DR AMBEDKAR INSTITUTE OF TECHONOLOGY

DEPARTMENT OF MECHNICAL ENGINEERING

SCHEME AND SYLLABUS

FOR

M.Tech MACHINE DESIGN

YEAR 2016-17

PROGRAM EDUCATIONAL OBJECTIVES

PEO1--Graduates will have knowledge in the discipline of Machine Design with hands on skill in using modern engineering tools to address real world engineering problems and be socially responsible.
PEO2– Graduates shall be successful in their career as analysts and designers of structural components of conventional and advanced materials, participating in a team or individually in an industry, research or academia.
PEO3– Graduates shall be proficient in their communication, presentation and will be prepared to engage in the process of life-long learning through professional development and research.

PROGRAM OUTCOMES

PO No.	Program Outcomes (PO)
PO1	Acquire in-depth knowledge of specific discipline or professional area, including wider and global perspective, with an ability to discriminate, evaluate, analyze and synthesize existing and new knowledge, and integration of the same for enhancement of knowledge.
PO2	Analyze complex engineering problems critically, apply independent judgment for synthesizing information to make intellectual and/or creative advances for conducting research in a wider theoretical, practical and policy context
PO3	Think laterally and originally, conceptualize and solve engineering problems, evaluate a wide range of potential solutions for those problems and arrive at feasible, optimal solutions after considering public health and safety, cultural, societal and environmental factors in the core areas of expertise.
PO4	Extract information pertinent to unfamiliar problems through literature survey and experiments, apply appropriate research methodologies, techniques and tools, design, conduct experiments, analyze and interpret data, demonstrate higher order skill and view things in a broader perspective, contribute individually/in group(s) to the development of scientific/technological knowledge in one or more domains of engineering.
PO5	Create, select, learn and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modeling, to complex engineering activities with an understanding of the limitations.
PO6	Possess knowledge and understanding of group dynamics, recognize opportunities and contribute positively to collaborative-multidisciplinary scientific research, demonstrate a capacity for self-management and teamwork, decision-making based on open-mindedness, objectivity and rational analysis in order to achieve common goals and further the learning of themselves as well as others.
PO7	Demonstrate knowledge and understanding of engineering and management principles and apply the same to one's own work, as a member and leader in a team, manage projects efficiently in respective disciplines and multidisciplinary environments after consideration of economic and financial factors.
PO8	Communicate with the engineering community, and with society at large, regarding complex engineering activities confidently and effectively, such as, being able to comprehend and write effective reports and design documentation by adhering to appropriate standards, make effective presentations, and give and receive clear instructions.
PO9	Recognize the need for, and have the preparation and ability to engage in life-long learning independently, with a high level of enthusiasm and commitment to improve knowledge and competence continuously.
PO10	Acquire professional and intellectual integrity, professional code of conduct, ethics of research and scholarship, consideration of the impact of research outcomes on professional practices and an understanding of responsibility to contribute to the community for sustainable development of society.
PO11	Observe and examine critically the outcomes of one's actions and make corrective

DR AMBEDKAR INSTITUTE OF TECHONOLOGY

M.TECH/ MACHINE DESIGN **CREDIT BASED**

Subject Code	Name of the Subject	I SEMSTER						
		MARKS	CREDITS	L	T	P	S	TOTAL
16MMD11	ADVANCED MECHANICS OF SOLIDS	100	04	4	0	0	0	4
16MMD12	FINITE ELEMENT METHOD	100	04	4	0	0	0	4
16MMD13	ADVANCED DESIGN OF MECHANISM	100	04	4	0	0	0	4
16MMD14	ADVANCED THEORY OF VIBRATIONS	100	04	4	0	0	0	4
16MMD15X	ELECTIVE-I	100	04	4	0	0	0	4
16MMDL16	VIBRATION LAB	100	02	0	0	02	0	2
16MMDS17	TECHNICAL SEMINAR	100	02	0	0	0	02	2
16MMDM18	MINI PROJECT OR INDUSTRIAL VISIT	100	02	0	0	0	02	2
	TOTAL	**800**	**26**	**20**	**00**	**02**	**04**	**26**

ELECTIVE –I

16MMD151 MECHATRONICS SYSTEMS DESIGN

16MMD152 DESIGN FOR MANUFACTURE

16MMD153 AUTOMOBILE SYSTEM DESIGN

Subject Code	Name of the Subject	II SEMSTER						
		MARKS	**CREDITS**	**L**	**T**	**P**	**S**	**TOTAL**
16MMD21	COMPOSITE MATERIAL TECHONOLOGY	100	04	4	0	0	0	4
16MMD22	ADVANCED MACHINE DESIGN	100	04	4	0	0	0	4
16MMD23	EXPERIMENTAL MECHANICS	100	04	4	0	0	0	4
16MMD24	TRIBOLOGY & BEARING DESIGN	100	04	4	0	0	0	4
16MMD25X	ELECTIVE-I	100	04	4	0	0	0	4
16MMDL26	FINITE ELEMENT ANALYSIS LAB	100	02	0	0	02	0	2
RM 27	RESEARCH METHODOLOGY	100	02	0	0	0	02	2
16MMDM28	MINI PROJECT //INDUSTRIAL VISIT/FIELD WORK/TECHNICAL	100	02	02	0	0	0	2
	TOTAL	**800**	**26**	**22**	**00**	**02**	**02**	**26**

ELECTIVE-I

16MMD251 THEORY OF PLASTICITY

16MMD252 ROTOR DYNAMICS

16MMD253 FINITE ELEMENT METHODS FOR HEAT TRANSFER AND FLUID FLOW ANALYSIS

Subject Code	Name of the Subject	III SEMSTER						
		MARKS	CREDITS	L	T	P	S	TOTAL
16MMD31	MIDTERM PRESENTATION ON INTERNSHIP	50	2	0	0	2	0	02
16MMD32	REPORT ON INTERNSHIP	100	13	0	0	13	0	13
16MMD33	EVALUATION AND VIVA-VOCE ON INTERNSHIP	100	05	0	0	05	0	05
16MMD32	PROJECT PHASE-1	50	00	0	0	0	0	PP
	TOTAL	**300**	**20**	**0**	**0**	**20**	**00**	**20**

NOTE: III Semester:

- **Internship**: The student shall undergo internship for 16 weeks.

  Preliminary Report submission and Evaluation after 8th week of Internship to be carried out by the Internal Guide of the college and a senior faculty for 50 marks

  Final report submission and evaluation to be carried out after 16th week of internship by the internal guide of the college and a senior faculty. Report evaluation to be completed within two weeks of submission for 100 marks.

  Viva-Voce on Internship - To be conducted by the Internship Guide (from the college) and the External Guide / Examiner within 2 weeks of Submission with a senior faculty / HOD as chairman for 100 marks

- **Project Phase: I**

  Problem formulation and submission of **synopsis** within 8 weeks from the commencement of 3rd semester, which shall be evaluated for 50 marks by the committee constituted for the purpose by the Head of the Department comprising the guide, senior faculty of the department with HOD as Chairman.

  Literature survey and progress done after 16 weeks shall be evaluated by guide and external examiner with senior faculty / HOD as chairman for 100 marks.

Subject Code	Name of the Subject	IV SEMSTER						
		MARKS	CREDITS	L	T	P	S	TOTAL
16MMD41	FRACTURE MECHANICS	100	04	4	0	0	0	4
16MMD42X	ELECTIVE-I	100	04	4	0	0	0	4
16MMD43	PROJECT PHASE-II	100	02	0	0	0	02	20
16MMD44	PROJECT VIVA- VOCE	200	18	0	0	18	0	
	TOTAL	**500**	**28**	**08**	**00**	**18**	**02**	**28**

ELECTIVE-I

16MMD421 COMPUTATIONAL FLUID DYNAMICS

16MMD422 SMART MATERIALS & STRUCTURES

16MMD423 DESIGN OPTIMIZATION

IV Semester:

- **Project Phase-II -** Internal Evaluation of progress in Project work shall be evaluated after 8 weeks for 100 marks by the committee constituted for the purpose by the Head of the Department comprising the guide and senior faculty of the department with HOD as Chairman.
- **Project Phase-III -** Internal Evaluation of Project Demonstration, which shall be evaluated after 15 weeks for 100 marks by the committee constituted for the purpose by the Head of the Department.
- **Final Evaluation** of Project Work and Viva-voce.
- **Final evaluation** of project to be carried out after 16 weeks from the date of commencement of 4th semester.
- **The Internal Examiner** (the project guide with a teaching experience of at least three years) and External Examiner with HOD as chairman will complete the final evaluation of Project.
- **Internal and External Examiners** shall carry out the evaluation for 100 Marks each and the average of these marks shall be the final marks of the Project Evaluation.
- **Viva – Voce**: The Viva-Voce shall be conducted jointly by Internal Examiner and External Examiner with HOD as chairman for 100 Marks.

ADVANCED MECHANICS OF SOLIDS

Course Code	**:**	**16MMD11**		**CIE Marks**	**:**	**50**
Hrs./Week	**:**	**L: T: P: 4:0:0**		**SEE Marks**	**:**	**50**
Credits	**:**	**04**		**SEE Duration**	**:**	**3 hours**

Course Objective:

This course aims at a comprehensive study of mechanics of solids. The topics covered are

1. Analysis of stress, strain and stress-strain relations.
2. Solution of plane elasticity problems in rectangular and polar coordinates using analytical methods including thermal loads, body forces and surface tractions
3. Formulation of 3-D boundary value problems
4. Torsion of prismatic bars

Course Content: Chapters/ Units

1. **Introduction:** Definition and notation for forces and stresses. Components of stresses, equations of equilibrium, specification of stress at a point. Principal stresses and Mohr's diagram in 3 dimensions. Boundary conditions, interaction of given surface forces. Strain components, specification of strain at a point compatibility equation.
   Stress- strain relation and the general equation of elasticity. Generalized Hooke's law in terms of engineering constant, formulation of elasticity problem. Existence and uniqueness of solution, Saint- Venant's principle. Principle of superposition and reciprocal theorem. **13 Hours**

2. **Plane stress and plane strain problems:** Bending of narrow cantilever beam under end load, simply supported beam with uniform load, use of Fourier series to solve two dimensional problems. Two dimensional problems in polar coordinates. Thin cylinder, pure bending of curved bar, rotating disc and cylinder, bending of curved bar by a force at the end, edge dislocation, effect of circular holes on stress distribution in plates, and vertical load of the straight boundary, forces acting on the end of wedge, stresses in circular disc. Thermal stresses- field equation, stresses in thin disk and long cylinder. 2-D problems in curvilinear coordinates. **13 Hours**

3. Torsion of prismatic bars, membrane analogy, torsion of thin open and closed tubes. **08 Hours**

4. Introduction to pure bending and deflection of plates and shells. **08 Hours**

5. Buckling of struts, stresses and strains in thick curved beam, cylinders and spheres. **08 Hours**

NOTE: the students are advised to prepare the report in the form of assignment to understand the subject and its relevance in the industry

TEXT BOOKS

1. Sadhu Singh, Theory of Elasticity, Khanna publisher
2. Applied elasticity- Wang C.T, Mc Graw Hill book company
3. L S Srinath "Advanced Mechanics of Solids " - Tata McGraw Hill Company.

REFERENCES

1. Theory of elasticity- Timoshenko and Goodier
2. Theory of plates and shells- Timoshenko, Mc Graw Hill book company
3. Dym C. L and Shames. I. H, Solid Mechanics: A variation Approach – McGraw Hill New York- 1973.

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO1	Apply basic concepts in continuum mechanics of solids viz. Stress and strain tensors, equilibrium, compatibility and constitutive equations. Mohr's diagram hook's law and methods of solution to elasticity problems, principle of superposition and reciprocal theorem.
CO 2	Study about bending of cantilever beams with different loading condition. Evaluate stresses and displacements in simple solids such as pressurized cylinders, shrink fitted cylinders, rotating disc and shaft, plate with hole and non-circular shafts and thin tubes under torsion.
CO 3	To understand an analyze the Torsion of prismatic bars, membrane analogy, torsion of thin open and closed tubes
CO 4	To understand the stresses developed due to pure bending and deflection of plates and shells.
CO 5	To understand the concepts of Buckling of struts, stresses and strains in thick curved beam, cylinders and spheres.

SCHEME OF EXAMINATION (QUESTION PAPER PATTERN)

1. Seven FULL questions to be set.
2. Five FULL questions to be answered.
3. Chapter-3, Chapter-,4 Chapter-5, are compulsory, with one question from each chapter
4. Chapter-1 and Chapter-2: two questions to be set with choice.

FINITE ELEMENT METHOD

Course Code	**:**	**16MMD12**		**CIE Marks**	**:**	**50**
Hrs/Week	**:**	**L: T: P: 4:0:0**		**SEE Marks**	**:**	**50**
Credits	**:**	**04**		**SEE Duration**	**:**	**3 hours**

Course Objectives

1. To present the Finite element method (FEM) as a numerical method for engineering analysis of continua and structures
2. To present Finite element formulation using variational and weighted residual approaches
3. To present Finite elements for the analysis of bars & trusses, beams & frames, plane stress & plane strain problems and 3-D solids, for thermal and dynamics problems.

Course Content: Chapters/ Units

1. **Approximations and round off errors**: Significant figures, accuracy and precision, error definitions, round off errors and truncation errors. Mathematical modeling and Engineering problem solving: Simple mathematical model, Conservation Laws of Engineering**.** **06 Hours**
   System of Linear Algebraic Equations and Eigen Value Problems: Introduction, Direct methods, Cramer's Rule, Gauss Elimination Method, Gauss-Jordan Elimination Method, Triangularization method, Cholesky Method, Partition method, error Analysis for direct methods, Iteration Methods. Eigen values and Eigen Vectors: Bounds on Eigen Values, Jacobi method for symmetric matrices. **06 Hours**

2. **Introduction to Finite Element Method:** Basic Steps in Finite Element Method to solve mechanical engineering (Solid, Fluid and Heat Transfer) problems: Functional approach and Galerkin approach, Displacement Approach: Admissible Functions, Convergence Criteria: Conforming and Non-Conforming elements, C_o C_1 and C_n Continuity Elements. Basic Equations, Element Characteristic Equations, Assembly Procedure, Boundary and Constraint Conditions. **06 Hours**
   Solid Mechanics: One-Dimensional Finite Element Formulations and Analysis – Bars-uniform, varying and stepped cross section-Basic (Linear) and Higher Order Elements Formulations for Axial, Torsional and Temperature Loads with problems. Beams- Basic (Linear) Element Formulation-for uniform, varying and stepped cross section- for different loading and boundary conditions with problems. Trusses, Plane Frames and Space Frame Basic (Linear) Elements Formulations for different boundary condition -Axial, Bending, Torsional, and Temperature Loads with problems. **06 Hours**

3. **Two-Dimensional Finite Element Formulations for Solid Mechanics Problems:** Triangular Membrane (TRIA 3, TRIA 6, TRIA 10) Element, Four-Noded Quadrilateral Membrane (QUAD 4, QUAD 8) Element Formulations for in-plane loading with sample problems.
   Triangular and Quadrilateral, Axis-symmetric basic and higher order Elements formulation for axis-symmetric loading only with sample problems.
   Three-Dimensional Finite Element Formulations for Solid Mechanics Problems: Finite Element Formulation of Tetrahedral Element (TET 4, TET 10), Hexahedral Element (HEXA 8, HEXA 20), for different loading conditions. Serendipity and Lagrange family Elements **10 Hours**

4. **Finite Element Formulations for Structural Mechanics Problems:** Basics of plates and shell theories: Classical thin plate Theory, Shear deformation Theory and Thick Plate theory. Finite Element Formulations for triangular and quadrilateral Plate elements. Finite element formulation of flat, curved, cylindrical and conical Shell elements **08 Hours**
5. **Dynamic Analysis:** Finite Element Formulation for point/lumped mass and distributed masses system, Finite Element Formulation of one-dimensional dynamic analysis: bar, truss, frame and beam element. Finite Element Formulation of Two-dimensional dynamic analysis: triangular membrane and axisymmetric element, quadrilateral membrane and axisymmetric element. Evaluation of eigen values and eigen vectors applicable to bars, shaft, beams, plane and space frame. **10 Hours**

NOTE: students are advised to prepare the report in the form of assignment to understand the subject and its relevance in the industry.

Text Books:

1. S.S. Sastry, Introductory Methods of Numerical Analysis, PHI, 2005.
2. Steven C. Chapra, Raymond P. Canale, Numerical Methods for Engineers, Tata McGraw Hill, 4th Ed, 2002.
3. M K Jain, S.R.K Iyengar, R K. Jain, Numerical methods for Scientific and engg computation, New Age International, 2003.
4. T. R. Chandrupatla and A. D. Belegundu, Introduction to Finite Elements in Engineering, Prentice Hall, 3rd Ed, 2002.
5. Lakshminarayana H. V., Finite Elements Analysis– Procedures in Engineering, Universities Press, 2004.

Reference Books:

1. Rao S. S., Finite Elements Method in Engineering- 4th Edition, Elsevier, 2006
2. P. Seshu, Textbook of Finite Element Analysis, PHI, 2004.
3. Bathe K. J., Finite Element Procedures, Prentice-Hall, 2006.
4. Cook R. D., Finite Element Modeling for Stress Analysis, Wiley,1995.
5. David. C. Lay, Linear Algebra and its applications, 3rd edition, Pearson Education, 2002

Course Outcomes:

Upon completion of this course, the students will be able to

CO1	It’s important for the students to have basic knowledge about applied mathematics
CO2	Apply basic concepts about developing governing equations by finite element method, Formulate and perform one dimensional,
CO3	Two-dimensional structural analysis using bar, beam, triangular and quadrilateral elements. for Solid Mechanics Problems
CO4	Formulate axisymmetric triangular element and analyze problems on solids of revolution.
CO5	Formulate mass matrices and compute eigen values and eigen vectors for a 1- D and 2D analysis of mechanical system.

SCHEME OF EXAMINATION (QUESTION PAPER PATTERN)

1. Seven FULL questions to be set.
2. Five FULL questions to be answered.
3. Chapter-3, Chapter-4, Chapter-5, are compulsory, with one question from each chapter
4. Chapter-1 and Chapter-2: two questions to be set with choice.

ADVANCED DESIGN OF MECHANISM

Course Code	**:**	**16MMD13**		**CIE Marks**	**:**	**50**
Hrs/Week	**:**	**L: T: P: 4:0:0**		**SEE Marks**	**:**	**50**
Credits	**:**	**04**		**SEE Duration**	**:**	**3 hours**

Course Objective:
To include dynamics considerations in the design of mechanisms for engineering applications is the objective of this course.

