOLOGY AND IPR

L	T	P	R	C
2	0	0	0	TWO

OBJECTIVES :
To understand the research information and the technologies involved in research. To know about the importance of IPR.

UNIT-I
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

Effective literature studies approaches, analysis Plagiarism, Research ethics

UNIT III
Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

UNIT IV
Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

UNIT V
Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

UNIT VI
New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

OUTCOMES: At the end of this course, students will be able to Understand research problem formulation.

1. Analyze research related information
2. Follow research ethics
3. Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
4. Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.
5 Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

REFERENCES:

1. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science &

engineering students'

2 Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"

3 Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide for beginners"

4 Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.

5 Mayall, "Industrial Design", McGraw Hill, 1992.

6 Niebel, "Product Design", McGraw Hill, 1974.

7 Asimov, "Introduction to Design", Prentice Hall, 1962.

8 Robert P. Merges, Peter S. Menell, Mark A. Lemley, " Intellectual Property in New Technological Age", 2016.

9 T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008

SEMESTER-III

		L	T	P	R	C
192MEP311PL	**PROJECT PHASE-I**	**0**	**0**	**0**	**16**	**8**

OBJECTIVES :

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

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

TOTAL :180

OUTCOMES:

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

SEMESTER-IV

		L	T	P	R	C
192MEP411PL	**PROJECT PHASE-II**	**0**	**0**	**0**	**28**	**14**

OBJECTIVES :

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

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

TOTAL :360

OUTCOMES:

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

PROFESSIONAL ELECTIVE-I

		L	T	P	R	C
192MEE101T	**QUALITY CONCEPTS IN DESIGN**	**3**	**0**	**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 : 45

OUTCOMES:

After completing this course, students will :

1. Able to get familiarized with various concepts in engineering design
2. Know about experimental design and quality control.
3. Know about engineering product development.
4. Have knowledge in design of experiments.
5. Familiarize with statistical methods in quality control.

REFERENCES:

1. Dieter, George E., “Engineering Design - A Materials and Processing Approach”, McGraw Hill, International Editions, Singapore, 2000.
2. Fundamentals of Quality control and improvement 2nd edition, Amitava Mitra, Pearson Education Asia, 2002.
3. Montgomery, D.C., Design and Analysis of experiments, John Wiley and Sons, 2003.
4. Phillip J.Rose, Taguchi techniques for quality engineering, McGraw Hill, 1996.
5. Product Design And Development, Karl t. Ulrich, Steven D. Eppinger,Tata Mcgraw-Hill- 2003

192MEE102T	OPTIMIZATION TECHNIQUES IN DESIGN	L	T	P	R	C
		3	0	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.

UNIT-I UNCONSTRAINED OPTIMIZATION TECHNIQUES 9

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 9

Optimization with equality and inequality constraints - Direct methods – Indirect methods using penalty functions, Lagrange multipliers - Geometric programming

UNIT III ADVANCED OPTIMIZATION TECHNIQUES 9

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 9

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 9

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

TOTAL : 45

OUTCOMES:

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

1. Get familiarized with the different approaches of Unconstrained optimization.
2. Get familiarized with the different approaches of constrained optimization.
3. Know about multistage optimization techniques.
4. Have knowledge in optimization on static structural applications.
5. Have knowledge in optimization on dynamic applications.

REFERENCES:

1. Goldberg, D.E., “Genetic Algorithms in Search, Optimization and Machine Learning”, Pearson, 2008.

2 Johnson Ray, C., “Optimum design of mechanical elements”, Wiley, John & Sons, 1990.

3 Kalyanmoy Deb, “Optimization for Engineering design algorithms and Examples”, Prentice Hall of India Pvt. 2004.

4 Rao, Singaresu, S., “Engineering Optimization – Theory & Practice”, New Age International (P) Limited, New Delhi, 2000.

5 Product Design And Development, Karl t. Ulrich, Steven D. Eppinger,Tata Mcgraw-Hill- 2003

192MEE103T	DESIGN OF PRESSURE VESSELS AND PIPING	L	T	P	R	C
		3	0	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 : 45

OUTCOMES:

After completing this course, students will :

1. Get familiarized with the various theories and practice on pressure vessel and piping design.
2. Have comprehensive understanding in stresses in pressure vessels
3. Have understanding on pressure vessel design
4. Have understanding on elasticity of cylindrical vessels
5. Know about stresses in piping design

REFERENCES:

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

192MEE104T	DESIGN OF MATERIAL HANDLING EQUIPMENTS (Use of Approved Data Book Is Permitted)	L	T	P	R	C
		3	0	0	0	3

OBJECTIVES :

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

UNIT-I MATERIALS HANDLING EQUIPMENT 5

Types, selection and applications

UNIT II DESIGN OF HOISTS 10

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

UNIT III DRIVES OF HOISTING GEAR 10

Hand and power drives - Traveling gear - Rail traveling mechanism - cantilever and monorail cranes - slewing, jib and luffing gear - cogwheel drive - selecting the motor ratings.

UNIT IV CONVEYORS 10

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

UNIT V ELEVATORS 10

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

TOTAL : 45 Periods

OUTCOMES:

After completing this course, students are able to :

1. Know about types of material handling equipments
2. Know about the design of hoists

3. Have understanding of gear hosting mechanisms
4. Have knowledge in conveyor design
5. Have understanding on elevator design.

REFERENCES:

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

192MEE105T	ADDITIVE MANUFACTURING AND TOOLING	L	T	P	R	C
		3	0	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- Applications.

UNIT II REVERSE ENGINEERING AND CAD MODELING 9

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

UNIT III LIQUID BASED AND SOLID BASED ADDITIVE MANUFACTURING SYSTEMS 9

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

UNIT IV POWDER BASED ADDITIVE MANUFACTURING SYSTEMS 9

Selective Laser Sintering (SLS): Principle, process, Indirect and direct SLS- powder structures,

materials, post processing, surface deviation and accuracy, Applications. Laser Engineered Net Shaping (LENS): Processes, materials, products, advantages, limitations and applications– Case Studies.

UNIT V TOOLING 9

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

TOTAL : 45 Periods

OUTCOMES:

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

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

REFERENCES:

1. Chua, C.K., Leong K.F. and Lim C.S., “Rapid prototyping: Principles and applications”, second edition, World Scientific Publishers, 2010.
2. Gebhardt, A., “Rapid prototyping”, Hanser Gardener Publications, 2003.
3. Gibson, I., Rosen, D.W. and Stucker, B., “Additive Manufacturing Methodologies: Rapid Prototyping to Direct Digital Manufacturing”, Springer, 2010.
4. Hilton, P.D. and Jacobs, P.F., Rapid Tooling: Technologies and Industrial Applications, CRC press, 2005.

192MEE106T INFORMATION ANALYTICS

L	T	P	R	C
3	0	0	0	3

OBJECTIVES :

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

UNIT-I DATA ANALYTICS LIFE CYCLE 9

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

UNIT II STATISTICS 9

Sampling Techniques - Data classification, Tabulation, Frequency and Graphic representation - Measures of central value - Arithmetic mean, Geometric mean, Harmonic mean, Mode, Median,

Quartiles, Deciles, Percentile - Measures of variation – Range, IQR, Quartile deviation, Mean deviation, standard deviation, coefficient variance, skewness, Moments & Kurtosis.

UNIT III PROBABILITY AND HYPOTHESIS TESTING 9

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

UNIT IV PREDICTIVE ANALYTICS 9

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

UNIT V TIME SERIES FORECASTING AND DESIGN OF EXPERIMENTS 9

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

TOTAL : 45 Periods

OUTCOMES:

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

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

REFERENCES:

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

PROFESSIONAL ELECTIVE-II

		L	T	P	R	C
192MEE201T	**INTEGRATED MECHANICAL DESIGN**	**3**	**0**	**0**	**0**	**3**

OBJECTIVES :

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

UNIT-I FUNDAMENTALS AND DESIGN OF SHAFTS 9

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

UNIT II DESIGN OF GEARS AND GEAR BOXES 9

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

UNIT III BRAKES & CLUTCHES 9

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

UNIT IV INTEGRATED DESIGN 18

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

TOTAL : 45 Periods

OUTCOMES:

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

1. Have knowledge in Design standards
2. Familiarize with design of shafts and gear boxes
3. Know about the design of brakes and clutches
4. Have understanding on concepts of integration of design of machines and structures.