Course Content: Chapters/ Units

1. **Geometry of Motion:** Introduction, analysis and synthesis, Mechanism terminology, planar, Spherical and spatial mechanisms, mobility, Grashoffs law, Equivalent mechanisms, Unique mechanisms, Kinematic analysis of plane mechanisms: Auxiliary point method using rotated velocity vector, Hall - Ault auxiliary point method, Goodman's indirect method. **8 Hours**

   6 Hours

2. **Generalized Principles of Dynamics:** Fundamental laws of motion, generalized coordinates, Configuration space, Constraints, Virtual work, principle of virtual work, Energy and momentum, Work and kinetic energy, Equilibrium and stability, Kinetic energy of a system, Angular momentum, Generalized momentum. Lagrange's Equation: Lagrange's equation from D'Alembert's principles, Examples, Hamilton’s equations, Hamilton’s principle, Lagrange's, equation from Hamilton’s principle, Derivation of Hamiltons equations, Examples. **13 Hours**

3. **System Dynamics:** Gyroscopic action in machines, Euler's equation of motion, Phase Plane representation, Phase plane Analysis, Response of Linear Systems to transient disturbances. Synthesis of Linkages: Type, number, and dimensional synthesis, Function generation, Path generation and Body guidance, Precision positions, Structural error, Chebyshev spacing, Two position synthesis of slider crank mechanisms, Crank-rocker mechanisms with optimum transmission angle Motion Generation: Poles and relative poles, Location of poles and relative poles, pooled, Curvature, Inflection circle. **13 Hours**

4. Graphical Methods of Dimensional Synthesis: Two position synthesis of crank and rocker mechanisms, three position synthesis, four position synthesis (point precision reduction) Overlay method, Coupler curve synthesis, Cognate linkages. Ana1ytical Methods of Dimensional Synthesis: Freudenstein's equation for four bar mechanism and slider crank mechanism, Examples, Bloch's method of synthesis, Analytical synthesis using complex algebra. **12 Hours**

5. Spatial Mechanisms: Introduction, Position analysis problem, Velocity and acceleration analysis, Eulerian angles. **6 Hours**

NOTE: the students are advised to prepare the report in the form of assignment to understand the subject and its relevance in the industry

Text Books:

1. Greenwood, "Classical Dynamics", Prentice Hall of India, 1988.
2. K.J. Waldron G.L. Kinzel, "Kinematics, Dynamics and Design of Machinery", Wiley India, 2007.

References Books:

1. J E Shigley, "Theory of Machines and Mechanism" -McGraw-Hill, 1995
2. A.G. Ambekar, "Mechanism and Machine Theory", PHI, 2007.
3. Ghosh and Mallick, "Theory of Mechanism and Mechan ism", East West press 2007.
4. David H. Myszka, "Machines and Mechanisms", Pearson Education, 2005.

Course Outcome:

Upon completion of this course, the student will be able to

CO1	The knowledge of dynamics considerations in mechanism design is essential to use commercial multi body dynamics software in mechanical engineering design.
CO2	Carry out mobility analysis of mechanism and perform velocity and acceleration of complex planer mechanism.
CO3	Synthesize mechanisms for function generation and path generation.
CO4	Analyze the Dynamics of Mechanical systems using D'Alembert's, Lagrange's, and Hamiltons Principles.
CO5	Demonstrate the skills to use software to analyze mechanisms, synthesis of linkages.

SCHEME OF EXAMINATION (QUESTION PAPER PATTERN)

1. Seven FULL questions to be set.
2. Five FULL questions to be answered.
3. Chapter-1, Chapter-4, Chapter-5, are compulsory, with one question from each chapter
4. Chapter-2 and Chapter-3: two questions to be set with choice.

ADVANCED THEORY OF VIBRATIONS

Course Code	**:**	**16MMD14**		**CIE Marks**	**:**	**50**
Hrs/Week	**:**	**L: T: P: 4:0:0**		**SEE Marks**	**:**	**50**
Credits	**:**	**04**		**SEE Duration**	**:**	**3 hours**

Course Objective:

To teach students how to use the theoretical principles of vibration, and vibration analysis techniques, for the practical solution of vibration problems. The course thus builds on student's prior knowledge of vibration theory, and concentrates on the applications. Thus the student will fully understand the importance of vibrations in mechanical design of machine parts that operate in vibratory conditions.

Course Content: Chapters/ Units

1. **Review of Mechanical Vibrations:** Basic concepts; free vibration of single degree of freedom systems with and without damping, forced vibration of single DOF-systems, Natural frequency.
   Transient Vibration of single Degree-of freedom systems: Impulse excitation, Arbitrary excitation, Laplace transform formulation, pulse excitation and rise time, Shock response spectrum, Shock isolation. **10 Hours**

2. **Vibration Control:** Introduction, Vibration isolation theory, Vibration isolation and motion isolation for harmonic excitation, practical aspects of vibration analysis, shock isolation, Dynamic vibration absorbers, Vibration dampers.
   Vibration Measurement and applications: Introduction, Transducers, Vibration pickups, Frequency measuring instruments, Vibration exciters, Signal analysis. **13 Hours**

3. **Modal analysis & Condition Monitoring:** Dynamic Testing of machines and Structures, Experimental Modal analysis, Machine Condition monitoring and diagnosis. Non-Linear Vibrations: Introduction, Sources of nonlinearity, Qualitative analysis of nonlinear systems. Phase plane, Conservative systems, Stability of equilibrium, Method of isoclines, Perturbation method, Method of iteration, Self-excited oscillations. **13 Hours**

4. **Random Vibrations:** Random phenomena, Time averaging and expected value, Frequency response function, Probability distribution, Correlation, Power spectrum and power spectral density, Fourier transforms, FTs and response. **08 Hours**
5. **Continuous Systems:** Vibrating string, longitudinal vibration of rods, Torsional vibration of rods, Euler equation for beams.
   Different methods of vibration dissipation in structural components for general and rotating machinery. **08 Hours**

NOTE: the students are advised to prepare the report in the form of assignment to understand the subject and its relevance in the industry

Text Books:

1. Theory of Vibration with Application, - William T. Thomson, Marie Dillon Dahleh, Chandramouli Padmanabhan, 5th edition Pearson Education
2. S. Graham Kelly, "Fundamentals of Mechanical Vibration" - McGraw-Hill, 2000
3. S. S. Rao, "Mechanical Vibrations", Pearson Education, 4^{th} edition.

Reference Books:

1. S. Graham Kelly, "Mechanical Vibrations", Schaum's Outlines, Tata McGraw Hill, 2007.
2. C Sujatha , "Vibrations and Acoustics – Measurement s and signal analysis Tata McGraw Hill, 2010

Course Outcome:

Upon completion of this course, the student will be able to

CO1	Model and analyze a free damped, undamped and forced response of a mechanical system.
CO2	Develop equation and analyze the transient response of a single degree freedom system.
CO3	Assess the response characteristics of a continuous mechanical system.
CO4	Analyze and discuss the behavior of single degree freedom system for linear and non-linear behavior.

SCHEME OF EXAMINATION (QUESTION PAPER PATTERN)

1. Seven FULL questions to be set.
2. Five FULL questions to be answered.
3. Chapter-1, Chapter-4, Chapter-5, are compulsory, with one question from each chapter
4. Chapter-2 and Chapter-3: two questions to be set with choice.

Elective-I

MECHATRONICS SYSTEMS DESIGN

Course Code	**:**	**16MMD151**		**CIE Marks**	**:**	**50**
Hrs/Week	**:**	**L: T: P: 4:0:0**		**SEE Marks**	**:**	**50**
Credits	**:**	**04**		**SEE Duration**	**:**	**3 hours**

Course Objective

1. To educate the student regarding integration of mechanical, electronic, electrical and computer systems in the design of CNC machine tools, Robots etc.
2. To provide students with an understanding of the Mechatronic Design Process, actuators, Sensors, transducers, Signal Conditioning, MEMS and Microsystems and also the Advanced Applications in Mechatronics.

Course Content: Chapters/ Units

1. **Introduction:** Definition and Introduction to Mechatronic Systems. Modeling &Simulation of Physical systems Overview of Mechatronic Products and their functioning, measurement systems. Control Systems, simple Controllers. Study of Sensors and Transducers: Pneumatic and Hydraulic Systems, Mechanical Actuation System, Electrical Actual Systems, Real time interfacing and Hardware components for Mechatronics. **13 Hours**

2. **Electrical Actuation Systems:** Electrical systems, Mechanical switches, Solid state switches, solenoids, DC & AC motors, Stepper motors.

   System Models: Mathematical models: - mechanical system building blocks, electrical system building blocks, thermal system building blocks, electromechanical systems, hydro-mechanical systems, pneumatic systems. **10 Hours**

3. **Signal Conditioning:** Signal conditioning, the operational amplifier, Protection, Filtering, Wheatstone Bridge, Digital signals, Multiplexers, Data Acquisition, Introduction to digital system processing, pulse-modulation.

   MEMS and Microsystems: Introduction, Working Principle, Materials for MEMS and Microsystems, Micro System fabrication process, Overview of Micro Manufacturing, Micro system Design, and Micro system Packaging. **13 Hours**

4. **Data Presentation Systems:** Basic System Models, System Models, Dynamic Response of system. **8 Hours**

5. **Advanced Applications in Mechatronics:** Fault Finding, Design, Arrangements and Practical Case Studies, Design for manufacturing, User-friendly design **8 Hours**

NOTE: the students are advised to prepare the report in the form of assignment to understand the subject and its relevance in the industry

Text Books:

1. W. Bolton, “Mechatronics” - Addison Wesley Longman Publication, 1999
2. HSU “MEMS and Microsystems design and manufacture”- Tata McGraw-Hill Education, 2002

Reference Books:

1. Kamm, “Understanding Electro-Mechanical Engineering an Introduction to Mechatronics”- IEEE Press, 1 edition ,1996
2. Shetty and Kolk “Mechatronics System Design”- Cengage Learning, 2010
3. Mahalik “Mechatronics”- Tata McGraw-Hill Education, 2003
4. HMT “Mechatronics”- Tata McGraw-Hill Education, 199 8
5. Michel.B. Histand& David. Alciatore, “Introduction to Mechatronics & Measurement Systems”–. Mc Graw Hill, 2002
6. “Fine Mechanics and Precision Instruments”- Pergamon Press, 1971.

Course Outcome:

Upon completion of this course, the student will be able to

CO1	Appreciate multi-disciplinary nature of modern engineering systems.
CO2	Model and analyze mechanical and electrical systems and their connection.
CO3	Be able to integrate mechanical, electronics, control and computer engineering in the design of mechatronics systems.
CO4	Address issues of design, fabrication, and packaging issues of Microsystems.

SCHEME OF EXAMINATION (QUESTION PAPER PATTERN)

1. Seven FULL questions to be set.
2. Five FULL questions to be answered.
3. Chapter-2, Chapter-4, Chapter-5, are compulsory, with one question from each chapter
4. Chapter-1 and Chapter-3: two questions to be set with choice.

DESIGN FOR MANUFACTURE

Course Code	**:**	**16MMD152**		**CIE Marks**	**:**	**50**
Hrs/Week	**:**	**L: T: P: 4:0:0**		**SEE Marks**	**:**	**50**
Credits	**:**	**04**		**SEE Duration**	**:**	**3 hours**

Course Objective:

To educate students a clear understanding of factors to be considered in designing parts and components with focus on manufacturability

Course Content: Chapters/ Units

1. **Effect of Materials and Manufacturing Process on Design:** Major phases of design. Effect of material properties on design Effect of manufacturing processes on design. Material selection process- cost per unit property, weighted properties and limits on properties methods.
   Tolerance Analysis: Process capability, mean, variance, skewness, kurtosis, Process capability metrics, Cp, Cpk, Cost aspects, Feature tolerances, Geometries tolerances, Geometric tolerances, Surface finish, Review of relationship between attainable tolerance grades and different machining process. Cumulative effect of tolerance- Sure fit law and truncated normal law.
   13 Hours

2. **Selective Assembly:** Interchangeable part manufacture and selective assembly, Deciding the number of groups -Model-1 : Group tolerance of mating parts equal, Model total and group tolerances of shaft equal. Control of axial play-Introducing secondary machining operations, laminated shims, examples.
   Datum Features: Functional datum, Datum for manufacturing, changing the datum. Examples.
   12 Hours

3. **Design Considerations**: Design of components with casting consideration. Pattern, Mould, and Parting line. Cored holes and machined holes. Identifying the possible and probable parting line. Casting requiring special sand cores. Designing to obviates and cores.
   Component Design: Component design with machining considerations link design for turning components-milling, Drilling and other related processes including finish- machining operations.
   13 Hours
4. True positional theory: Comparison between co-ordinate and convention method of feature location. Tolerance and true position tolerancing virtual size concept, Floating and fixed fasteners. Projected tolerance zone. Assembly with gasket, zero position tolerance. Functional gauges, Paper layout gauging. **7 Hours**

5. Design of Gauges: Design of gauges for checking components in assemble with emphasis on various types of limit gauges for both hole and shaft. **7 Hours**

NOTE: the students are advised to prepare the report in the form of assignment to understand the subject and its relevance in the industry

Text Books:

1. Harry Peck, “Designing for Manufacturing”, Pitman Publications, 1983.
2. Dieter, “Machine Design” - McGraw-Hill Higher Education, -2008
3. R.K. Jain, “Engineering Metrology", Khanna Publishers, 1986

Reference Books:

1. Product design for manufacture and assembly - Geoffrey Boothroyd, Peter dewhurst, Winston Knight, Merceldekker. Inc. CRC Press, Third Edition
2. Material selection and Design, Vol. 20 - ASM Hand book.

Course Outcomes:

Upon completion of this course, the student will be able to

CO1	Understand the role of manufacture and assembly in development of mechanical parts and their assemblies.
CO2	Apply manufacturing considerations in the design and development of components made of casting and machining.
CO3	Apply geometrical dimensioning and tolerances issues in mechanical design.

SCHEME OF EXAMINATION (QUESTION PAPER PATTERN)

5. Seven FULL questions to be set.
6. Five FULL questions to be answered.
7. Chapter-2, Chapter-4, Chapter-5, are compulsory, with one question from each chapter
8. Chapter-1 and Chapter-3: two questions to be set with choice.

AUTOMOBILE SYSTEM DESIGN

Course Code	**:**	**16MMD153**		**CIE Marks**	**:**	**50**
Hrs/Week	**:**	**L: T: P: 4:0:0**		**SEE Marks**	**:**	**50**
Credits	**:**	**04**		**SEE Duration**	**:**	**3 hours**

Course Objective:
This course would facilitate understanding of the stages involved in automobile system design. The student will be exposed to industrial practices in design of various systems of an automobile.

Course Content: Chapters/ Units

1. Body Shapes: Aerodynamic Shapes, drag forces for small family cars.
Fuel Injection: Spray formation, direct injection for single cylinder engines (both SI & CI), energy audit. **10 Hours**

2. Design of I.C. Engine I: Combustion fundamentals, combustion chamber design, cylinder head design for both SI & C. I. Engines. **8 Hours**

3. Design of I.C. Engine II: Design of crankshaft, camshaft, connecting rod, piston & piston rings for small family cars (max up to 3cylinders). **12 Hours**

4. Transmission System: Design of transmission systems – gearbox (max of 4-speeds), differential.
Suspension System: Vibration fundamentals, vibration analysis (single & two degree of freedom, vibration due to engine unbalance, application to vehicle suspension. **12 Hours**

5. Cooling System: Heat exchangers, application to design of cooling system (water cooled).
Emission Control: Common emission control systems, measurement of missions, exhaust gas emission testing. **10 Hours**

NOTE: the students are advised to prepare the report in the form of assignment to understand the subject and its relevance in the industry

Text Books:

1. **Design of Automotive Engines**, **-** A. Kolchin& V. Demidov, MIR Publishers, Moscow
2. **The motor vehicle, Newton steeds & Garratte -** Ili fee& sons Ltd., London
3. **I.C. Engines -** Edward F Obert, International text book company.

Reference Books:

1. **Introduction to combustion** - Turns
2. **Automobile Mechanic -**, N.K. Giri, Khanna Publications, 1994
3. **I.C. Engines** - Maleev, McGraw Hill book company, 1976
4. **Diesel engine design** – Heldt P.M. Chilton company New York.
5. **Problems on design of machine elements -** V.M. Faires & Wingreen, McMillan Company., 1965
6. **Design of I.C. Engines -** John Heywood, TMH

Course Outcome:

Upon completion of this course, the student will be able to

CO1	The student will be able to apply the knowledge in creating a preliminary design of automobile sub systems.
CO2	Students are exposed to aerodynamic analysis of the auto mobiles.
CO3	Students are exposed to engine performances, combustion analysis and exhaust gas analysis to meet the BIS standards (10000 series).

SCHEME OF EXAMINATION (QUESTION PAPER PATTERN)

1. Seven FULL questions to be set.
2. Five FULL questions to be answered.
3. Chapter-1, Chapter-2, Chapter-5, are compulsory, with one question from each chapter
4. Chapter-3 and Chapter-4: two questions to be set with choice.

Design Engineering Laboratory – Lab 1

Course Code	**:**	**16MMDL16**		**CIE Marks**	**:**	**50**
Hrs/Week	**:**	**L: T: P: 0:0:3**		**SEE Marks**	**:**	**50**
Credits	**:**	**02**		**SEE Duration**	**:**	**3 hours**

Note:

1) These are independent laboratory exercises
2) A student may be given one or two problems stated herein
3) Student must submit a comprehensive report on the problem solved and give a Presentation on the same for Internal Evaluation
4) Any one of the exercises done from the following list has to be asked in the Examination for evaluation.

Course Content:

Experiment #1
Vibration analysis using portable vibration meter with FFT analyzer.

Experiment #2
Modal analysis

Experiment #3
Vibration analysis using accelerometers

a) Uni-axial
b) Tri-axial
c) High temperature Tri-axial

Experiment #4
Vibration Shaker

Experimental #5
Vibration analysis on Beams

Experiment #6
Torsional vibration

Experiment #7
Vibration Characteristics of a Spring Mass Damper System.
Part A: Analytical Solutions.
Part C: Correlation Studies.

Experiment #8
Stress analysis in curved beam in 2D
Part A: Experimental studies using Strain Gauge Instrumentation.
Part B: 2D Photo elastic Investigation.