REFERENCES:

1. Alexandrov, M., Materials Handling Equipments, MIR Publishers, 1981.
2. Boltzharol, A., Materials Handling Handbook, The Ronald Press Company, 1958.
3. Maitra G.M., “Hand Book of Gear Design”, Tata McGraw Hill, 1985.

4 Newcomb, T.P. and Spur, R.T., “Automobile Brakes and Braking Systems”, Chapman and Hall, 2nd Edition, 1975.

5 Norton L. R., “Machine Design – An Integrated Approach” Pearson Education, 2005

6 Prasad. L. V., “Machine Design”, Tata McGraw Hill, New Delhi, 1992.

7 Shigley, J.E., “Mechanical Engineering Design”, McGraw Hill, 1986.

Approved Data Books

1 P.S.G. Tech., “Design Data Book”, Kalaikathir Achchagam, Coimbatore, 2003.

2 Lingaiah. K. and Narayana Iyengar, “Machine Design Data Hand Book”, Vol. 1 & 2, Suma Publishers, Bangalore, 1983

192MEE202T	MODAL ANALYSIS OF MECHANICAL SYSTEMS	L	T	P	R	C
		3	0	0	0	3

OBJECTIVES :

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

UNIT-I INTRODUCTION 6

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

UNIT II VIBRATIONS 12

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

UNIT III MOBILITY MEASUREMENT TECHNIQUES 10

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

UNIT IV MODAL PARAMETER EXTRACTION METHODS 11

Introduction – Preliminary checks of FRF Data – SDOF Modal Analysis-I – Peak-amplitude – DOF

Modal Analysis-II – Circle Fit Method – SDOF Modal Analysis III – Inverse Method –Residuals – MDOF curve-fitting procedures – MDOF curve fitting in the Time Domain – Global or Multi- Curve fitting – Non linear systems.

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

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

TOTAL : 45 Periods

OUTCOMES:

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

1. Familiar with modal testing and techniques
2. Have knowledge in vibration data acquisition techniques
3. Have understanding in mobility measurement techniques
4. Have comprehensive knowledge on modal parameter extraction methods
5. Have knowledge in mathematical models in modal testing

REFERENCES:

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

192MEE203T	ADVANCED METAL FORMING TECHNIQUES	L	T	P	R	C
		3	0	0	0	3

OBJECTIVES :

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

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

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

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

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

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

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

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

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

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

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

TOTAL : 45 Periods

OUTCOMES:

After completing this course, students will :

1 Familiarize with latest metal forming techniques

2. Understand the theory of forming process

3. Know about sheet metal forming techniques

4. Familiar with powder metallurgy techniques for various industrial applications.

5. Know about applications of electromagnetic forming

REFERENCES:

1. Altan T., Metal forming – Fundamentals and applications – American Society of Metals, Metals park, 2003.

2 Altan.T, Soo-Ik-Oh, Gegel, HL – Metal forming, fundamentals and Applications, American Society of Metals, Metals Park, Ohio, 1983.

3 ASM Hand book, Forming and Forging, Ninth edition, Vol – 14, 2003

4 Dieter G.E., Mechanical Metallurgy (Revised Edition II) McGraw Hill Co., 2004

5 Marciniak,Z., Duncan J.L., Hu S.J., 'Mechanics of Sheet Metal Forming', Butterworth- Heinemann An Imprint of Elesevier, 2006

6 Proc. Of National Seminar on "Advances in Metal Forming" MIT, March 2000

7 Proc. Of National Seminar on "Advances in Metal Forming" MIT, March 2000

8 SAE Transactions, Journal of Materials and Manufacturing Section 5, 1993-2007

9 Shiro Kobayashi, Soo-Ik-Oh-Altan, T,Metal forming and Finite Element Method, Oxford University Press, 2001.

192MEE204T **TRIBOLOGY IN DESIGN**

L	T	P	R	C
3	0	0	0	3

OBJECTIVES :

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

UNIT-I SURFACE INTERACTION AND FRICTION 7

Topography of Surfaces – Surface features – Properties and measurement – Surface interaction – Adhesive Theory of Sliding Friction – Rolling Friction – Friction properties of metallic and non metallic materials – Friction in extreme conditions – Thermal considerations in sliding contact

UNIT II WEAR AND SURFACE TREATMENT 8

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

UNIT III LUBRICANTS AND LUBRICATION REGIMES 8

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

UNIT IV THEORY OF HYDRODYNAMIC AND HYDROSTATIC LUBRICATION 12

Reynolds Equation,-Assumptions and limitations-One and two dimensional Reynolds Equation- Reynolds and Sommerfeld boundary conditions- Pressure wave, flow, load capacity and friction

calculations in Hydrodynamic bearings-Long and short bearings-Pad bearings and Journal bearings-Squeeze film effects-Thermal considerations-Hydrostatic lubrication of Pad bearing- Pressure , flow , load and friction calculations-Stiffness considerations- Various types of flow restrictors in hydrostatic bearings.

UNIT V **HIGH PRESSURE CONTACTS AND ELASTO HYDRODYNAMIC LUBRICATION** **10**

Rolling contacts of Elastic solids**-** contact stresses – Hertzian stress equation- Spherical and cylindrical contacts-Contact Fatigue life- Oil film effects- Elasto Hydrodynamic lubrication Theory-Soft and hard EHL-Reynolds equation for elasto hydrodynamic lubrication- - Film shape within and outside contact zones-Film thickness and friction calculation- Rolling bearings- Stresses and deflections-Traction drives.

TOTAL : 45 Periods

OUTCOMES:

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

1 Ability to select material / surface properties based on the tribological requirements

2. Methodology for deciding lubricants and lubrication regimes for different operating conditions

3. Know about hydrodynamic lubrication theory

4. Analysis ability of different types of bearings for given load / speed conditions.

5. Have knowledge in various stresses in bearings

REFERENCES:

1. Cameron, A. “Basic Lubrication Theory”, Ellis Herward Ltd., UK, 1981

2 G.W.Stachowiak & A.W .Batchelor , Engineering Tribology, Butterworth - Heinemann, UK, 2005

3 Halling, J. (Editor) – “Principles of Tribology “, Macmillian – 1984.

4 Rabinowicz.E, “Friction and Wear of materials”, John Willey &Sons ,UK,1995

5 S.K.Basu, S.N.Sengupta & B.B.Ahuja ,”Fundamentals of Tribology”, Prentice – Hall of India Pvt Ltd , New Delhi, 2005

192MEE205T	**SURFACE ENGINEERING**	**L**	**T**	**P**	**R**	**C**
		3	**0**	**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 **FRICTION** **7**

Topography of Surfaces – Surface features-Properties and measurement – Surface interaction – Adhesive Theory of Sliding Friction –Rolling Friction-Friction properties of metallic and non-metallic

materials – friction in extreme conditions –Thermal considerations in sliding contact

UNIT II WEAR 6

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

UNIT III CORROSION 12

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

UNIT IV SURFACE TREATMENTS 10

Introduction – Surface properties, Superficial layer – Changing surface metallurgy – Wear resistant coatings and Surface treatments – Techniques – PVD – CVD – Physical CVD – Ion implantation – Surface welding – Thermal spraying – Laser surface hardening and alloying, Applications of coatings and surface treatments in wear and friction control – Characteristics of Wear resistant coatings – New trends in coating technology – DLC – CNC – Thick coatings – Nano-engineered coatings – Other coatings, Corrosion resistant coatings