TECHNICAL SEMINAR

Course Code	**:**	**16MMDS17**		**CIE Marks**	**:**	**50**
Hrs/Week	**:**	**L: T: P: S 0:0:0:3**		**SEE Marks**	**:**	**50**
Credits	**:**	**02**		**SEE Duration**	**:**	**3 hours**

- **Seminar**: At the end of second CIE each student is required to present the seminar of his/her interested field (Related to design subjects).
- Report submissions and final Evaluation is to be carried out by the Internal Guide of the college and a senior faculty along with HOD.

MINI PROJECT/ INDUSTRIAL VISIT/ FIELD WORK

Course Code	**:**	**16MMDM18**		**CIE Marks**	**:**	**50**
Hrs/Week	**:**	**L: T: P: S 0:0:0:3**		**SEE Marks**	**:**	**50**
Credits	**:**	**02**		**SEE Duration**	**:**	**3 hours**

- **Industrial Visit**: At the end of second CIE the industrial visit will be arranged in the domain field, each student is required to submit the report of the visit.
- Report submissions and final Evaluation is to be carried out by the Internal Guide of the college and a senior faculty along with HOD.

II Semester

COMPOSITE MATERIALS TECHNOLOGY

Course Code	**:**	**16MMD21**		**CIE Marks**	**:**	**50**
Hrs/Week	**:**	**L: T: P: 4:0:0**		**SEE Marks**	**:**	**50**
Credits	**:**	**04**		**SEE Duration**	**:**	**3 hours**

Course Objective:
Mechanics of composite materials provides a methodology for stress analysis and progressive failure analysis of laminated composite structures for aerospace, automobile, marine and other engineering applications.

Course Content: Chapters/ Units

1. **Introduction to Composite Materials:** Definition, Classification, Types of matrices material and reinforcements, Characteristics &selection, Fiber composites, laminated composites, Particulate composites, Prepegs, and sandwich construction.
   Metal Matrix Composites: Reinforcement materials, Types, Characteristics and selection, Base metals, Selection, Applications
   Macro Mechanics of a Lamina: Hooke's law for different types of materials, Number of elastic constants, Derivation of nine independent constants for orthotropic material, Two - dimensional relationship of compliance and stiffness matrix. Hooke's law for two-dimensional angle lamina, engineering constants - Numerical problems. Invariant properties. Stress-Strain relations for lamina of arbitrary orientation, Numerical problems. **10 Hours**

2. **Micro Mechanical Analysis of a Lamina:** Introduction, Evaluation of the four elastic moduli, Rule of mixture, Numerical problems. Experimental Characterization of Lamina- Elastic Moduli and Strengths
   Failure Criteria: Failure criteria for an elementary composite layer or Ply, Maximum Stress and Strain Criteria, Approximate strength criteria, Inter-laminar Strength, Tsa-Hill theory, Tsai, Wu tensor theory, Numerical problem, practical recommendations. **12 Hours**

3. **Macro Mechanical Analysis of Laminate**: Introduction, code, Kirchoff hypothesis, Classical Lamination Theory, A, B, and D matrices (Detailed derivation), Special cases of laminates, Numerical problems. Shear Deformation Theory, A, B, D and E matrices (Detailed derivation)
   10 Hours

4. **Analysis of Composite Structures:** Optimization of Laminates, composite laminates of uniform strength, application of optimal composite structures, composite pressure vessels, spinning composite disks, composite lattice structures. **8 Hours**

5. **Manufacturing and Testing:** Layup and curing - open and closed Mould processing, Hand lay-up techniques, Bag moulding and filament winding. Pultrusion, Pulforming, Thermoforming, Injection moulding, Cutting, Machining, joining and repair. NDT tests – Purpose, Types of defects, NDT method - Ultrasonic inspection, Radiography, Acoustic emission and Acoustic ultrasonic method.
   Applications: Aircrafts, missiles, Space hardware, automobile, Electrical and Electronics, Marine, Recreational and sports equipment-future potential of composites. **12 Hours**

NOTE: the students are advised to prepare the report in the form of assignment to understand the subject and its relevance in the industry

Text Books:

1. Autar K. Kaw, Mechanics of Composite materials, CRC Press, 2nd Ed, 2005.
2. Madhijit Mukhopadhay, Mechanics of Composite Materials & Structures, Universities Press, 2004.

Reference Books:

1. J. N. Reddy, Mechanics of Laminated Composite Plates & Shells, CRD Press, 2nd Ed, 2004.
2. Mein Schwartz, Composite Materials handbook, McGraw Hill, 1984.
3. Rober M. Jones, Mechanics of Composite Materials, Taylor & Francis, 1998.
4. Michael W, Hyer, Stress analysis of fiber Reinforced Composite Materials, Mc-Graw Hill International, 2009.
5. Composite Material Science and Engineering, Krishan K. Chawla, Springer, 3e, 2012.
6. Fiber Reinforced Composites, P.C. Mallik, Marcel Decker, 1993.

Course Outcomes:

Upon completion of this course, the student will be able to

CO1	Identify the role of matrices and reinforcements used in practical composite structures.
CO2	Analyze problems on micro and macro mechanical behavior of lamina.
CO3	Assess the strength of laminated composite and predict its failure for given static loading conditions.
CO4	Develop understanding of different methods of manufacturing and testing of composites.

SCHEME OF EXAMINATION (QUESTION PAPER PATTERN)

1. Seven FULL questions to be set.
2. Five FULL questions to be answered.
3. Chapter-1, Chapter-3, Chapter-4, are compulsory, with one question from each chapter
4. Chapter-2 and Chapter-5: two questions to be set with choice.

ADVANCED MACHINE DESIGN

Course Code	**:**	**16MMD22**		**CIE Marks**	**:**	**50**
Hrs/Week	**:**	**L: T: P: 4:0:0**		**SEE Marks**	**:**	**50**
Credits	**:**	**04**		**SEE Duration**	**:**	**3 hours**

Course Objective:
This course enables the student to identify failure modes and evolve design by analysis methodology. Design against fatigue failure is given explicit attention.

Course Content: Chapters/ Units

1. **Introduction:** Role of failure prevention analysis in mechanical design, Modes of mechanical failure, Review of failure theories for ductile and brittle materials including Mohr's theory and modified Mohr's theory, Numerical examples.
   Fatigue of Materials: Introductory concepts, High cycle and low cycle fatigue, Fatigue design models, Fatigue design methods, Fatigue design criteria, Fatigue testing, Test methods and standard test specimens, Fatigue fracture surfaces and macroscopic features, Fatigue mechanisms and microscopic features. **12 Hours**

2. **Stress-Life (S-N) Approach:** S-N curves, Statistical nature of fatigue test data, General S-N behavior, Mean stress effects, Different factors influencing S-N behavior, S-N curve representation and approximations, Constant life diagrams, Fatigue life estimation using S-N approach.
   Strain-Life(ε-N) approach: Monotonic stress-strain behavior, Strain controlled test methods, Cyclic stress-strain behavior, Strain based approach to life estimation, Determination of strain life fatigue properties, Mean stress effects, Effect of surface finish, Life estimation by ε-N approach.
   13 Hours

3. **LEFM Approach:** LEFM concepts, Crack tip plastic zone, Fracture toughness, Fatigue crack growth, Mean stress effects, Crack growth life estimation. Notches and their effects: Concentrations and gradients in stress and strain, S-N approach for notched membranes, mean stress effects and Haigh diagrams, Notch strain analysis and the strain – life approach, Neuber's rule, Glinka's rule, applications of fracture mechanics to crack growth at notches. **13 Hours**

4. **Fatigue from Variable Amplitude Loading:** Spectrum loads and cumulative damage, Damage quantification and the concepts of damage fraction and accumulation, Cumulative damage theories, Load interaction and sequence effects, Cycle counting methods, Life estimation using stress life approach. **7 Hours**

5. **Surface Failure:** Introduction, Surface geometry, Mating surface, Friction, Adhesive wear, Abrasive wear, Corrosion wear, Surface fatigue spherical contact, cylindrical contact, General contact, Dynamic contact stresses, Surface fatigue strength. **7 Hours**

NOTE: Students are advised to prepare the report in the form of assignment to understand the subject and its relevance in the industry

Text Books:

1. Ralph I. Stephens, Ali Fatemi, Robert, Henry o. Fuchs, “Metal Fatigue in engineering”, John Wiley New York, Second edition. 2001.
2. Failure of Materials in Mechanical Design, Jack. A. Collins, John Wiley, New York 1992.
3. Robert L. Norton, “Machine Design”, Pearson Education India, 2000

Reference Books:

1. Suresh, “Fatigue of Materials”, Cambridge University Press, -1998
2. Julie. A. Benantine, “Fundamentals of Metal Fatigue Analysis”, Prentice Hall,1990
3. Fatigue and Fracture, ASM Hand Book, Vol 19,2002.

Course Outcomes:

Upon completion of this course, the student will be able to

CO1	Predict failure of engineering components using appropriate failure theories.
CO2	Identify and explain the types of fractures of engineered materials and their characteristic features;
CO3	Estimate life of components using stress life, strain life and LEFM approach.
CO4	Categorize different types of surface failures.

SCHEME OF EXAMINATION (QUESTION PAPER PATTERN)

1. Seven FULL questions to be set.
2. Five FULL questions to be answered.
3. Chapter-1, Chapter-4, Chapter-5, are compulsory, with one question from each chapter
4. Chapter-2 and Chapter-3: two questions to be set with choice.

EXPERIMENTAL MECHANICS

Course Code	**:**	**16MMD23**		**CIE Marks**	**:**	**50**
Hrs/Week	**:**	**L: T: P: 4:0:0**		**SEE Marks**	**:**	**50**
Credits	**:**	**04**		**SEE Duration**	**:**	**3 hours**

Course Objective:

This course aims at a comprehensive study of mechanics of solids. The objective of this course is to familiarize the student with state-of-the-art experimental techniques namely strain gauges, photo elasticity, moiré interferometry, brittle coating, moiré fringes and holography.

Course Content: Chapters/ Units

1. **Introduction**: Definition of terms, calibration, standards, dimension and units, generalized measurement system, Basic concepts in dynamic measurements, system response, distortion, impedance matching, experiment planning.

   Analysis of Experimental Data: Cause and types of experimental errors, error analysis. Statistical analysis of experimental data- Probability distribution, gaussian, normal distribution. Chi-square test, Method of least square, correlation coefficient, multivariable regression, standard deviation of mean, graphical analysis and curve fitting, general consideration in data analysis. **12 Hours**

2. **Data Acquisition and Processing:** General data acquisition system, signal conditioning revisited, data transmission, Analog-to-Digital and Digital-to- Analog conversion, Basic components (storage and display) of data acquisition system. Computer program as a substitute for wired logic.

   Force, Torque and Strain Measurement: Mass balance measurement, Elastic Element for force measurement, torque measurement. Strain Gages -Strain sensitivity of gage metals, Gage construction, Gage sensitivity and gage factor, Performance characteristics, Environmental effects Strain, gage circuits, Potentiometer, Wheat Stone's bridges, Constant current circuits. Strain Analysis Methods-Two element and three element, rectangular and delta rosettes, Correction for transverse strains effects, stress gage - plane shear gage, Stress intensity factor gage. **12 Hours**

3. **Stress Analysis:** Two-Dimensional Photo elasticity **-** Nature of light, - wave theory of light, - optical interference - Polariscopes stress optic law - effect of stressed model in plane and circular Polariscopes, Isoclinic chromatics fringe order determination - Fringe multiplication techniques - Calibration Photo elastic model materials. Separation methods shear difference method, Analytical separation methods, Model to prototype scaling**.** **10 Hours**

4. **Three-Dimensional Photo elasticity:** Stress freezing method, General slice, Effective stresses, Stresses separation, Shear deference method, Oblique incidence method Secondary principals' stresses, Scattered light photo elasticity, Principals, Polari scope and stress data analyses**.** **8 Hours**

5. **Coating Methods:** a) Photo elastic Coating Method-Birefringence coating techniques Sensitivity Reinforcing and thickness effects – data reduction - Stress separation techniques Photo elastic strain gauges. b) Brittle Coatings Method: Brittle coating technique Principles data analysis - coating materials, Coating techniques. c) Moire Technique - Geometrical approach, Displacement approach- sensitivity of Moire data reduction, In plane and out plane Moire methods, Moire photography, Moire grid production.

Holography: Introduction, Equation for plane waves and spherical waves, Intensity, Coherence, Spherical radiator as an object (record process), Hurter, Driffield curves, Reconstruction process, Holographic interferometry, Realtime. and double exposure methods, Displacement measurement, Isopachics. **10 Hours**

NOTE: the students are advised to prepare the report in the form of assignment to understand the subject and its relevance in the industry

Text Books:

1. **Holman,** "Experimental Methods for Engineers" 7th Edition, Tata McGraw-Hill Companies, Inc, New York, 2007.
2. **R. S. Sirohi, H. C. Radha Krishna,** "Mechanical measurements" New Age International Pvt. Ltd., New Delhi, 2004
3. **Experimental Stress Analysis** - Srinath, Lingaiah, Raghavan, Gargesa, Ramachandra and Pant, Tata McGraw Hill, 1984.
4. **Instrumentation, Measurement and Analysis -**Nakra &Chaudhry, B C Nakra K Chaudhry, Tata McGraw-Hill Companies, Inc, New York, Seventh Edition, 2006.

Reference Books:

1. **Measurement Systems Application and Design -** Doeblin E. A., 4th (S.I.) Edition, McGraw Hill, New York. 1989
2. **Design and Analysis of Experiments -** Montgomery D.C., John Wiley & Sons, 1997.
3. **Experimental Stress Analysis** - Dally and Riley, McGraw Hill, 1991.
4. **Experimental Stress Analysis -** Sadhu Singh, Khanna publisher, 1990.
5. **Photoelasticity Vol I and Vol II -** M.M. Frocht, John Wiley and sons, 1969.
6. **Strain Gauge Primer -** Perry and Lissner, McGraw Hill, 1962.

Course Outcomes:

Upon completion of this course, the student will be able to

CO1	Understand functional requirements of a generalized measurement system and identify suitable components for an application.
CO2	Use concepts of Data Acquisition, Processing and apply the same for interpretation and analysis of experimental data.
CO3	Determine stresses and strains in a structure using different methods such as strain gages, photo-elasticity, brittle coating and holography.
CO4	Identify and apply suitable experimental stress analysis to practical problems

<u>SCHEME OF EXAMINATION (QUESTION PAPER PATTERN)</u>

1. Seven FULL questions to be set.
2. Five FULL questions to be answered.
3. Chapter-3, Chapter-4, Chapter-5, are compulsory, with one question from each chapter
4. Chapter-1 and Chapter-2: two questions to be set with choice.

TRIBOLOGY AND BEARING DESIGN

Course Code	**:**	**16MMD24**		**CIE Marks**	**:**	**50**
Hrs/Week	**:**	**L: T: P: 4:0:0**		**SEE Marks**	**:**	**50**
Credits	**:**	**04**		**SEE Duration**	**:**	**3 hours**

Course Objective:

Gives in-depth knowledge regarding hydrodynamic, hydrostatic lubrication and various bearings, with their design and applications

Course Content: Chapters/ Units

1. **Introduction to Tribology:** Introduction, Friction, Wear, Wear Characterization, Regimes of lubrication, Classification of contacts, lubrication theories, Effect of pressure and temperature on viscosity. Newton's Law of viscous forces, Flow through stationary parallel plates. Hagen's Poiseuille’s theory, viscometers. Numerical problems, Concept of lightly loaded bearings, Petroff's equation, Numerical problems. **8 Hours**

2. **Hydrodynamic Lubrications:** Pressure development mechanism. Converging and diverging films and pressure induced flow. Reynolds's 2D equation with assumptions. Introduction to idealized slide bearing with fixed shoe and Pivoted shoes. Expression for load carrying capacity. Location of center of pressure, effect of end leakage on performance, Numerical problems

   Journal Bearings: Introduction to idealized full journal bearings. Load carrying capacity of idealized full journal bearings, Sommer Feld number and its significance, short and partial bearings, Comparison between lightly loaded and heavily loaded bearings, effects of end leakage on performance, Numerical problems. **12 Hours**

3. **Hydrostatic Bearings:** Hydrostatic thrust bearings, hydrostatic circular pad, annular pad, rectangular pad bearings, types of flow restrictors, expression for discharge, load carrying capacity and condition for minimum power loss, numerical problems, and hydrostatic journal bearings.

   EHL Contacts: Introduction to Elasto- hydrodynamic lubricated bearings. Introduction to 'EHL' constant, Grubin type solution. **12 Hours**

4. **Antifriction bearings:** Advantages, selection, nominal life, static and dynamic load bearing capacity, probability of survival, equivalent load, cubic mean load, bearing mountings.

   Porous Bearings: Introduction to porous and gas lubricated bearings. Governing differential equation for gas lubricated bearings, Equations for porous bearings and working principal, Fretting phenomenon and its stages. **10 Hours**

5. **Magnetic Bearings:** Introduction to magnetic bearings, Active magnetic bearings. Different equations used in magnetic bearings and working principal. Advantages and disadvantages of magnetic bearings, Electrical analogy, Magneto-hydrodynamic bearings.

   Advanced bearing systems and their advantages over conventional bearing systems, testing of different types of bearings **10 hours**

NOTE: Students are advised to prepare the report in the form of assignment to understand the subject and its relevance in the industry

Text Books

1. Mujamdar.B.C "Introduction to Tribology of Bearing", Wheeler Publishing, New Delhi 2001
2. Radzimovsky, "Lubrication of Bearings - Theoretical principles and design" Oxford press Company, 2000

Reference Books

1. Dudley D. Fulier " Theory and practice of Lubrication for Engineers", New YorkCompany.1998
2. Moore "Principles and applications of Tribology" Pergamon press, 1975
3. Oscar Pinkus, Beno Sternlicht, "Theory of hydro dynamic lubrication", McGraw-Hill, 1961
4. G W Stachowiak, A W Batchelor, "Engineering Tribology", Elsevier publication 1993.
5. Hydrostatic and hybrid bearings, Butterworth 1983.
6. F. M. Stansfield, Hydrostatic bearings for machine tools and similar applications, Machinery Publishing, 1970

Course Outcome:

Upon completion of this course, the student will be able to

CO1	Students develop skills to design and selection of bearings on Various tribological factors to be considered in moving and rotating parts.
CO2	The students are exposed to orient towards the various types of bearings and their applications.
CO3	Students are exposed to synthesis and analysis of the bearings including fault diagnosis.

SCHEME OF EXAMINATION (QUESTION PAPER PATTERN)

1. Seven FULL questions to be set.
2. Five FULL questions to be answered.
3. Chapter-1, Chapter-4, Chapter-5, are compulsory, with one question from each chapter
4. Chapter-2 and Chapter-3: two questions to be set with choice.