UNIT V ENGINEERING MATERIALS 10

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

TOTAL : 45 Periods

OUTCOMES:

After completing this course, students will :

1 Get familiarized with the various theories of friction

2. Have knowledge on wear characteristics

3 Know about corrosion protection methods

4 Have knowledge on surface treatment methods of which are necessary to solve the industrial

5 Know about advanced materials that have thrust on research.

REFERENCES:

1. Fontana G., “Corrosion Engineering”, McGraw Hill, 1985

2 G.W.Stachowiak & A.W .Batchelor , “Engineering Tribology”, Butterworth-Heinemann, UK, 2005

3 Halling, J. (Editor) – “Principles of Tribology “, Macmillian – 1984.

4 Rabinowicz.E, “Friction and Wear of materials”, John Willey & Sons,UK,1995

5 S.K.Basu, S.N.Sengupta & B.B.Ahuja ,”Fundamentals of Tribology”, Prentice – Hall of India Pvt Ltd , New Delhi, 2005

6 Williams J.A. “Engineering Tribology”, Oxford Univ. Press, 1994

192MEE206T	ADVANCED MECHANICS OF MATERIALS	L	T	P	R	C
		3	0	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

UNIT IV TORSION OF NON-CIRCULAR SECTIONS 7

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

UNIT V STRESSES IN ROTATING MEMBERS AND CONTACT STRESSES 9

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

TOTAL : 45 Periods

OUTCOMES:

After completing this course, students will :

1 Build knowledge on problems in linear elasticity

2. Solve problems in unsymmetrical bending

3 Analyze stresses in curved members

4 Solve problems in Torsion of non circular sections

5 Be familiarized with the stresses under different loading conditions.

REFERENCES:

1. Allan F. Bower, “Applied Mechanics of Solids”, CRC press – Special Indian Edition -2012.

2 Arthur P Boresi, Richard J. Schmidt, “Advanced mechanics of materials”, John Wiley, 2002.

3 G H Ryder Strength of Materials Macmillan, India Ltd, 2007.

4 K. Baskar and T.K. Varadan, “Theory of Isotropic/Orthotropic Elasticity”, Ane Books Pvt. Ltd., New Delhi, 2009

5 Robert D. Cook, Warren C. Young, "Advanced Mechanics of Materials", Mc- millan pub. Co., 1985.

6 Srinath. L.S., “Advanced Mechanics of solids”, Tata McGraw Hill, 1992.

7 Timoshenko and Goodier, "Theory of Elasticity", McGraw Hill.1

PROFESSIONAL ELECTIVE-III

		L	T	P	R	C
192MEE301T	**PRODUCT LIFECYCLE MANAGEMENT**	**3**	**0**	**0**	**0**	**3**

OBJECTIVES :

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

UNIT-I HISTORY, CONCEPTS AND TERMINOLOGY OF PLM 9

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

UNIT II PLM/PDM FUNCTIONS AND FEATURES 9

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

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

Case studies based on top few commercial PLM/PDM tools

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

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

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

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

TOTAL: 45 Periods

OUTCOMES:

The students will be able to

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

REFERENCES:

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

192MEE302T **DESIGN FOR INTERNET OF THINGS**

L	T	P	R	C
3	0	0	0	3

OBJECTIVES :

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

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

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

UNIT II **IoT STRUCTURE** **9**

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

UNIT III **IoT NETWORKING** **9**

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

UNIT IV **IoT ARCHITECTURE** **9**

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

UNIT V **ARCHITECTURE MODELING** **9**

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

TOTAL:45 Periods

OUTCOMES:

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

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

REFERENCES:

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

192MEE303T	DESIGN OF HYDRAULIC AND PNEUMATIC SYSTEMS	L	T	P	R	C
		3	0	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 equipment-selection of components - design calculations - logic circuits - switching circuits - fringe conditions modules and these integration - sequential circuits - cascade methods – mapping methods - step counter method - compound circuit design - combination circuit design- Karnaugh - Veitch map.