Elective-II

THEORY OF PLASTICITY

Course Code	**:**	**16MMD251**		**CIE Marks**	**:**	**50**
Hrs/Week	**:**	**L: T: P: 4:0:0**		**SEE Marks**	**:**	**50**
Credits	**:**	**04**		**SEE Duration**	**:**	**3 hours**

Course Objective:
This course focuses on stress-strain relations, yield criteria and associated flow rules for elastic-plastic analysis of components and structures

Course Content: Chapters/ Units

1. Definition and scope of the subject, Brief review of elasticity, Octahedral normal and shear stresses, Spherical and deviatoric stress, Invariance in terms of the deviatoric stresses, Idealized stress-strain diagrams for different material models, Engineering and natural strains, Mathematical relationships between true stress and true strains, Cubical dilation, finite strains co- efficient Octahedral strain, Strain rate and the strain rate tensor. **11 Hours**

2. Material Models, Stress-strain relations, Yield criteria for ductile metal, Von Mises, Tresca, Yield surface for an Isotropic Plastic materials, Stress space, Experimental verification of Yield criteria, Yield criteria for an anisotropic material, flow rule normality, Yield locus, Symmetry convexity, Deformation of isotropic and kinematic hardening, bilinear stress-strain relationship, power law hardening, deformation theory of plasticity, J2 flow theory, J2incremental theory. **11 Hours**

3. Plastic stress-strain relations, Prandtl-Rouss Saint Venant, Levy-Von Mises, Experimental verification of the Prandtl- Rouss equation Upper and lower bound theorems and corollaries, Application to problems Uni-axial tension and compression, Stages of plastic yielding. **10 Hours**

4. Bending of beams, Torsion of rods and tubes, Nonlinear bending and torsion equations, Simple forms of indentation problems using upper bounds, Application of Metal forming: Extrusion, Drawing, Rolling and Forging. **10 Hours**

5. Slip line theory, Introduction, Basic equations for incompressible two-dimensional flows, continuity equations, Stresses in conditions of plain Strain convention for slip-lines, Geometry of slip lines, Properties of slip lines, Computational Plasticity- Finite element method, Formulations, Plasticity models. **10 Hours**

NOTE: the students are advised to prepare the report in the form of assignment to understand the subject and its relevance in the industry

Text Books

1. Engineering Plasticity - Theory and Application to Metal Forming Process -R.A.C..Slater, McMillan Press Ltd., 1977
2. Theory of Plasticity and Metal forming Process - Sadhu Singh, Khanna Publishers, Delhi, 1999.

Reference Books

1. Introduction to the Theory of Plasticity for Engineers- Haffman and Sachs, LLC, 2012.
2. Theory of plasticity - J Chakrabarty, Butterworth, 2006.
3. Plasticity for Mechanical Engineers - Johnson and Mellor, Van Nostrand, 1966.

Course Outcomes:

Upon completion of this course, the student will be able to

CO1	Analyze and determine the elastic and elastoplastic stress- strain behavior of solid deformable bodies subjected to various types of loads.
CO2	Analyze and asses the yielding behavior in metallic material using suitable yield criteria.
CO3	Develop plastic stress-strain relation for large plastic deformation and apply same along with knowledge of yield criteria to various metal forming process.
CO4	Develop fundamental equations of slip line field theory.

SCHEME OF EXAMINATION (QUESTION PAPER PATTERN)

1. Seven FULL questions to be set.
2. Five FULL questions to be answered.
3. Chapter-3, Chapter-4, Chapter-5, are compulsory, with one question from each chapter
4. Chapter-1 and Chapter-2: two questions to be set with choice.

ROTOR DYNAMICS

Course Code	**:**	**16MMD252**		**CIE Marks**	**:**	**50**
Hrs/Week	**:**	**L: T: P: 4:0:0**		**SEE Marks**	**:**	**50**
Credits	**:**	**04**		**SEE Duration**	**:**	**3 hours**

Course Objective:
This course is of interest to turbo machinery designers. Specifically modeling of bearings, shafts and rotor stages (compressors, turbines including blades) to predict instability like whirling including gyroscopic and corialis effect.

Course Content: Chapters/ Units

1. **Fluid Film Lubrication:** Basic theory of fluid film lubrication, Derivation of generalized Reynolds equations, Boundary conditions, Fluid film stiffness and Damping coefficients, Stability and dynamic response for hydrodynamic journal bearing, Two lobe journal bearings.
   Stability of Flexible Shafts: Introduction, equation of motion of a flexible shaft with rigid support, Radial elastic friction forces, Rotary friction, friction Independent of velocity, friction dependent on frequency, Different shaft stiffness Constant, gyroscopic effects, Nonlinear problems of large deformation applied forces, instability of rotors in magnetic field. **14 Hours**

2. **Critical Speed:** Dunkerley's method, Rayleigh's method, Stodola's method. Rotor Bearing System: Instability of rotors due to the effect of hydrodynamic oil layer in the bearings, support flexibility, Simple model with one concentrated mass at the center **6 Hours**

3. **Turbo rotor System Stability by Transfer Matrix Formulation:** General turbo rotor system, development of element transfer matrices, the matrix differential equation, effect of shear and rotary inertia, the elastic rotors supported in bearings, numerical solutions. **10 Hours**

4. **Turbo rotor System Stability by Finite Element Formulation:** General turbo rotor system, generalized forces and co-ordinates system assembly element matrices, Consistent mass matrix formulation, Lumped mass model, linearized model for journal bearings, System dynamic equations Fix stability analysis non dimensional stability analysis, unbalance response and Transient analysis. **14 Hours**

5. **Blade Vibration:** Centrifugal effect, Transfer matrix and Finite element, approaches. **8 Hours**

NOTE: the students are advised to prepare the report in the form of assignment to understand the subject and its relevance in the industry.

Reference Books:

1. Cameron, "Principles of Lubrication", Longman Publishing Group, 1986
2. Bolotin, "Nonconservative problems of the Theory of elastic stability", Macmillan, 1963
3. Peztel, Lockie, "Matrix Methods in Elasto Mechanic s", McGraw-Hill, 1963.
4. Timoshenko, "Vibration Problems in Engineering", Ox ford City Press, 2011
5. Zienkiewicz, "The finite element method in engineering science", McGraw-Hill, 1971

Course Outcomes:

Upon completion of this course, the student will be able to

CO1	Model a rotating machine element theoretically for rotor dynamic analysis.
CO2	Analyze Free and Forced lateral response of simple rotor models and of more complex systems including shafts, bearings, seals and stators.
CO3	Formulate Finite element and carry out analysis for Turborotor System Stability.
CO4	Apply Finite element approach to blade vibration.

<u>SCHEME OF EXAMINATION (QUESTION PAPER PATTERN)</u>

1. Seven FULL questions to be set.
2. Five FULL questions to be answered.
3. Chapter-2, Chapter-3, Chapter-5, are compulsory, with one question from each chapter
4. Chapter-1 and Chapter-4: two questions to be set with choice.

FINITE ELEMENT METHODS FOR HEAT TRANSFER AND FLUID FLOW ANALYSIS

Course Code	**:**	**16MMD253**		**CIE Marks**	**:**	**50**
Hrs/Week	**:**	**L: T: P: 4:0:0**		**SEE Marks**	**:**	**50**
Credits	**:**	**04**		**SEE Duration**	**:**	**3 hours**

Course Objective:
The student will learn finite element formulation of various modes of heat transfer and fluid flow and to solve numerical examples.

Course Content: Chapters/ Units

1. **Introduction to Heat Transfer and Fluid Mechanics:** Mathematical Preliminaries, Governing equations of a continuum, Governing equation in terms of primitive variables, porous equations, low speed compressible flow equations, auxiliary transport equations, chemically reacting systems, boundary conditions, change of phase, enclosure radiation.
   2. **Finite Element Methods:** Introduction, model differential equation, finite element approximations, interpolation functions, library of finite elements, modeling considerations, assembly of elements, numerical integration, discussion of results with some practical examples, time dependent problems.
   12 Hours

2. **Steady State Conduction Heat Transfer:** Introduction, one dimensional linear, quadratic element. Homogeneous, composite wall with uniform and varying cross-sectional area. Radial heat flow in a cylinder. Conduction –convection systems. Numerical examples.
   Conduction Heat Transfer: Interpolation functions for tetrahedral, hexahedral, pyramid and prism elements. Numerical integration, computation of surface flux, semi-discrete finite element model, solution of nonlinear equations for transient problems. Radiation algorithms. Variable properties.
   12 Hours

3. **Advanced topic in Conduction:** specialty elements, computation of boundary conditions, bulk nodes, reactive materials, material motions Example problems on conduction, radiation, temperature dependent conductivity, anisotropic conduction, brazing and welding, investment casting. **8 Hours**

4. **Flows of Viscous Incompressible Fluids:** Governing equation, mixed finite element model, penalty finite element models. Finite element models of porous flow
   Computational consideration: Interpolation functions for triangular, quadrilateral, tetrahedral and hexahedral elements. Evaluation of element matrices in penalty model, pressure calculation and traction boundary conditions. Numerical examples. **10 Hours**

5. **Coupled Fluid Flow and Heat Transfer:** Introduction to non-isothermal incompressible flows, governing equations and boundary condition. Mixed, penalty finite element model. Finite element model for porous flow. Non-isothermal low speed compressible flows: governing equation, boundary conditions, mixed finite element model and solution methods. Convection with change of phase, convection with enclosure radiation, turbulent heat transfer, chemically reacting systems. Numerical examples. **10 Hours**

NOTE: the students are advised to prepare the report in the form of assignment to understand the subject and its relevance in the industry

Text Books:

1. J N Reddy, David K. Gartling, "The finite element method in heat transfer and flu id dynamics", CRC, 2004.
2. Roland Wynne Lewis, Perumal Nithiarasu, K. N. Seetharamu," Fundamentals of the finite element method for heat and fluid flow"
   John Wiley, 2004

Reference Books:

1. Ching Jen Chen, R. A. Bernatz, "Finite analytic method in flows and heat transfer", Taylor & Francis.
2. Gianni Comini, Stefano Del Giudice, Carlo Nonino, "Finite Element Analysis in Heat Transfer: Basic Formulation and Linear problems" Taylorand Francis, 1994.

Course Outcomes:

Upon completion of this course, the student will be able to

CO1	This course enables the student to use numerical methods for solving problems of fluid flow and heat transfer.
CO2	Analyze of the continuum mechanics problems like fluid flow, heat transfer.
CO3	Analyze of incompressible and compressible fluids.
CO4	Analyze modes of conduction in various mechanical systems

SCHEME OF EXAMINATION (QUESTION PAPER PATTERN)

1. Seven FULL questions to be set.
2. Five FULL questions to be answered.
3. Chapter-3, Chapter-4, Chapter-5, are compulsory, with one question from each chapter
4. Chapter-1 and Chapter-2: two questions to be set with choice.

Design Engineering Laboratory - Lab 2

Course Code	**:**	**16MMDL26**		**CIE Marks**	**:**	**50**
Hrs/Week	**:**	**L: T: P: 0:0:3**		**SEE Marks**	**:**	**50**
Credits	**:**	**02**		**SEE Duration**	**:**	**3 hours**

Note:

1) These are independent laboratory exercises
2) A student may be given one or two problems stated herein
3) Student must submit a comprehensive report on the problem solved and give a Presentation on the same for Internal Evaluation
4) Any one of the exercises done from the following list has to be asked in the Examination for evaluation.

Course Content:

Experiment #1 Structural Analysis
Part A: FE Modeling of a stiffened Panel using a commercial preprocessor.
Part B: Buckling, Bending and Modal analysis of stiffened Panels.
Part C: Parametric Studies.

Experiment #2 Design Optimization
Part A: Shape Optimization of a rotating annular disk.
Part B: Weight Minimization of a Rail Car Suspension Spring.
Part C: Topology Optimization of a Bracket.

Experiment #3 Thermal analysis
Part A: Square Plate with Temperature Prescribed on one edge and Opposite edge insulated.
Part B: A Thick Square Plate with the Top Surface exposed to a Fluid at high temperature, Bottom Surface at room temperature, Lateral Surfaces Insulated.

Experiment #4 Thermal Stress Analysis
Part A: A Thick-Walled Cylinder with specified Temperature at inner and outer Surfaces.
Part B: A Thick-Walled Cylinder filled with a Fluid at high temperature and Outer Surface exposed to atmosphere.

Experiment#5 CFD Analysis
Part A: CFD Analysis of a Hydro Dynamic Bearing using commercial code.
Part B: Comparison of predicted Pressure and Velocity distributions with Target solutions.
Part C: Experimental Investigations using a Journal Bearing Test Rig.
Part D: Correlation Studies.

Experiment #6 Welded Joints.
Part A: Fabrication and Testing.
Part B: FE Modeling and Failure Analysis.
Part C: Correlation Studies.

Experiment #7 Bolted Joints.

Part A: Fabrication and Testing.

Part B: FE Modeling and Failure Analysis.

Part C: Correlation Studies.

Experiment #8 Adhesive Bonded Joints.

Part A: Fabrication and Testing.

Part B: FE Modeling and Failure Analysis.

Part C: Correlation Studies.

RESEARCH METHODOLOGY

Course Code	**:**	**RM 27**		**CIE Marks**	**:**	**50**
Hrs/Week	**:**	**L: T: P: 2:0:0**		**SEE Marks**	**:**	**50**
Credits	**:**	**02**		**SEE Duration**	**:**	**3 hours**

Course Learning Objectives: Students are expected to

- Have a basic understanding of the underlying principles of quantitative and qualitative research
- Identify the overall process of designing a research study from its inception to its report.
- Choose the most appropriate research method to address a particular research question
- Gain a overview of a range of quantitative and qualitative approaches to data analysis

1. **Overview of Research:** Research and its types, identifying and defining research problem and introduction to different research designs. Essential constituents of Literature Review. Basic principles of experimental design, Primary data and Secondary Data, methods of primary data collection, classification of secondary data, designing questionnaires and schedules. **8 Hours**

2. **Sampling Methods:** Probability sampling: simple random sampling, systematic sampling, stratified sampling, cluster sampling and multistage sampling. Non-probability sampling: convenience sampling, judgment sampling, quota sampling. Sampling distributions. **6 Hours**

3. **Processing and analysis of Data:** Statistical measures and their significance: Central tendencies, variation, skewness, Kurtosis, time series analysis, correlation and regression, Testing of Hypotheses: Parametric (t and Chi Square). **6 Hours**

4. **Essential of Report writing and Ethical issues**: Significance of Report Writing, Different Steps in Writing Report, Layout of the Research Report, Ethical issues related to Research, Plagiarism and self- Plagiarism, Publishing. **6 Hours**

Reference Books:

1. Krishnaswami, K.N., Sivakumar, A. I. and Mathirajan, M., Management Research Methodology, Pearson Education: New Delhi.
2. Kothari C.R., Research Methodology Methods and techniques by, New Age International Publishers, 2nd edition
3. Levin, R.I. and Rubin, D.S., Statistics for Management, 7th Edition, Pearson Education: New Delhi.

Course Outcome:

At the end of the course students will:

CO1	Describe a range of quantitative and qualitative research designs and identify the advantages and disadvantages associated with these designs
CO2	Choose appropriate quantitative or qualitative method to collect data
CO3	Analyze and test the given data using appropriate methods
CO4	Design an appropriate mixed-method research study to answer a research question

MINI PROJECT/ INDUSTRIAL VISIT/ FIELD WORK

Course Code	**:**	**16MMDM28**		**CIE Marks**	**:**	**50**
Hrs/Week	**:**	**L: T: P: S 0:0:0:3**		**SEE Marks**	**:**	**50**
Credits	**:**	**02**		**SEE Duration**	**:**	**3 hours**

- **Industrial Visit**: At the end of second CIE the industrial visit will be arranged in the domain field, each student is required to submit the report of the visit.
- Report submissions and final Evaluation is to be carried out by the Internal Guide of the college and a senior faculty along with HOD.

OR

- **Seminar**: At the end of second CIE each student is required to present the seminar of his/her interested field (Related to design subjects).
- Report submissions and final Evaluation is to be carried out by the Internal Guide of the college and a senior faculty along with HOD.

Semester III

INTERNSHIP

Internship: The student shall undergo internship for 16 weeks.

Preliminary Report submission and Evaluation after 8th week of Internship to be carried out by the Internal Guide of the college and a senior faculty for 100 marks

Final Report submission and Evaluation after 16th week of Internship to be carried out by the Internal Guide of the college and a senior faculty. Report Evaluation to be completed within two weeks of submission for 100 marks.

Viva-Voce on Internship - To be conducted by the Internship Guide (from the college) and the External Guide / Examiner within 2 weeks of Submission with a senior faculty / HOD as chairman for 100 marks

Project Phase: I

Problem formulation and submission of **synopsis** within 8 weeks from the commencement of 3rd semester, which shall be evaluated for 50 marks by the committee constituted for the purpose by the Head of the Department comprising the guide, senior faculty of the department with HOD as Chairman.

Literature survey and progress done after 16 weeks shall be evaluated by guide and external examiner with senior faculty / HOD as chairman for 100 marks.

IV Semester

Project Phase-II - Internal Evaluation of progress in Project work shall be evaluated after 8 weeks for 100 marks by the committee constituted for the purpose by the Head of the Department comprising the guide and senior faculty of the department with HOD as Chairman.

Project Phase-III - Internal Evaluation of Project Demonstration, which shall be evaluated after 15 weeks for 100 marks by the committee constituted for the purpose by the Head of the Department.

Final Evaluation of Project Work and Viva-voce.

Final evaluation of project to be carried out after 16 weeks from the date of commencement of 4^{th} semester.

The Internal Examiner (the project guide with a teaching experience of at least three years) and External Examiner with HOD as chairman will complete the final evaluation of Project.

Internal and External Examiners shall carry out the evaluation for 100 Marks each and the average of these marks shall be the final marks of the Project Evaluation.

Viva – Voce: The Viva-Voce shall be conducted jointly by Internal Examiner and External Examiner with HOD as chairman for 100 Marks.

FRACTURE MECHANICS

Course Code	**:**	**16MMD41**		**CIE Marks**	**:**	**50**
Hrs/Week	**:**	**L: T: P: 4:0:0**		**SEE Marks**	**:**	**50**
Credits	**:**	**04**		**SEE Duration**	**:**	**3 hours**

Course Objective:

Fracture mechanics provides a methodology for prediction, prevention and control of fracture in materials, components and structures. It provides a background for damage tolerant design. It quantifies toughness as materials resistance to crack propagation.

Course Content: Chapters/ Units

1. **Fracture mechanics principles:** Introduction and historical review, Sources of micro and macro cracks. Stress concentration due to elliptical hole, Strength ideal materials, Griffith's energy balance approach. Fracture mechanics approach to design. NDT and Various NDT methods used in fracture mechanics, Numerical problems. The Airy stress functions. Complex stress function. Solution to crack problems. Effect of finite size. Special cases, Elliptical cracks, Numerical problems. **13 Hours**

2. Plasticity effects, Irwin plastic zone correction. Dugdale approach. The shape of the plastic zone for plane stress and plane strain cases, Plastic constraint factor. The Thickness effect, numerical problems.
   Determination of Stress intensity factors and plane strain fracture toughness: Introduction, analysis and numerical methods, experimental methods, estimation of stress intensity factors. Plane strain fracture toughness test, The Standard test. Size requirements. Non-linearity. Applicability. **13Hours**

3. The energy release rate, Criteria for crack growth. The crack resistance (R curve). Compliance, J integral. Tearing modulus. Stability.
   Elastic plastic fracture mechanics: Fracture beyond general yield. The Crack-tip opening displacement. The Use of CTOD criteria. Experimental determination of CTOD. Parameters affecting the critical CTOD. Use of J integral. Limitation of J integral. **12 Hours**

4. **Dynamics and crack arrest:** Crack speed and kinetic energy. Dynamic stress intensity and elastic energy release rate. Crack branching. Principles of crack arrest. Crack arrest in practice. Dynamic fracture toughness**.** **6 Hours**

5. **Fatigue crack propagation and applications of fracture mechanics:** Crack growth and the stress intensity factor. Factors affecting crack propagation. variable amplitude service loading, means to provide fail-safety, required information for fracture mechanics approach, Mixed mode (combined) loading and design criteria. **8 Hours**

NOTE: the students are advised to prepare the report in the form of assignment to understand the subject and its relevance in the industry

Text Books:

1. David Broek, “Elementary Engineering Fracture Mechanics”, Springer Netherlands,2011
2. Anderson, “Fracture Mechanics-Fundamental and Application”, T.L CRC press1998.

Reference Books:

1. Karen Hellan, “Introduction to fracture mechanics”, McGraw Hill, 2nd Edition
2. S.A. Meguid, “Engineering fracture mechanics” Elsevier Applied Science, 1989
3. Jayatilaka, “Fracture of Engineering Brittle Materials”, Applied Science Publishers, 1979
4. Rolfe and Barsom, “Fracture and Fatigue Control in Structures”, Prentice Hall, 1977
5. Knott, “Fundamentals of fracture mechanisms”, Butter worth’s, 1973

Course Outcome:

At the end of the course students will:

CO1	Develop fundamental understanding of the effects of crack like defects on the performance of aerospace, civil, and mechanical engineering structures.
CO2	Select appropriate materials for engineering structures to ensure damage tolerance.
CO3	Employ modern numerical methods to determine critical crack sizes and fatigue crack propagation rates in engineering structures.
CO4	Gain appreciation of the status of academic research in field of fracture mechanics.

SCHEME OF EXAMINATION (QUESTION PAPER PATTERN)

1. Seven FULL questions to be set.
2. Five FULL questions to be answered.
3. Chapter-3, Chapter-4, Chapter-5, are compulsory, with one question from each chapter
4. Chapter-1 and Chapter-2: two questions to be set with choice.

ELECTIVE-I

COMPUTATIONAL FLUID DYNAMICS

Course Code	**:**	**16MMD421**		**CIE Marks**	**:**	**50**
Hrs/Week	**:**	**L: T: P: 4:0:0**		**SEE Marks**	**:**	**50**
Credits	**:**	**04**		**SEE Duration**	**:**	**3 hours**

Course Objective:
This course would create awareness about the theory behind fluid dynamics computations as applied in analysis tools.

Course Content: Chapters/ Units

1. Basic Concepts - Dimensionless form of equations; Simplified mathematical models; Hyperbolic, Parabolic & Elliptic systems; Properties of numerical solutions (Consistency, Stability, Conservation, Convergence and Accuracy). **8 Hours**

2. Finite Difference Methods - Discretization; Boundary conditions; error propagation; Introduction to spectral methods; examples. **10 Hours**

3. Finite volume method - Surface & volume integrals; Interpolation & differentiation; Boundary conditions; Examples. **10 Hours**

4. Gaussian Elimination; LU decomposition; Tridiagonal Systems; Iterative methods; convergence; ADI & other splitting methods. Multi-grid method - Coupled equations; Simultaneous solutions, sequential solutions & under relaxation. Nonlinear systems **12 Hours**

5. Initial value problem & Boundary value problems; Implicit & Explicit Schemes; 2D and 3D examples. Heat and Mass transfer Problems; Multi Phase Flows. **12 Hours**

NOTE: the students are advised to prepare the report in the form of assignment to understand the subject and its relevance in the industry

Text Books:

1. Computational Methods for Fluid Dynamics, 3rd edition - J.H. Ferziger& M. Peric, Springer, 2002.
2. Numerical Solutions of Partial Differential Equations, Finite Difference methods, 3rd ed., - G.D. Smith, Oxford University Press. 1986.

Reference Books:

1. **Computational Fluid Dynamics -** T. J. Chung, Cambridge Univ. Press, 2002.
2. **Partial Differential Equations for Scientists and Engineers -** Farlow, John Wiley, 1982.

Course Outcome:

The student will be able to analyze and obtain numerical solutions to fluid dynamics problems

CO1	The course will equip the students with the necessary knowledge to use computational techniques related to flow mechanics.
CO2	Understand and apply finite difference, finite volume and finite element methods to fluid flow problems
CO3	Understand and apply compressible flow solvers
CO4	Understand the issues surrounding two phase flow modeling

SCHEME OF EXAMINATION (QUESTION PAPER PATTERN)

1. Seven FULL questions to be set.
2. Five FULL questions to be answered.
3. Chapter-1, Chapter-2, Chapter-3, are compulsory, with one question from each chapter
4. Chapter-4 and Chapter-5: two questions to be set with choice.

SMART MATERIALS AND STRUCTURES

Course Code	**:**	**16MMD422**		**CIE Marks**	**:**	**50**
Hrs/Week	**:**	**L: T: P: 4:0:0**		**SEE Marks**	**:**	**50**
Credits	**:**	**04**		**SEE Duration**	**:**	**3 hours**

Course Objective:
Knowledge of smart materials and structures is essential designing mechanical systems for advanced engineering applications, the course aims at training students in smart materials and structures application and analysis

Course Content: Chapters/ Units

1. **Smart Structures**: Types of Smart Structures, Potential Feasibility of Smart Structures, Key Elements of Smart Structures, Applications of Smart Structures. Piezoelectric materials, Properties, piezoelectric Constitutive Relations, Depoling and Coersive Field, field strain relation. Hysteresis, Creep and Strain Rate effects, Inchworm Linear Motor.
   Beam Modeling: Beam Modeling with induced strain Rate effects, Inchworm Linear Motor Beam Modeling with induced strain Actuation-single Actuators, dual Actuators, Pure Extension, Pure Bending harmonic excitation, Bernoulli-Euler beam Model, problems, Piezoelectric Applications.
   12 Hours

2. **Shape memory Alloy:** Experimental Phenomenology, Shape Memory Effect, Phase Transformation, Tanaka's Constitutive Model, testing of SMA Wires, Vibration Control through SMA, Multiplexing. Applications Of SMA and Problems.
   ER and MR Fluids: Mechanisms and properties, Fluid Composition and behavior, The Bingham Plastic and Related Models, Pre-Yield Response. Post-Yield flow applications in Clutches, Dampers and Others. **14 Hours**

3. **Vibration Absorbers:** series and Parallel Damped Vibrations (Overview), Active Vibration Absorbers, Fiber Optics, Physical Phenomena, Characteristics, Sensors, Fiber Optics in Crack Detection, applications.
   Control of Structures: Modeling, Control Strategies and Limitations, Active Structures in Practice. **14 Hours**

4. **MEMS** – Mechanical Properties of MEMS Materials, Scaling of Mechanical Systems, Fundamentals of Theory, The Intrinsic Characteristics of MEMS, Miniaturization, Microelectronics Integration. **6 Hours**

5. **Devices:** Sensors and Actuators, Conductivity of Semiconductors, Crystal Planes and Orientation, (Stress and Strain Relations, Flexural Beam Bending Analysis Under Simple Loading Conditions), Polymers in MEMS, Optical MEMS Applications. **6 Hours**

NOTE: the students are advised to prepare the report in the form of assignment to understand the subject and its relevance in the industry

TEXT BOOKS:

1. Smart Materials and Structures - M. V. Gandhi and B. So, Thompson, Chapman and Hall, London; New York, 1992 (ISBN: 0412370107).
2. Smart Structures and Materials - B. Culshaw, Artech House, Boston, 1996 (ISBN :0890066817).
3. Smart Structures: Analysis and Design - A. V. Srinivasan, Cambridge University Press, Cambridge; New York, 2001 (ISBN: 0521650267).

REFERENCE BOOKS:

1. Electro ceramics: Materials, Properties and Applications - A. J. Moulson and J. M. Herbert. John Wiley & Sons, ISBN: 0471497429
2. Piezoelectric Sensories: Force, Strain, Pressure, Acceleration and Acoustic Emission Sensors. Materials and Amplifiers, Springer, Berlin; New York, 2002 (ISBN: 3540422595).
3. Piezoelectric Actuators and Wtrasonic Motors - K. Uchino, Kluwer Academic Publishers, Boston, 1997 (ISBN: 0792398114).
4. Handbook of Giant Magneto strictive Materials - G. Engdahl, Academic Press, San Diego, Calif.; London, 2000 (ISBN: 012238640X).
5. Shape Memory Materials - K. Otsuka and C. M. Wayman, Cambridge University Press, Cambridge; New York, 199~ (ISBN: 052144487X).

Course Outcome:

At the completion of this course, students will be able to:

CO1	Understand the behavior and applicability of various smart materials.
CO2	Design Simple models for smart structures and materials
CO3	Perform simulation of smart structures and material application.
CO4	Conduct experiments to verify the predictions.

SCHEME OF EXAMINATION (QUESTION PAPER PATTERN)

1. Seven FULL questions to be set.
2. Five FULL questions to be answered.
3. Chapter-1, Chapter-4, Chapter-5, are compulsory, with one question from each chapter
4. Chapter-2 and Chapter-3: two questions to be set with choice.

DESIGN OPTIMIZATION

Course Code	**:**	**16MMD423**		**CIE Marks**	**:**	**50**
Hrs/Week	**:**	**L: T: P: 4:0:0**		**SEE Marks**	**:**	**50**
Credits	**:**	**04**		**SEE Duration**	**:**	**3 hours**

Course Objective:
It aids the students to acquire the basics of optimum design, Classical Optimization Techniques, Non - linear Programming, Unconstrained Optimization Techniques, Integer Programming and Dynamic Programming.

Course Content: Chapters/ Units

Chapters / Units:

1. **Engineering Design Practice:** Evolution of Design Technology, Introduction to Design and the Design Process, Design versus Analysis, Role of Computers in Design Cycle, Impact of CAE on Design, Numerical Modeling with FEA and Correlation with Physical Tests.
   Applications of Optimization in Engineering Design: Automotive, Aerospace and General Industry Applications, Optimization of Metallic and Composite Structures, Minimization and Maximization Problems, MDO and MOO. **10 Hours**

2. **Optimum Design Problem Formulation**: Types of Optimization Problems, The Mathematics of Optimization, Design Variables and Design Constraints, Feasible and Infeasible Designs, Equality and Inequality Constraints, Discrete and Continuous Optimization, Linear and Non-Linear Optimization.
   Optimization Theory – Fundamental Concepts, Global and Local Minimum, Gradient Vector and Hessian Matrix, Concept of Necessary and Sufficient Conditions, Constrained and Unconstrained Problems, Lagrange Multipliers and Kuhn Tucker Conditions. **12 Hours**

3. **Sensitivity Analysis, Linear and** Non-Linear Approximations. Gradient Based Optimization Methods – Dual and Direct.
   Optimization Disciplines: Conceptual Design Optimization and Design Fine Tuning, Combined Optimization, Optimization of Multiple Static and Dynamic Loads, Transient Simulations, Equivalent Static Load Methods. **10 Hours**

4. **Manufacturability in Optimization Problems:** Design for Manufacturing, Manufacturing Methods and Rules, Applying Manufacturing Constraints to Optimization Problems.
   Design Interpretation: Unbound Problems, Over Constrained Problems, Problems with No of Multiple Solutions, Active and Inactive Constraints, Constraint Violations and Constraint Screening, Design Move Limits, Local and Global Optimum. **12 Hours**

5. **Dynamic Programming:** Introduction, Multistage decision processes, Principle of optimality, Computational Procedure in dynamic programming, Initial value problem, Examples. **8 Hours**

Text Books:

1. S.S. Rao, Engineering Optimization: Theory and Practice, John Wiley, 2009
2. JasbirArora, Introduction to Optimum Design, McGraw Hill, 2011.

Reference Books:

1. Optimization and Probability in System Engg - Ram, Van Nostrand.
2. Optimization methods - K. V. Mital and C. Mohan, New age International Publishers, 1999.
3. Optimization methods for Engg. Design - R.L Fox, Addison – Wesley, 1971.

Course Outcome:

At the completion of this course, students will be able to:

CO1	It provides the student with knowledge required to optimize an existing design with single or multiple objective functions.
CO2	Skills acquired through commercial optimization programs
CO3	Acquire the knowledge of engineering system design

SCHEME OF EXAMINATION (QUESTION PAPER PATTERN)

1. Seven FULL questions to be set.
2. Five FULL questions to be answered.
3. Chapter-1, Chapter-3, Chapter-5, are compulsory, with one question from each chapter
4. Chapter-2 and Chapter-4: two questions to be set with choice.

DR AMBEDKAR INSTITUTE OF TECHONOLOGY

DEPARTMENT OF MECHNICAL ENGINEERING

SCHEME AND SYLLABUS

FOR

M.Tech MACHINE DESIGN

YEAR 2017-18

PROGRAM EDUCATIONAL OBJECTIVES

PEO1--Graduates will have knowledge in the discipline of Machine Design with hands on skill in using modern engineering tools to address real world engineering problems and be socially responsible.
PEO2– Graduates shall be successful in their career as analysts and designers of structural components of conventional and advanced materials, participating in a team or individually in an industry, research or academia.
PEO3– Graduates shall be proficient in their communication, presentation and will be prepared to engage in the process of life-long learning through professional development and research.

PROGRAM OUTCOMES

PO No.	Program Outcomes (PO)
PO1	Acquire in-depth knowledge of specific discipline or professional area, including wider and global perspective, with an ability to discriminate, evaluate, analyze and synthesize existing and new knowledge, and integration of the same for enhancement of knowledge.
PO2	Analyze complex engineering problems critically, apply independent judgment for synthesizing information to make intellectual and/or creative advances for conducting research in a wider theoretical, practical and policy context
PO3	Think laterally and originally, conceptualize and solve engineering problems, evaluate a wide range of potential solutions for those problems and arrive at feasible, optimal solutions after considering public health and safety, cultural, societal and environmental factors in the core areas of expertise.
PO4	Extract information pertinent to unfamiliar problems through literature survey and experiments, apply appropriate research methodologies, techniques and tools, design, conduct experiments, analyze and interpret data, demonstrate higher order skill and view things in a broader perspective, contribute individually/in group(s) to the development of scientific/technological knowledge in one or more domains of engineering.
PO5	Create, select, learn and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modeling, to complex engineering activities with an understanding of the limitations.
PO6	Possess knowledge and understanding of group dynamics, recognize opportunities and contribute positively to collaborative-multidisciplinary scientific research, demonstrate a capacity for self-management and teamwork, decision-making based on open-mindedness, objectivity and rational analysis in order to achieve common goals and further the learning of themselves as well as others.
PO7	Demonstrate knowledge and understanding of engineering and management principles and apply the same to one's own work, as a member and leader in a team, manage projects efficiently in respective disciplines and multidisciplinary environments after consideration of economic and financial factors.
PO8	Communicate with the engineering community, and with society at large, regarding complex engineering activities confidently and effectively, such as, being able to comprehend and write effective reports and design documentation by adhering to appropriate standards, make effective presentations, and give and receive clear instructions.
PO9	Recognize the need for, and have the preparation and ability to engage in life-long learning independently, with a high level of enthusiasm and commitment to improve knowledge and competence continuously.
PO10	Acquire professional and intellectual integrity, professional code of conduct, ethics of research and scholarship, consideration of the impact of research outcomes on professional practices and an understanding of responsibility to contribute to the community for sustainable development of society.
PO11	Observe and examine critically the outcomes of one's actions and make corrective

DR AMBEDKAR INSTITUTE OF TECHONOLOGY

M.TECH/ MACHINE DESIGN **CREDIT BASED**

Subject Code	Name of the Subject	I SEMSTER						
		MARKS	CREDITS	L	T	P	S	TOTAL
16MMD11	ADVANCED MECHANICS OF SOLIDS	100	04	4	0	0	0	4
16MMD12	FINITE ELEMENT METHOD	100	04	4	0	0	0	4
16MMD13	ADVANCED DESIGN OF MECHANISM	100	04	4	0	0	0	4
16MMD14	ADVANCED THEORY OF VIBRATIONS	100	04	4	0	0	0	4
16MMD15X	ELECTIVE-I	100	04	4	0	0	0	4
16MMDL16	VIBRATION LAB	100	02	0	0	02	0	2
16MMDS17	TECHNICAL SEMINAR	100	02	0	0	0	02	2
16MMDM18	MINI PROJECT OR INDUSTRIAL VISIT	100	02	0	0	0	02	2
	TOTAL	**800**	**26**	**20**	**00**	**02**	**04**	**26**

ELECTIVE –I

16MMD151 MECHATRONICS SYSTEMS DESIGN

16MMD152 DESIGN FOR MANUFACTURE

16MMD153 AUTOMOBILE SYSTEM DESIGN

Subject Code	Name of the Subject	II SEMSTER						
		MARKS	**CREDITS**	**L**	**T**	**P**	**S**	**TOTAL**
16MMD21	COMPOSITE MATERIAL TECHONOLOGY	100	04	4	0	0	0	4
16MMD22	ADVANCED MACHINE DESIGN	100	04	4	0	0	0	4
16MMD23	EXPERIMENTAL MECHANICS	100	04	4	0	0	0	4
16MMD24	TRIBOLOGY & BEARING DESIGN	100	04	4	0	0	0	4
16MMD25X	ELECTIVE-I	100	04	4	0	0	0	4
16MMDL26	FINITE ELEMENT ANALYSIS LAB	100	02	0	0	02	0	2
RM 27	RESEARCH METHODOLOGY	100	02	0	0	0	02	2
16MMDM28	MINI PROJECT //INDUSTRIAL VISIT/FIELD WORK/TECHNICAL	100	02	02	0	0	0	2
	TOTAL	**800**	**26**	**22**	**00**	**02**	**02**	**26**

ELECTIVE-I

16MMD251 THEORY OF PLASTICITY

16MMD252 ROTOR DYNAMICS

16MMD253 FINITE ELEMENT METHODS FOR HEAT TRANSFER AND FLUID FLOW ANALYSIS

Subject Code	Name of the Subject	III SEMSTER						
		MARKS	CREDITS	L	T	P	S	TOTAL
16MMD31	MIDTERM PRESENTATION ON INTERNSHIP	50	2	0	0	2	0	02
16MMD32	REPORT ON INTERNSHIP	100	13	0	0	13	0	13
16MMD33	EVALUATION AND VIVA-VOCE ON INTERNSHIP	100	05	0	0	05	0	05
16MMD32	PROJECT PHASE-1	50	00	0	0	0	0	PP
	TOTAL	**300**	**20**	**0**	**0**	**20**	**00**	**20**

NOTE: III Semester:

- **Internship**: The student shall undergo internship for 16 weeks.