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

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

TOTAL:45 Periods

OUTCOMES:

The Student will be able to

1. Understand the concept and principles of fluid flow and fluid properties.
2. Understand the working, selection & characteristics of pumps and actuators.
3. Understand the working of various valves and actuating systems
4. Impart students on the science, use and application of hydraulic and pneumatic as fluid power in industry.
5. Understand the concept of using microprocessor, automation & maintenance
6. Impart knowledge on the methodology of basic and advanced design of hydraulic and pneumatic systems.

REFERENCES:

1. Andrew Parr, “Hydraulic and Pneumatics” (HB), Jaico Publishing House, 1999.

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

192MEE304T	COMPUTATIONAL FLUID DYNAMICS	L	T	P	R	C
		3	0	0	0	3

OBJECTIVES :

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

UNIT-I **GOVERNING DIFFERENTIAL EQUATIONS AND DISCRETISATION TECHNIQUES** **8**

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

UNIT II **DIFFUSION PROCESSES: FINITE VOLUME METHOD** **10**

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

UNIT III **CONVECTION - DIFFUSION PROCESSES: FINITE VOLUME METHOD** **9**

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

UNIT IV **FLOW PROCESSES: FINITE VOLUME METHOD** **8**

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

UNIT V **MODELLING OF COMBUSTION AND TURBULENCE** **10**

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

TOTAL:45 Periods

OUTCOMES:

On successful completion of this course

1. The student will be able to develop finite volume discretized forms of the CFD equations
2. The student will be able to to understand the various solving methodologies and to create confidence to solve complex problems in the field of heat transfer and fluid dynamics.

3. The student will be able to formulate explicit & implicit algorithms for solving the Euler Equations & Navier Strokes Equations.
4. The student will be able to apply the concepts of CFD to analyse the fluid flow and heat transfer in thermal systems.
5. The student will be able to illustrate the working concepts of thermal engineering.

REFERENCES:

1. Ghoshdastidar, P.S., "Computer Simulation of Flow and Heat Transfer", Tata McGraw-Hill Publishing Company Limited, New Delhi, 1998.
2. Jiyuan Tu, Guan Heng Yeoh, Chaogun Liu, "Computational Fluid Dynamics A Practical Approach" Butterworth – Heinemann An Imprint of Elsevier, Madison, U.S.A., 2008
3. John D. Anderson. JR. "Computational Fluid Dynamics the Basics with Applications" McGraw-Hill International Editions, 1995.
4. Muralidhar, K., and Sundararajan, T., "Computational Fluid Flow and Heat Transfer", Narosa Publishing House, New Delhi, 2003.
5. Subas and V.Patankar "Numerical heat transfer fluid flow", Hemisphere Publishing Corporation,1980.
6. Versteeg and Malalasekera, N, "An Introduction to computational Fluid Dynamics The Finite Volume Method," Pearson Education, Ltd., Second Edition, 2014.

192MEE305T BIOMECHANICS

L	T	P	R	C
3	0	0	0	3

OBJECTIVES :

The student should be made to:

1. Be exposed to principles of mechanics.
2. Learn the mechanics of physiological systems.
3. Be familiar with the mathematical models used in the analysis of biomechanical systems

UNIT-I INTRODUCTION TO MECHANICS 9

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

UNIT II BIOFLUID MECHANICS 9

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

UNIT III BIOSOLID MECHANICS 9

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

UNIT IV BIOMECHANICS OF JOINTS AND IMPLANTS 9

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

UNIT V **MODELING AND ERGONOMICS** **9**

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

TOTAL:45 Periods

OUTCOMES:

At the end of the course, the student should be able to:

1. Explain the mechanics of physiological systems.
2. Identify relationships between structure and function in tissues and the implications/importance of these relationships
3. Identify the appropriate viscoelasticity model for the mechanical behavior of a given biological tissue.
4. Analyze the biomechanical systems.
5. Analyze the forces at a skeletal joint for various static and dynamic human activities.