  Preliminary Report submission and Evaluation after 8th week of Internship to be carried out by the Internal Guide of the college and a senior faculty for 50 marks

  Final report submission and evaluation to be carried out after 16^{th} week of internship by the internal guide of the college and a senior faculty. Report evaluation to be completed within two weeks of submission for 100 marks.

  Viva-Voce on Internship - To be conducted by the Internship Guide (from the college) and the External Guide / Examiner within 2 weeks of Submission with a senior faculty / HOD as chairman for 100 marks

- **Project Phase: I**

  Problem formulation and submission of **synopsis** within 8 weeks from the commencement of 3rd semester, which shall be evaluated for 50 marks by the committee constituted for the purpose by the Head of the Department comprising the guide, senior faculty of the department with HOD as Chairman.

  Literature survey and progress done after 16 weeks shall be evaluated by guide and external examiner with senior faculty / HOD as chairman for 100 marks.

Subject Code	Name of the Subject	IV SEMSTER						
		MARKS	CREDITS	L	T	P	S	TOTAL
16MMD41	FRACTURE MECHANICS	100	04	4	0	0	0	4
16MMD42X	ELECTIVE-I	100	04	4	0	0	0	4
16MMD43	PROJECT PHASE-II	100	02	0	0	0	02	20
16MMD44	PROJECT VIVA- VOCE	200	18	0	0	18	0	
	TOTAL	**500**	**28**	**08**	**00**	**18**	**02**	**28**

ELECTIVE-I

16MMD421 COMPUTATIONAL FLUID DYNAMICS

16MMD422 SMART MATERIALS & STRUCTURES

16MMD423 DESIGN OPTIMIZATION

IV Semester:

- **Project Phase-II -** Internal Evaluation of progress in Project work shall be evaluated after 8 weeks for 100 marks by the committee constituted for the purpose by the Head of the Department comprising the guide and senior faculty of the department with HOD as Chairman.
- **Project Phase-III** - Internal Evaluation of Project Demonstration, which shall be evaluated after 15 weeks for 100 marks by the committee constituted for the purpose by the Head of the Department.
- **Final Evaluation** of Project Work and Viva-voce.
- **Final evaluation** of project to be carried out after 16 weeks from the date of commencement of 4th semester.
- **The Internal Examiner** (the project guide with a teaching experience of at least three years) and External Examiner with HOD as chairman will complete the final evaluation of Project.
- **Internal and External Examiners** shall carry out the evaluation for 100 Marks each and the average of these marks shall be the final marks of the Project Evaluation.
- **Viva – Voce**: The Viva-Voce shall be conducted jointly by Internal Examiner and External Examiner with HOD as chairman for 100 Marks.

ADVANCED MECHANICS OF SOLIDS

Course Code	**:**	**16MMD11**		**CIE Marks**	**:**	**50**
Hrs./Week	**:**	**L: T: P: 4:0:0**		**SEE Marks**	**:**	**50**
Credits	**:**	**04**		**SEE Duration**	**:**	**3 hours**

Course Objective:

This course aims at a comprehensive study of mechanics of solids. The topics covered are

1. Analysis of stress, strain and stress-strain relations.
2. Solution of plane elasticity problems in rectangular and polar coordinates using analytical methods including thermal loads, body forces and surface tractions
3. Formulation of 3-D boundary value problems
4. Torsion of prismatic bars

Course Content: Chapters/ Units

1. **Introduction:** Definition and notation for forces and stresses. Components of stresses, equations of equilibrium, specification of stress at a point. Principal stresses and Mohr's diagram in 3 dimensions. Boundary conditions, interaction of given surface forces. Strain components, specification of strain at a point compatibility equation.
   Stress- strain relation and the general equation of elasticity. Generalized Hooke's law in terms of engineering constant, formulation of elasticity problem. Existence and uniqueness of solution, Saint- Venant's principle. Principle of superposition and reciprocal theorem. **13 Hours**

2. **Plane stress and plane strain problems:** Bending of narrow cantilever beam under end load, simply supported beam with uniform load, use of Fourier series to solve two dimensional problems. Two dimensional problems in polar coordinates. Thin cylinder, pure bending of curved bar, rotating disc and cylinder, bending of curved bar by a force at the end, edge dislocation, effect of circular holes on stress distribution in plates, and vertical load of the straight boundary, forces acting on the end of wedge, stresses in circular disc. Thermal stresses- field equation, stresses in thin disk and long cylinder. 2-D problems in curvilinear coordinates. **13 Hours**

3. Torsion of prismatic bars, membrane analogy, torsion of thin open and closed tubes. **08 Hours**

4. Introduction to pure bending and deflection of plates and shells. **08 Hours**

5. Buckling of struts, stresses and strains in thick curved beam, cylinders and spheres. **08 Hours**

NOTE: the students are advised to prepare the report in the form of assignment to understand the subject and its relevance in the industry

TEXT BOOKS

1. Sadhu Singh, Theory of Elasticity, Khanna publisher
2. Applied elasticity- Wang C.T, Mc Graw Hill book company
3. L S Srinath "Advanced Mechanics of Solids " - Tata McGraw Hill Company.

REFERENCES

1. Theory of elasticity- Timoshenko and Goodier
2. Theory of plates and shells- Timoshenko, Mc Graw Hill book company
3. Dym C. L and Shames. I. H, Solid Mechanics: A variation Approach – McGraw Hill New York-1973.

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO1	Apply basic concepts in continuum mechanics of solids viz. Stress and strain tensors, equilibrium, compatibility and constitutive equations. Mohr's diagram hook's law and methods of solution to elasticity problems, principle of superposition and reciprocal theorem.
CO 2	Study about bending of cantilever beams with different loading condition. Evaluate stresses and displacements in simple solids such as pressurized cylinders, shrink fitted cylinders, rotating disc and shaft, plate with hole and non-circular shafts and thin tubes under torsion.
CO 3	To understand an analyze the Torsion of prismatic bars, membrane analogy, torsion of thin open and closed tubes
CO 4	To understand the stresses developed due to pure bending and deflection of plates and shells.
CO 5	To understand the concepts of Buckling of struts, stresses and strains in thick curved beam, cylinders and spheres.

SCHEME OF EXAMINATION (QUESTION PAPER PATTERN)

1. Seven FULL questions to be set.
2. Five FULL questions to be answered.
3. Chapter-3, Chapter-,4 Chapter-5, are compulsory, with one question from each chapter
4. Chapter-1 and Chapter-2: two questions to be set with choice.

FINITE ELEMENT METHOD

Course Code	:	16MMD12		CIE Marks	:	50
Hrs/Week	:	L: T: P: 4:0:0		SEE Marks	:	50
Credits	:	04		SEE Duration	:	3 hours

Course Objectives

1. To present the Finite element method (FEM) as a numerical method for engineering analysis of continua and structures
2. To present Finite element formulation using variational and weighted residual approaches
3. To present Finite elements for the analysis of bars & trusses, beams & frames, plane stress & plane strain problems and 3-D solids, for thermal and dynamics problems.

Course Content: Chapters/ Units

1. **Approximations and round off errors**: Significant figures, accuracy and precision, error definitions, round off errors and truncation errors. Mathematical modeling and Engineering problem solving: Simple mathematical model, Conservation Laws of Engineering**.** **06 Hours**

   System of Linear Algebraic Equations and Eigen Value Problems: Introduction, Direct methods, Cramer's Rule, Gauss Elimination Method, Gauss-Jordan Elimination Method, Triangularization method, Cholesky Method, Partition method, error Analysis for direct methods, Iteration Methods. Eigen values and Eigen Vectors: Bounds on Eigen Values, Jacobi method for symmetric matrices. **06 Hours**

2. **Introduction to Finite Element Method:** Basic Steps in Finite Element Method to solve mechanical engineering (Solid, Fluid and Heat Transfer) problems: Functional approach and Galerkin approach, Displacement Approach: Admissible Functions, Convergence Criteria: Conforming and Non-Conforming elements, C_o C_1 and C_n Continuity Elements. Basic Equations, Element Characteristic Equations, Assembly Procedure, Boundary and Constraint Conditions. **06 Hours**

   Solid Mechanics: One-Dimensional Finite Element Formulations and Analysis – Bars-uniform, varying and stepped cross section-Basic (Linear) and Higher Order Elements Formulations for Axial, Torsional and Temperature Loads with problems. Beams- Basic (Linear) Element Formulation-for uniform, varying and stepped cross section- for different loading and boundary conditions with problems. Trusses, Plane Frames and Space Frame Basic (Linear) Elements Formulations for different boundary condition -Axial, Bending, Torsional, and Temperature Loads with problems. **06 Hours**

3. **Two-Dimensional Finite Element Formulations for Solid Mechanics Problems:** Triangular Membrane (TRIA 3, TRIA 6, TRIA 10) Element, Four-Noded Quadrilateral Membrane (QUAD 4, QUAD 8) Element Formulations for in-plane loading with sample problems.

   Triangular and Quadrilateral, Axis-symmetric basic and higher order Elements formulation for axis-symmetric loading only with sample problems.

   Three-Dimensional Finite Element Formulations for Solid Mechanics Problems: Finite Element Formulation of Tetrahedral Element (TET 4, TET 10), Hexahedral Element (HEXA 8, HEXA 20), for different loading conditions. Serendipity and Lagrange family Elements **10 Hours**

4. **Finite Element Formulations for Structural Mechanics Problems:** Basics of plates and shell theories: Classical thin plate Theory, Shear deformation Theory and Thick Plate theory. Finite Element Formulations for triangular and quadrilateral Plate elements. Finite element formulation of flat, curved, cylindrical and conical Shell elements **08 Hours**
5. **Dynamic Analysis:** Finite Element Formulation for point/lumped mass and distributed masses system, Finite Element Formulation of one-dimensional dynamic analysis: bar, truss, frame and beam element. Finite Element Formulation of Two-dimensional dynamic analysis: triangular membrane and axisymmetric element, quadrilateral membrane and axisymmetric element. Evaluation of eigen values and eigen vectors applicable to bars, shaft, beams, plane and space frame. **10 Hours**

NOTE: students are advised to prepare the report in the form of assignment to understand the subject and its relevance in the industry.

Text Books:

1. S.S. Sastry, Introductory Methods of Numerical Analysis, PHI, 2005.
2. Steven C. Chapra, Raymond P. Canale, Numerical Methods for Engineers, Tata McGraw Hill, 4th Ed, 2002.
3. M K Jain, S.R.K Iyengar, R K. Jain, Numerical methods for Scientific and engg computation, New Age International, 2003.
4. T. R. Chandrupatla and A. D. Belegundu, Introduction to Finite Elements in Engineering, Prentice Hall, 3rd Ed, 2002.
5. Lakshminarayana H. V., Finite Elements Analysis– Procedures in Engineering, Universities Press, 2004.

Reference Books:

1. Rao S. S., Finite Elements Method in Engineering- 4th Edition, Elsevier, 2006
2. P. Seshu, Textbook of Finite Element Analysis, PHI, 2004.
3. Bathe K. J., Finite Element Procedures, Prentice-Hall, 2006.
4. Cook R. D., Finite Element Modeling for Stress Analysis, Wiley,1995.
5. David. C. Lay, Linear Algebra and its applications, 3rd edition, Pearson Education, 2002

Course Outcomes:

Upon completion of this course, the students will be able to

CO1	It's important for the students to have basic knowledge about applied mathematics
CO2	Apply basic concepts about developing governing equations by finite element method, Formulate and perform one dimensional,
CO3	Two-dimensional structural analysis using bar, beam, triangular and quadrilateral elements. for Solid Mechanics Problems
CO4	Formulate axisymmetric triangular element and analyze problems on solids of revolution.
CO5	Formulate mass matrices and compute eigen values and eigen vectors for a 1- D and 2D analysis of mechanical system.

SCHEME OF EXAMINATION (QUESTION PAPER PATTERN)

1. Seven FULL questions to be set.
2. Five FULL questions to be answered.
3. Chapter-3, Chapter-4, Chapter-5, are compulsory, with one question from each chapter
4. Chapter-1 and Chapter-2: two questions to be set with choice.

ADVANCED DESIGN OF MECHANISM

Course Code	**:**	**16MMD13**		**CIE Marks**	**:**	**50**
Hrs/Week	**:**	**L: T: P: 4:0:0**		**SEE Marks**	**:**	**50**
Credits	**:**	**04**		**SEE Duration**	**:**	**3 hours**

Course Objective:
To include dynamics considerations in the design of mechanisms for engineering applications is the objective of this course.

Course Content: Chapters/ Units

1. **Geometry of Motion:** Introduction, analysis and synthesis, Mechanism terminology, planar, Spherical and spatial mechanisms, mobility, Grashoffs law, Equivalent mechanisms, Unique mechanisms, Kinematic analysis of plane mechanisms: Auxiliary point method using rotated velocity vector, Hall - Ault auxiliary point method, Goodman's indirect method. **8 Hours**

2. **Generalized Principles of Dynamics:** Fundamental laws of motion, generalized coordinates, Configuration space, Constraints, Virtual work, principle of virtual work, Energy and momentum, Work and kinetic energy, Equilibrium and stability, Kinetic energy of a system, Angular momentum, Generalized momentum. Lagrange's Equation: Lagrange's equation from D'Alembert's principles, Examples, Hamilton's equations, Hamilton's principle, Lagrange's, equation from Hamilton's principle, Derivation of Hamiltons equations, Examples. **13 Hours**

3. **System Dynamics:** Gyroscopic action in machines, Euler's equation of motion, Phase Plane representation, Phase plane Analysis, Response of Linear Systems to transient disturbances. Synthesis of Linkages: Type, number, and dimensional synthesis, Function generation, Path generation and Body guidance, Precision positions, Structural error, Chebyshev spacing, Two position synthesis of slider crank mechanisms, Crank-rocker mechanisms with optimum transmission angle Motion Generation: Poles and relative poles, Location of poles and relative poles, pooled, Curvature, Inflection circle. **13 Hours**

4. Graphical Methods of Dimensional Synthesis: Two position synthesis of crank and rocker mechanisms, three position synthesis, four position synthesis (point precision reduction) Overlay method, Coupler curve synthesis, Cognate linkages. Ana1ytical Methods of Dimensional Synthesis: Freudenstein's equation for four bar mechanism and slider crank mechanism, Examples, Bloch's method of synthesis, Analytical synthesis using complex algebra. **12 Hours**

5. Spatial Mechanisms: Introduction, Position analysis problem, Velocity and acceleration analysis, Eulerian angles. **6 Hours**

NOTE: the students are advised to prepare the report in the form of assignment to understand the subject and its relevance in the industry

Text Books:

1. Greenwood, "Classical Dynamics", Prentice Hall of India, 1988.
2. K.J. Waldron G.L. Kinzel, "Kinematics, Dynamics and Design of Machinery", Wiley India, 2007.

References Books:

1. J E Shigley, "Theory of Machines and Mechanism" -McGraw-Hill, 1995
2. A.G. Ambekar, "Mechanism and Machine Theory", PHI, 2007.
3. Ghosh and Mallick, "Theory of Mechanism and Mechan ism", East West press 2007.
4. David H. Myszka, "Machines and Mechanisms", Pearson Education, 2005.

Course Outcome:

Upon completion of this course, the student will be able to

CO1	The knowledge of dynamics considerations in mechanism design is essential to use commercial multi body dynamics software in mechanical engineering design.
CO2	Carry out mobility analysis of mechanism and perform velocity and acceleration of complex planer mechanism.
CO3	Synthesize mechanisms for function generation and path generation.
CO4	Analyze the Dynamics of Mechanical systems using D'Alembert's, Lagrange's, and Hamiltons Principles.
CO5	Demonstrate the skills to use software to analyze mechanisms, synthesis of linkages.

SCHEME OF EXAMINATION (QUESTION PAPER PATTERN)

1. Seven FULL questions to be set.
2. Five FULL questions to be answered.
3. Chapter-1, Chapter-4, Chapter-5, are compulsory, with one question from each chapter
4. Chapter-2 and Chapter-3: two questions to be set with choice.

ADVANCED THEORY OF VIBRATIONS

Course Code	**:**	**16MMD14**		**CIE Marks**	**:**	**50**
Hrs/Week	**:**	**L: T: P: 4:0:0**		**SEE Marks**	**:**	**50**
Credits	**:**	**04**		**SEE Duration**	**:**	**3 hours**

Course Objective:

To teach students how to use the theoretical principles of vibration, and vibration analysis techniques, for the practical solution of vibration problems. The course thus builds on student's prior knowledge of vibration theory, and concentrates on the applications. Thus the student will fully understand the importance of vibrations in mechanical design of machine parts that operate in vibratory conditions.

Course Content: Chapters/ Units

1. **Review of Mechanical Vibrations:** Basic concepts; free vibration of single degree of freedom systems with and without damping, forced vibration of single DOF-systems, Natural frequency.
   Transient Vibration of single Degree-of freedom systems: Impulse excitation, Arbitrary excitation, Laplace transform formulation, pulse excitation and rise time, Shock response spectrum, Shock isolation. **10 Hours**

2. **Vibration Control:** Introduction, Vibration isolation theory, Vibration isolation and motion isolation for harmonic excitation, practical aspects of vibration analysis, shock isolation, Dynamic vibration absorbers, Vibration dampers.
   Vibration Measurement and applications: Introduction, Transducers, Vibration pickups, Frequency measuring instruments, Vibration exciters, Signal analysis. **13 Hours**

3. **Modal analysis & Condition Monitoring:** Dynamic Testing of machines and Structures, Experimental Modal analysis, Machine Condition monitoring and diagnosis. Non-Linear Vibrations: Introduction, Sources of nonlinearity, Qualitative analysis of nonlinear systems. Phase plane, Conservative systems, Stability of equilibrium, Method of isoclines, Perturbation method, Method of iteration, Self-excited oscillations. **13 Hours**

4. **Random Vibrations:** Random phenomena, Time averaging and expected value, Frequency response function, Probability distribution, Correlation, Power spectrum and power spectral density, Fourier transforms, FTs and response. **08 Hours**
5. **Continuous Systems:** Vibrating string, longitudinal vibration of rods, Torsional vibration of rods, Euler equation for beams.
   Different methods of vibration dissipation in structural components for general and rotating machinery. **08 Hours**

NOTE: the students are advised to prepare the report in the form of assignment to understand the subject and its relevance in the industry

Text Books:

1. Theory of Vibration with Application, - William T. Thomson, Marie Dillon Dahleh, Chandramouli Padmanabhan, 5th edition Pearson Education
2. S. Graham Kelly, "Fundamentals of Mechanical Vibration" - McGraw-Hill, 2000
3. S. S. Rao, "Mechanical Vibrations", Pearson Education, 4^{th} edition.

Reference Books:

1. S. Graham Kelly, "Mechanical Vibrations", Schaum's Outlines, Tata McGraw Hill, 2007.
2. C Sujatha, "Vibrations and Acoustics – Measurement s and signal analysis Tata McGraw Hill, 2010

Course Outcome:

Upon completion of this course, the student will be able to

CO1	Model and analyze a free damped, undamped and forced response of a mechanical system.
CO2	Develop equation and analyze the transient response of a single degree freedom system.
CO3	Assess the response characteristics of a continuous mechanical system.
CO4	Analyze and discuss the behavior of single degree freedom system for linear and non-linear behavior.

<u>SCHEME OF EXAMINATION (QUESTION PAPER PATTERN)</u>

1. Seven FULL questions to be set.
2. Five FULL questions to be answered.
3. Chapter-1, Chapter-4, Chapter-5, are compulsory, with one question from each chapter
4. Chapter-2 and Chapter-3: two questions to be set with choice.

Elective-I

MECHATRONICS SYSTEMS DESIGN

Course Code	**:**	**16MMD151**		**CIE Marks**	**:**	**50**
Hrs/Week	**:**	**L: T: P: 4:0:0**		**SEE Marks**	**:**	**50**
Credits	**:**	**04**		**SEE Duration**	**:**	**3 hours**

Course Objective

1. To educate the student regarding integration of mechanical, electronic, electrical and computer systems in the design of CNC machine tools, Robots etc.
2. To provide students with an understanding of the Mechatronic Design Process, actuators, Sensors, transducers, Signal Conditioning, MEMS and Microsystems and also the Advanced Applications in Mechatronics.

Course Content: Chapters/ Units

1. **Introduction:** Definition and Introduction to Mechatronic Systems. Modeling &Simulation of Physical systems Overview of Mechatronic Products and their functioning, measurement systems. Control Systems, simple Controllers. Study of Sensors and Transducers: Pneumatic and Hydraulic Systems, Mechanical Actuation System, Electrical Actual Systems, Real time interfacing and Hardware components for Mechatronics. **13 Hours**

2. **Electrical Actuation Systems:** Electrical systems, Mechanical switches, Solid state switches, solenoids, DC & AC motors, Stepper motors.
   System Models: Mathematical models: - mechanical system building blocks, electrical system building blocks, thermal system building blocks, electromechanical systems, hydro-mechanical systems, pneumatic systems. **10 Hours**

3. **Signal Conditioning:** Signal conditioning, the operational amplifier, Protection, Filtering, Wheatstone Bridge, Digital signals, Multiplexers, Data Acquisition, Introduction to digital system processing, pulse-modulation.
   MEMS and Microsystems: Introduction, Working Principle, Materials for MEMS and Microsystems, Micro System fabrication process, Overview of Micro Manufacturing, Micro system Design, and Micro system Packaging. **13 Hours**

4. **Data Presentation Systems:** Basic System Models, System Models, Dynamic Response of system. **8 Hours**

5. **Advanced Applications in Mechatronics:** Fault Finding, Design, Arrangements and Practical Case Studies, Design for manufacturing, User-friendly design **8 Hours**

NOTE: the students are advised to prepare the report in the form of assignment to understand the subject and its relevance in the industry

Text Books:

1. W. Bolton, “Mechatronics” - Addison Wesley Longman Publication, 1999
2. HSU “MEMS and Microsystems design and manufacture”- Tata McGraw-Hill Education, 2002

Reference Books:

1. Kamm, “Understanding Electro-Mechanical Engineering an Introduction to Mechatronics”- IEEE Press, 1 edition ,1996
2. Shetty and Kolk “Mechatronics System Design”- Cengage Learning, 2010
3. Mahalik “Mechatronics”- Tata McGraw-Hill Education, 2003
4. HMT “Mechatronics”- Tata McGraw-Hill Education, 199 8
5. Michel.B. Histand& David. Alciatore, “Introduction to Mechatronics & Measurement Systems”–. Mc Graw Hill, 2002
6. “Fine Mechanics and Precision Instruments”- Pergamon Press, 1971.

Course Outcome:

Upon completion of this course, the student will be able to

CO1	Appreciate multi-disciplinary nature of modern engineering systems.
CO2	Model and analyze mechanical and electrical systems and their connection.
CO3	Be able to integrate mechanical, electronics, control and computer engineering in the design of mechatronics systems.
CO4	Address issues of design, fabrication, and packaging issues of Microsystems.

SCHEME OF EXAMINATION (QUESTION PAPER PATTERN)

1. Seven FULL questions to be set.
2. Five FULL questions to be answered.
3. Chapter-2, Chapter-4, Chapter-5, are compulsory, with one question from each chapter
4. Chapter-1 and Chapter-3: two questions to be set with choice.

DESIGN FOR MANUFACTURE

Course Code	**:**	**16MMD152**		**CIE Marks**	**:**	**50**
Hrs/Week	**:**	**L: T: P: 4:0:0**		**SEE Marks**	**:**	**50**
Credits	**:**	**04**		**SEE Duration**	**:**	**3 hours**

Course Objective:

To educate students a clear understanding of factors to be considered in designing parts and components with focus on manufacturability

Course Content: Chapters/ Units

1. **Effect of Materials and Manufacturing Process on Design:** Major phases of design. Effect of material properties on design Effect of manufacturing processes on design. Material selection process- cost per unit property, weighted properties and limits on properties methods.
   Tolerance Analysis: Process capability, mean, variance, skewness, kurtosis, Process capability metrics, Cp, Cpk, Cost aspects, Feature tolerances, Geometries tolerances, Geometric tolerances, Surface finish, Review of relationship between attainable tolerance grades and different machining process. Cumulative effect of tolerance- Sure fit law and truncated normal law.
   13 Hours

2. **Selective Assembly:** Interchangeable part manufacture and selective assembly, Deciding the number of groups -Model-1 : Group tolerance of mating parts equal, Model total and group tolerances of shaft equal. Control of axial play-Introducing secondary machining operations, laminated shims, examples.
   Datum Features: Functional datum, Datum for manufacturing, changing the datum. Examples.
   12 Hours

3. **Design Considerations**: Design of components with casting consideration. Pattern, Mould, and Parting line. Cored holes and machined holes. Identifying the possible and probable parting line. Casting requiring special sand cores. Designing to obviates and cores.
   Component Design: Component design with machining considerations link design for turning components-milling, Drilling and other related processes including finish- machining operations.
   13 Hours
4. True positional theory: Comparison between co-ordinate and convention method of feature location. Tolerance and true position tolerancing virtual size concept, Floating and fixed fasteners. Projected tolerance zone. Assembly with gasket, zero position tolerance. Functional gauges, Paper layout gauging. **7 Hours**

5. Design of Gauges: Design of gauges for checking components in assemble with emphasis on various types of limit gauges for both hole and shaft. **7 Hours**

NOTE: the students are advised to prepare the report in the form of assignment to understand the subject and its relevance in the industry

Text Books:

1. Harry Peck, “Designing for Manufacturing”, Pitman Publications, 1983.
2. Dieter, “Machine Design” - McGraw-Hill Higher Education, -2008
3. R.K. Jain, “Engineering Metrology", Khanna Publishers, 1986

Reference Books:

1. Product design for manufacture and assembly - Geoffrey Boothroyd, Peter dewhurst, Winston Knight, Merceldekker. Inc. CRC Press, Third Edition
2. Material selection and Design, Vol. 20 - ASM Hand book.

Course Outcomes:

Upon completion of this course, the student will be able to

CO1	Understand the role of manufacture and assembly in development of mechanical parts and their assemblies.
CO2	Apply manufacturing considerations in the design and development of components made of casting and machining.
CO3	Apply geometrical dimensioning and tolerances issues in mechanical design.

SCHEME OF EXAMINATION (QUESTION PAPER PATTERN)

5. Seven FULL questions to be set.
6. Five FULL questions to be answered.
7. Chapter-2, Chapter-4, Chapter-5, are compulsory, with one question from each chapter
8. Chapter-1 and Chapter-3: two questions to be set with choice.

AUTOMOBILE SYSTEM DESIGN

Course Code	**:**	**16MMD153**		**CIE Marks**	**:**	**50**
Hrs/Week	**:**	**L: T: P: 4:0:0**		**SEE Marks**	**:**	**50**
Credits	**:**	**04**		**SEE Duration**	**:**	**3 hours**

Course Objective:
This course would facilitate understanding of the stages involved in automobile system design. The student will be exposed to industrial practices in design of various systems of an automobile.

Course Content: Chapters/ Units

1. **Body Shapes**: Aerodynamic Shapes, drag forces for small family cars.
Fuel Injection: Spray formation, direct injection for single cylinder engines (both SI & CI), energy audit. **10 Hours**

2. **Design of I.C. Engine** I: Combustion fundamentals, combustion chamber design, cylinder head design for both SI & C. I. Engines. **8 Hours**

3. **Design of I.C. Engine II**: Design of crankshaft, camshaft, connecting rod, piston & piston rings for small family cars (max up to 3cylinders). **12 Hours**

4. **Transmission System**: Design of transmission systems – gearbox (max of 4-speeds), differential.
Suspension System: Vibration fundamentals, vibration analysis (single & two degree of freedom, vibration due to engine unbalance, application to vehicle suspension. **12 Hours**

5. **Cooling System**: Heat exchangers, application to design of cooling system (water cooled).
Emission Control: Common emission control systems, measurement of missions, exhaust gas emission testing. **10 Hours**

NOTE: the students are advised to prepare the report in the form of assignment to understand the subject and its relevance in the industry

Text Books:

1. **Design of Automotive Engines**, **-** A. Kolchin& V. Demidov, MIR Publishers, Moscow
2. **The motor vehicle, Newton steeds & Garratte -** Ili fee& sons Ltd., London
3. **I.C. Engines -** Edward F Obert, International text book company.

Reference Books:

1. **Introduction to combustion** - Turns
2. **Automobile Mechanic -**, N.K. Giri, Khanna Publications, 1994
3. **I.C. Engines** - Maleev, McGraw Hill book company, 1976
4. **Diesel engine design** – Heldt P.M. Chilton company New York.
5. **Problems on design of machine elements -** V.M. Faires & Wingreen, McMillan Company., 1965
6. **Design of I.C. Engines -** John Heywood, TMH

Course Outcome:

Upon completion of this course, the student will be able to

CO1	The student will be able to apply the knowledge in creating a preliminary design of automobile sub systems.
CO2	Students are exposed to aerodynamic analysis of the auto mobiles.
CO3	Students are exposed to engine performances, combustion analysis and exhaust gas analysis to meet the BIS standards (10000 series).

SCHEME OF EXAMINATION (QUESTION PAPER PATTERN)

1. Seven FULL questions to be set.
2. Five FULL questions to be answered.
3. Chapter-1, Chapter-2, Chapter-5, are compulsory, with one question from each chapter
4. Chapter-3 and Chapter-4: two questions to be set with choice.

Design Engineering Laboratory – Lab 1

Course Code	**:**	**16MMDL16**		**CIE Marks**	**:**	**50**
Hrs/Week	**:**	**L: T: P: 0:0:3**		**SEE Marks**	**:**	**50**
Credits	**:**	**02**		**SEE Duration**	**:**	**3 hours**

Note:

1) These are independent laboratory exercises
2) A student may be given one or two problems stated herein
3) Student must submit a comprehensive report on the problem solved and give a Presentation on the same for Internal Evaluation
4) Any one of the exercises done from the following list has to be asked in the Examination for evaluation.

Course Content:

Experiment #1
Vibration analysis using portable vibration meter with FFT analyzer.

Experiment #2
Modal analysis

Experiment #3
Vibration analysis using accelerometers
- **a)** Uni-axial
- **b)** Tri-axial
- **c)** High temperature Tri-axial

Experiment #4
Vibration Shaker

Experimental #5
Vibration analysis on Beams

Experiment #6
Torsional vibration

Experiment #7
Vibration Characteristics of a Spring Mass Damper System.
Part A: Analytical Solutions.
Part C: Correlation Studies.

Experiment #8
Stress analysis in curved beam in 2D
Part A: Experimental studies using Strain Gauge Instrumentation.
Part B: 2D Photo elastic Investigation.

TECHNICAL SEMINAR

Course Code	**:**	**16MMDS17**		**CIE Marks**	**:**	**50**
Hrs/Week	**:**	**L: T: P: S 0:0:0:3**		**SEE Marks**	**:**	**50**
Credits	**:**	**02**		**SEE Duration**	**:**	**3 hours**

- **Seminar**: At the end of second CIE each student is required to present the seminar of his/her interested field (Related to design subjects).
- Report submissions and final Evaluation is to be carried out by the Internal Guide of the college and a senior faculty along with HOD.

MINI PROJECT/ INDUSTRIAL VISIT/ FIELD WORK

Course Code	**:**	**16MMDM18**		**CIE Marks**	**:**	**50**
Hrs/Week	**:**	**L: T: P: S 0:0:0:3**		**SEE Marks**	**:**	**50**
Credits	**:**	**02**		**SEE Duration**	**:**	**3 hours**

- **Industrial Visit**: At the end of second CIE the industrial visit will be arranged in the domain field, each student is required to submit the report of the visit.
- Report submissions and final Evaluation is to be carried out by the Internal Guide of the college and a senior faculty along with HOD.

II Semester

COMPOSITE MATERIALS TECHNOLOGY

Course Code	**:**	**16MMD21**		**CIE Marks**	**:**	**50**
Hrs/Week	**:**	**L: T: P: 4:0:0**		**SEE Marks**	**:**	**50**
Credits	**:**	**04**		**SEE Duration**	**:**	**3 hours**

Course Objective:
Mechanics of composite materials provides a methodology for stress analysis and progressive failure analysis of laminated composite structures for aerospace, automobile, marine and other engineering applications.

Course Content: Chapters/ Units

1. **Introduction to Composite Materials:** Definition, Classification, Types of matrices material and reinforcements, Characteristics &selection, Fiber composites, laminated composites, Particulate composites, Prepegs, and sandwich construction.
   Metal Matrix Composites: Reinforcement materials, Types, Characteristics and selection, Base metals, Selection, Applications
   Macro Mechanics of a Lamina: Hooke's law for different types of materials, Number of elastic constants, Derivation of nine independent constants for orthotropic material, Two - dimensional relationship of compliance and stiffness matrix. Hooke's law for two-dimensional angle lamina, engineering constants - Numerical problems. Invariant properties. Stress-Strain relations for lamina of arbitrary orientation, Numerical problems. **10 Hours**

2. **Micro Mechanical Analysis of a Lamina:** Introduction, Evaluation of the four elastic moduli, Rule of mixture, Numerical problems. Experimental Characterization of Lamina- Elastic Moduli and Strengths
   Failure Criteria: Failure criteria for an elementary composite layer or Ply, Maximum Stress and Strain Criteria, Approximate strength criteria, Inter-laminar Strength, Tsa-Hill theory, Tsai, Wu tensor theory, Numerical problem, practical recommendations. **12 Hours**

3. **Macro Mechanical Analysis of Laminate**: Introduction, code, Kirchoff hypothesis, Classical Lamination Theory, A, B, and D matrices (Detailed derivation), Special cases of laminates, Numerical problems. Shear Deformation Theory, A, B, D and E matrices (Detailed derivation) **10 Hours**

4. **Analysis of Composite Structures:** Optimization of Laminates, composite laminates of uniform strength, application of optimal composite structures, composite pressure vessels, spinning composite disks, composite lattice structures. **8 Hours**

5. **Manufacturing and Testing:** Layup and curing - open and closed Mould processing, Hand lay-up techniques, Bag moulding and filament winding. Pultrusion, Pulforming, Thermoforming, Injection moulding, Cutting, Machining, joining and repair. NDT tests – Purpose, Types of defects, NDT method - Ultrasonic inspection, Radiography, Acoustic emission and Acoustic ultrasonic method.
   Applications: Aircrafts, missiles, Space hardware, automobile, Electrical and Electronics, Marine, Recreational and sports equipment-future potential of composites. **12 Hours**

NOTE: the students are advised to prepare the report in the form of assignment to understand the subject and its relevance in the industry

Text Books:

1. Autar K. Kaw, Mechanics of Composite materials, CRC Press, 2^{nd} Ed, 2005.
2. Madhijit Mukhopadhay, Mechanics of Composite Materials & Structures, Universities Press, 2004.

Reference Books:

1. J. N. Reddy, Mechanics of Laminated Composite Plates & Shells, CRD Press, 2^{nd} Ed, 2004.
2. Mein Schwartz, Composite Materials handbook, McGraw Hill, 1984.
3. Rober M. Jones, Mechanics of Composite Materials, Taylor & Francis, 1998.
4. Michael W, Hyer, Stress analysis of fiber Reinforced Composite Materials, Mc-Graw Hill International, 2009.
5. Composite Material Science and Engineering, Krishan K. Chawla, Springer, 3e, 2012.
6. Fiber Reinforced Composites, P.C. Mallik, Marcel Decker, 1993.