REFERENCES:

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

PROFESSIONAL ELECTIVE-IV

		L	T	P	R	C
192MEE306T	**DESIGN FOR MANUFACTURE, ASSEMBLY AND ENVIRONMENTS**	**3**	**0**	**0**	**0**	**3**

OBJECTIVES:

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

UNIT-I **INTRODUCTION** **5**

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

UNIT II **FACTORS INFLUENCING FORM DESIGN** **13**

Working principle, Material, Manufacture, Design- Possible solutions - Materials choice – Influence of materials on form design - form design of welded members, forgings and castings.

UNIT III **COMPONENT DESIGN - MACHINING CONSIDERATION** **8**

Design features to facilitate machining - drills - milling cutters - keyways - Doweling procedures, counter sunk screws - Reduction of machined area- simplification by separation - simplification by amalgamation - Design for machinability - Design for economy - Design for clampability – Design for accessibility - Design for assembly – Product design for manual assembly - Product design for

automatic assembly – Robotic assembly.

UNIT IV COMPONENT DESIGN – CASTING CONSIDERATION 10

Redesign of castings based on Parting line considerations - Minimizing core requirements, machined holes, redesign of cast members to obviate cores. Identification of uneconomical design - Modifying the design - group technology - Computer Applications for DFMA

UNIT V DESIGN FOR THE ENVIRONMENT 9

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

TOTAL: 45 Periods

OUTCOMES:

The students will be able to:

1. Understand the quality aspects of design for manufacture and assembly.
2. Apply Boothroyd method of DFM for product design and assembly.
3. Apply the concept of DFM for casting, welding, forming and assembly.
4. Identify the design factors and processes as per customer specifications.
5. Apply the DFM method for a given product.
6. Design a product considering the environmental impact during its lifecycle.

REFERENCES:

1. Boothroyd, G, 1980 Design for Assembly Automation and Product Design. New York, Marcel Dekker.
2. Boothroyd, G, Heartz and Nike, Product Design for Manufacture, Marcel Dekker, 1994.
3. Bralla, Design for Manufacture handbook, McGraw hill, 1999.
4. Dickson, John. R, and Corroda Poly, Engineering Design and Design for Manufacture and Structural Approach, Field Stone Publisher, USA, 1995.
5. Fixel, J. Design for the Environment McGraw Hill., 1996.
6. Graedel T. Allen By. B, Design for the Environment Angle Wood Cliff, Prentice Hall. Reason Pub., 1996.
7. Harry Peck, Designing for manufacture, Pitman– 1973.
8. Kevin Otto and Kristin Wood, Product Design. Pearson Publication, (Fourth Impression) 2009.

192MEE307T	PRODUCT DESIGN FOR SUSTAINABILITY	L	T	P	R	C
		3	0	0	0	3

OBJECTIVES:

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

UNIT-I BASIC CONCEPTS IN SUSTAINABILITY 9

Understanding the language of sustainable engineering design, construction and operation. Natural

resources terminology. Carrying capacity. Sustainable development, corporate responsibility, biophysical constraints, environmental management.

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

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

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

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

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

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

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

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

TOTAL: 45 Periods

OUTCOMES:

The student will be able to

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

REFERENCES:

1. Clarke, Abigail & John K. Gershenson 2006. Design for the Life Cycle. Life-cycle Engineering Laboratory, Department of Mechanical Engineering-Engineering Mechanics, Michigan Technological University.
2. Finster, Mark P., 2013. Sustainable Perspectives to Design and Innovation.
3. Ramaswamy, Rohit, 1996. Design and Management of Service Processes: Keeping Customers for Life, Prentice Hall.
4. Schmitt, Brent, Customer Experience Management, Wiley and Sons, 2003.

192MEE308T	BEARING DESIGN AND ROTOR DYNAMICS	L	T	P	R	C
		3	0	0	0	3

OBJECTIVE:

1. To know about different types of bearings available for machine design and their operating principles
2. To design hydrodynamic/ hydrostatic / rolling bearing for given specifications and analyze the bearings for their performance
3. 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 Nonmetallic bearings.

UNIT II DESIGN OF FLUID FILM BEARINGS 10

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

UNIT III SELECTION AND DESIGN OF ROLLING BEARINGS 10

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

UNIT IV DYNAMICS OF HYDRODYNAMIC BEARINGS 10

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

UNIT V ROTOR DYNAMICS 9

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

TOTAL: 45 Periods

OUTCOME:

The student will be able to

1. Classify and select different types of bearings for various applications
2. Analyze of all types of bearings for their performance.
3. Design and make specifications of all types of bearings
4. Conduct dynamic / vibration analysis on bearings
5. Be acquainted with the different techniques used for troubleshooting of bearings.

REFERENCES:

1. Cameron, A. “Basic Lubrication Theory”, Ellis Herward Ltd., UK, 1981

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

192MEE309T COMPOSITE MATERIALS AND MECHANICS

L	T	P	R	C
3	0	0	0	3

OBJECTIVE

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

UNIT-I INTRODUCTION TO COMPOSITE MATERIALS 10

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

UNIT II MANUFACTURING OF COMPOSITES 10

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

UNIT III INTRODUCTION, LAMINA CONSTITUTIVE EQUATIONS 12

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

UNIT IV LAMINA STRENGTH ANALYSIS AND ANALYSIS OF LAMINATED FLAT PLATES 8

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

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

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

TOTAL: 45 Periods

OUTCOME

The student will be able to

1. Understand the fundamentals of composite material strength and its mechanical behaviour.
2. Understand the analysis of fiber reinforced Laminate design for different combinations of plies with different orientations of the fiber.
3. Analyze the Thermo-mechanical behavior and study of residual stresses in Laminates during processing.
4. Understand the Implementation of Classical Laminate Theory (CLT) and analyse the residual stresses in an isotropic layered structure such as electronic chips.
5. Design layered components such as fiber reinforced polymer composites; isotropic layered structures (example electronic chips) etc and understand its manufacturing methodologies.

REFERENCES:

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

192MEE310T **PLATES AND SHELLS**

L	T	P	R	C
3	0	0	0	3

OBJECTIVE:

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

UNIT-I **GENERAL INTRODUCTION** **7**

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

UNIT II **CLASSICAL THEORY OF PLATES** **10**

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

UNIT III **BUCKLING ANALYSIS OF RECTANGULAR PLATES** **10**

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

UNIT IV **VIBRATION OF PLATES** **9**

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

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

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

TOTAL: 45 Periods

OUTCOMES:

The students will be able to

1. Understand the behaviour of these commonly occurring structural elements in engineering design.
2. Design and analyse them in their normal design practice.
3. Understand the behaviour of plates and analytical techniques to solve the two-dimensional structural engineering problems.
4. Construct the mathematical models of structural systems.
5. Apply differential equations for the calculation of response of two-dimensional problems.

REFERENCES:

1. Dr. N. Subramanian, Principles of Space Structures, Wheeler Publishing Co. 1999.
2. K. Baskar and T.K. Varadan, "Plates- Theories and Applications", Ane Books Pvt. Ltd., New Delhi, 2013.
3. Ramasamy, G.S., Design and Construction of Concrete Shells Roofs, CBS Publishers, 1986.
4. Reddy, J.N., "Theory and Analysis of Elastic Plates & Shells", C.R.C. Press, NY, USA, 2nd Edition 2002.

5 Szilard, R., Theory and Analysis of Plates, Prentice Hall Inc., 1995.
6 Timoshenko, S. and Krieger S.W. Theory of Plates and Shells, McGraw Hill Book Company New York 1990.
7. Timoshenko, S. Theory of Plates and Shells, McGraw Hill, 1990.
8. Wilhelm Flügge, Stresses in Shells, Springer – Verlag, 1962.