Course Outcomes:

Upon completion of this course, the student will be able to

CO1	Identify the role of matrices and reinforcements used in practical composite structures.
CO2	Analyze problems on micro and macro mechanical behavior of lamina.
CO3	Assess the strength of laminated composite and predict its failure for given static loading conditions.
CO4	Develop understanding of different methods of manufacturing and testing of composites.

SCHEME OF EXAMINATION (QUESTION PAPER PATTERN)

1. Seven FULL questions to be set.
2. Five FULL questions to be answered.
3. Chapter-1, Chapter-3, Chapter-4, are compulsory, with one question from each chapter
4. Chapter-2 and Chapter-5: two questions to be set with choice.

ADVANCED MACHINE DESIGN

Course Code	**:**	**16MMD22**		**CIE Marks**	**:**	**50**
Hrs/Week	**:**	**L: T: P: 4:0:0**		**SEE Marks**	**:**	**50**
Credits	**:**	**04**		**SEE Duration**	**:**	**3 hours**

Course Objective:
This course enables the student to identify failure modes and evolve design by analysis methodology. Design against fatigue failure is given explicit attention.

Course Content: Chapters/ Units

1. **Introduction:** Role of failure prevention analysis in mechanical design, Modes of mechanical failure, Review of failure theories for ductile and brittle materials including Mohr's theory and modified Mohr's theory, Numerical examples.
   Fatigue of Materials: Introductory concepts, High cycle and low cycle fatigue, Fatigue design models, Fatigue design methods, Fatigue design criteria, Fatigue testing, Test methods and standard test specimens, Fatigue fracture surfaces and macroscopic features, Fatigue mechanisms and microscopic features. **12 Hours**

2. **Stress-Life (S-N) Approach:** S-N curves, Statistical nature of fatigue test data, General S-N behavior, Mean stress effects, Different factors influencing S-N behavior, S-N curve representation and approximations, Constant life diagrams, Fatigue life estimation using S-N approach.
   Strain-Life(ε-N) approach: Monotonic stress-strain behavior, Strain controlled test methods, Cyclic stress-strain behavior, Strain based approach to life estimation, Determination of strain life fatigue properties, Mean stress effects, Effect of surface finish, Life estimation by ε-N approach.
   13 Hours

3. **LEFM Approach:** LEFM concepts, Crack tip plastic zone, Fracture toughness, Fatigue crack growth, Mean stress effects, Crack growth life estimation. Notches and their effects: Concentrations and gradients in stress and strain, S-N approach for notched membranes, mean stress effects and Haigh diagrams, Notch strain analysis and the strain – life approach, Neuber's rule, Glinka's rule, applications of fracture mechanics to crack growth at notches. **13 Hours**

4. **Fatigue from Variable Amplitude Loading:** Spectrum loads and cumulative damage, Damage quantification and the concepts of damage fraction and accumulation, Cumulative damage theories, Load interaction and sequence effects, Cycle counting methods, Life estimation using stress life approach. **7 Hours**

5. **Surface Failure:** Introduction, Surface geometry, Mating surface, Friction, Adhesive wear, Abrasive wear, Corrosion wear, Surface fatigue spherical contact, cylindrical contact, General contact, Dynamic contact stresses, Surface fatigue strength. **7 Hours**

NOTE: Students are advised to prepare the report in the form of assignment to understand the subject and its relevance in the industry

Text Books:

1. Ralph I. Stephens, Ali Fatemi, Robert, Henry o. Fuchs, “Metal Fatigue in engineering”, John Wiley New York, Second edition. 2001.
2. Failure of Materials in Mechanical Design, Jack. A. Collins, John Wiley, New York 1992.
3. Robert L. Norton, “Machine Design”, Pearson Education India, 2000

Reference Books:

1. Suresh, “Fatigue of Materials”, Cambridge University Press, -1998
2. Julie. A. Benantine, “Fundamentals of Metal Fatigue Analysis”, Prentice Hall,1990
3. Fatigue and Fracture, ASM Hand Book, Vol 19,2002.

Course Outcomes:

Upon completion of this course, the student will be able to

CO1	Predict failure of engineering components using appropriate failure theories.
CO2	Identify and explain the types of fractures of engineered materials and their characteristic features;
CO3	Estimate life of components using stress life, strain life and LEFM approach.
CO4	Categorize different types of surface failures.

<u>SCHEME OF EXAMINATION (QUESTION PAPER PATTERN)</u>

1. Seven FULL questions to be set.
2. Five FULL questions to be answered.
3. Chapter-1, Chapter-4, Chapter-5, are compulsory, with one question from each chapter
4. Chapter-2 and Chapter-3: two questions to be set with choice.

EXPERIMENTAL MECHANICS

Course Code	:	16MMD23		**CIE Marks**	:	**50**
Hrs/Week	:	**L: T: P: 4:0:0**		**SEE Marks**	:	**50**
Credits	:	**04**		**SEE Duration**	:	**3 hours**

Course Objective:

This course aims at a comprehensive study of mechanics of solids. The objective of this course is to familiarize the student with state-of-the-art experimental techniques namely strain gauges, photo elasticity, moiré interferometry, brittle coating, moiré fringes and holography.

Course Content: Chapters/ Units

1. **Introduction**: Definition of terms, calibration, standards, dimension and units, generalized measurement system, Basic concepts in dynamic measurements, system response, distortion, impedance matching, experiment planning.
   Analysis of Experimental Data: Cause and types of experimental errors, error analysis. Statistical analysis of experimental data- Probability distribution, gaussian, normal distribution. Chi-square test, Method of least square, correlation coefficient, multivariable regression, standard deviation of mean, graphical analysis and curve fitting, general consideration in data analysis. **12 Hours**

2. **Data Acquisition and Processing:** General data acquisition system, signal conditioning revisited, data transmission, Analog-to-Digital and Digital-to- Analog conversion, Basic components (storage and display) of data acquisition system. Computer program as a substitute for wired logic.
   Force, Torque and Strain Measurement: Mass balance measurement, Elastic Element for force measurement, torque measurement. Strain Gages -Strain sensitivity of gage metals, Gage construction, Gage sensitivity and gage factor, Performance characteristics, Environmental effects Strain, gage circuits, Potentiometer, Wheat Stone's bridges, Constant current circuits. Strain Analysis Methods-Two element and three element, rectangular and delta rosettes, Correction for transverse strains effects, stress gage - plane shear gage, Stress intensity factor gage. **12 Hours**

3. **Stress Analysis:** Two-Dimensional Photo elasticity **-** Nature of light, - wave theory of light, - optical interference - Polariscopes stress optic law - effect of stressed model in plane and circular Polariscopes, Isoclinic chromatics fringe order determination - Fringe multiplication techniques - Calibration Photo elastic model materials. Separation methods shear difference method, Analytical separation methods, Model to prototype scaling**.** **10 Hours**

4. **Three-Dimensional Photo elasticity:** Stress freezing method, General slice, Effective stresses, Stresses separation, Shear deference method, Oblique incidence method Secondary principals' stresses, Scattered light photo elasticity, Principals, Polari scope and stress data analyses**.** **8 Hours**

5. **Coating Methods:** a) Photo elastic Coating Method-Birefringence coating techniques Sensitivity Reinforcing and thickness effects – data reduction - Stress separation techniques Photo elastic strain gauges. b) Brittle Coatings Method: Brittle coating technique Principles data analysis - coating materials, Coating techniques. c) Moire Technique - Geometrical approach, Displacement approach- sensitivity of Moire data reduction, In plane and out plane Moire methods, Moire photography, Moire grid production.

Holography: Introduction, Equation for plane waves and spherical waves, Intensity, Coherence, Spherical radiator as an object (record process), Hurter, Driffield curves, Reconstruction process, Holographic interferometry, Realtime. and double exposure methods, Displacement measurement, Isopachics. **10 Hours**

NOTE: the students are advised to prepare the report in the form of assignment to understand the subject and its relevance in the industry

Text Books:

1. **Holman,** "Experimental Methods for Engineers" 7th Edition, Tata McGraw-Hill Companies, Inc, New York, 2007.
2. **R. S. Sirohi, H. C. Radha Krishna,** "Mechanical measurements" New Age International Pvt. Ltd., New Delhi, 2004
3. **Experimental Stress Analysis** - Srinath, Lingaiah, Raghavan, Gargesa, Ramachandra and Pant, Tata McGraw Hill, 1984.
4. **Instrumentation, Measurement and Analysis -**Nakra &Chaudhry, B C Nakra K Chaudhry, Tata McGraw-Hill Companies, Inc, New York, Seventh Edition, 2006.

Reference Books:

1. **Measurement Systems Application and Design -** Doeblin E. A., 4th (S.I.) Edition, McGraw Hill, New York. 1989
2. **Design and Analysis of Experiments -** Montgomery D.C., John Wiley & Sons, 1997.
3. **Experimental Stress Analysis** - Dally and Riley, McGraw Hill, 1991.
4. **Experimental Stress Analysis -** Sadhu Singh, Khanna publisher, 1990.
5. **Photoelasticity Vol I and Vol II -** M.M. Frocht, John Wiley and sons, 1969.
6. **Strain Gauge Primer -** Perry and Lissner, McGraw Hill, 1962.

Course Outcomes:

Upon completion of this course, the student will be able to

CO1	Understand functional requirements of a generalized measurement system and identify suitable components for an application.
CO2	Use concepts of Data Acquisition, Processing and apply the same for interpretation and analysis of experimental data.
CO3	Determine stresses and strains in a structure using different methods such as strain gages, photo-elasticity, brittle coating and holography.
CO4	Identify and apply suitable experimental stress analysis to practical problems

SCHEME OF EXAMINATION (QUESTION PAPER PATTERN)

1. Seven FULL questions to be set.
2. Five FULL questions to be answered.
3. Chapter-3, Chapter-4, Chapter-5, are compulsory, with one question from each chapter
4. Chapter-1 and Chapter-2: two questions to be set with choice.

TRIBOLOGY AND BEARING DESIGN

Course Code	**:**	**16MMD24**		**CIE Marks**	**:**	**50**
Hrs/Week	**:**	**L: T: P: 4:0:0**		**SEE Marks**	**:**	**50**
Credits	**:**	**04**		**SEE Duration**	**:**	**3 hours**

Course Objective:

Gives in-depth knowledge regarding hydrodynamic, hydrostatic lubrication and various bearings, with their design and applications

Course Content: Chapters/ Units

1. **Introduction to Tribology:** Introduction, Friction, Wear, Wear Characterization, Regimes of lubrication, Classification of contacts, lubrication theories, Effect of pressure and temperature on viscosity. Newton's Law of viscous forces, Flow through stationary parallel plates. Hagen's Poiseuille's theory, viscometers. Numerical problems, Concept of lightly loaded bearings, Petroff's equation, Numerical problems. **8 Hours**

2. **Hydrodynamic Lubrications:** Pressure development mechanism. Converging and diverging films and pressure induced flow. Reynolds's 2D equation with assumptions. Introduction to idealized slide bearing with fixed shoe and Pivoted shoes. Expression for load carrying capacity. Location of center of pressure, effect of end leakage on performance, Numerical problems

   Journal Bearings: Introduction to idealized full journal bearings. Load carrying capacity of idealized full journal bearings, Sommer Feld number and its significance, short and partial bearings, Comparison between lightly loaded and heavily loaded bearings, effects of end leakage on performance, Numerical problems. **12 Hours**

3. **Hydrostatic Bearings:** Hydrostatic thrust bearings, hydrostatic circular pad, annular pad, rectangular pad bearings, types of flow restrictors, expression for discharge, load carrying capacity and condition for minimum power loss, numerical problems, and hydrostatic journal bearings.

   EHL Contacts: Introduction to Elasto- hydrodynamic lubricated bearings. Introduction to 'EHL' constant, Grubin type solution. **12 Hours**

4. **Antifriction bearings:** Advantages, selection, nominal life, static and dynamic load bearing capacity, probability of survival, equivalent load, cubic mean load, bearing mountings.

   Porous Bearings: Introduction to porous and gas lubricated bearings. Governing differential equation for gas lubricated bearings, Equations for porous bearings and working principal, Fretting phenomenon and its stages. **10 Hours**

5. **Magnetic Bearings:** Introduction to magnetic bearings, Active magnetic bearings. Different equations used in magnetic bearings and working principal. Advantages and disadvantages of magnetic bearings, Electrical analogy, Magneto-hydrodynamic bearings.

   Advanced bearing systems and their advantages over conventional bearing systems, testing of different types of bearings **10 hours**

NOTE: Students are advised to prepare the report in the form of assignment to understand the subject and its relevance in the industry

Text Books

1. Mujamdar.B.C "Introduction to Tribology of Bearing", Wheeler Publishing, New Delhi 2001
2. Radzimovsky, "Lubrication of Bearings - Theoretical principles and design" Oxford press Company, 2000

Reference Books

1. Dudley D. Fulier " Theory and practice of Lubrication for Engineers", New YorkCompany.1998
2. Moore "Principles and applications of Tribology" Pergamon press, 1975
3. Oscar Pinkus, Beno Sternlicht, "Theory of hydro dynamic lubrication", McGraw-Hill, 1961
4. G W Stachowiak, A W Batchelor, "Engineering Tribology", Elsevier publication 1993.
5. Hydrostatic and hybrid bearings, Butterworth 1983.
6. F. M. Stansfield, Hydrostatic bearings for machine tools and similar applications, Machinery Publishing, 1970

Course Outcome:

Upon completion of this course, the student will be able to

CO1	Students develop skills to design and selection of bearings on Various tribological factors to be considered in moving and rotating parts.
CO2	The students are exposed to orient towards the various types of bearings and their applications.
CO3	Students are exposed to synthesis and analysis of the bearings including fault diagnosis.

SCHEME OF EXAMINATION (QUESTION PAPER PATTERN)

1. Seven FULL questions to be set.
2. Five FULL questions to be answered.
3. Chapter-1, Chapter-4, Chapter-5, are compulsory, with one question from each chapter
4. Chapter-2 and Chapter-3: two questions to be set with choice.

Elective-II

THEORY OF PLASTICITY

Course Code	**:**	**16MMD251**		**CIE Marks**	**:**	**50**
Hrs/Week	**:**	**L: T: P: 4:0:0**		**SEE Marks**	**:**	**50**
Credits	**:**	**04**		**SEE Duration**	**:**	**3 hours**

Course Objective:
This course focuses on stress-strain relations, yield criteria and associated flow rules for elastic-plastic analysis of components and structures

Course Content: Chapters/ Units

1. Definition and scope of the subject, Brief review of elasticity, Octahedral normal and shear stresses, Spherical and deviatoric stress, Invariance in terms of the deviatoric stresses, Idealized stress-strain diagrams for different material models, Engineering and natural strains, Mathematical relationships between true stress and true strains, Cubical dilation, finite strains co- efficient Octahedral strain, Strain rate and the strain rate tensor. **11 Hours**

2. Material Models, Stress-strain relations, Yield criteria for ductile metal, Von Mises, Tresca, Yield surface for an Isotropic Plastic materials, Stress space, Experimental verification of Yield criteria, Yield criteria for an anisotropic material, flow rule normality, Yield locus, Symmetry convexity, Deformation of isotropic and kinematic hardening, bilinear stress-strain relationship, power law hardening, deformation theory of plasticity, J2 flow theory, J2incremental theory. **11 Hours**

3. Plastic stress-strain relations, Prandtl-Rouss Saint Venant, Levy-Von Mises, Experimental verification of the Prandtl- Rouss equation Upper and lower bound theorems and corollaries, Application to problems Uni-axial tension and compression, Stages of plastic yielding. **10 Hours**

4. Bending of beams, Torsion of rods and tubes, Nonlinear bending and torsion equations, Simple forms of indentation problems using upper bounds, Application of Metal forming: Extrusion, Drawing, Rolling and Forging. **10 Hours**

5. Slip line theory, Introduction, Basic equations for incompressible two-dimensional flows, continuity equations, Stresses in conditions of plain Strain convention for slip-lines, Geometry of slip lines, Properties of slip lines, Computational Plasticity- Finite element method, Formulations, Plasticity models. **10 Hours**

NOTE: the students are advised to prepare the report in the form of assignment to understand the subject and its relevance in the industry

Text Books

1. Engineering Plasticity - Theory and Application to Metal Forming Process -R.A.C..Slater, McMillan Press Ltd., 1977
2. Theory of Plasticity and Metal forming Process - Sadhu Singh, Khanna Publishers, Delhi, 1999.

Reference Books

1. Introduction to the Theory of Plasticity for Engineers- Haffman and Sachs, LLC, 2012.
2. Theory of plasticity - J Chakrabarty, Butterworth, 2006.
3. Plasticity for Mechanical Engineers - Johnson and Mellor, Van Nostrand, 1966.

Course Outcomes:

Upon completion of this course, the student will be able to

CO1	Analyze and determine the elastic and elastoplastic stress- strain behavior of solid deformable bodies subjected to various types of loads.
CO2	Analyze and asses the yielding behavior in metallic material using suitable yield criteria.
CO3	Develop plastic stress-strain relation for large plastic deformation and apply same along with knowledge of yield criteria to various metal forming process.
CO4	Develop fundamental equations of slip line field theory.

SCHEME OF EXAMINATION (QUESTION PAPER PATTERN)

1. Seven FULL questions to be set.
2. Five FULL questions to be answered.
3. Chapter-3, Chapter-4, Chapter-5, are compulsory, with one question from each chapter
4. Chapter-1 and Chapter-2: two questions to be set with choice.

ROTOR DYNAMICS

Course Code	**:**	**16MMD252**		**CIE Marks**	**:**	**50**
Hrs/Week	**:**	**L: T: P: 4:0:0**		**SEE Marks**	**:**	**50**
Credits	**:**	**04**		**SEE Duration**	**:**	**3 hours**

Course Objective:
This course is of interest to turbo machinery designers. Specifically modeling of bearings, shafts and rotor stages (compressors, turbines including blades) to predict instability like whirling including gyroscopic and corialis effect.

Course Content: Chapters/ Units

1. **Fluid Film Lubrication:** Basic theory of fluid film lubrication, Derivation of generalized Reynolds equations, Boundary conditions, Fluid film stiffness and Damping coefficients, Stability and dynamic response for hydrodynamic journal bearing, Two lobe journal bearings.
   Stability of Flexible Shafts: Introduction, equation of motion of a flexible shaft with rigid support, Radial elastic friction forces, Rotary friction, friction Independent of velocity, friction dependent on frequency, Different shaft stiffness Constant, gyroscopic effects, Nonlinear problems of large deformation applied forces, instability of rotors in magnetic field. **14 Hours**

2. **Critical Speed:** Dunkerley's method, Rayleigh's method, Stodola's method. Rotor Bearing System: Instability of rotors due to the effect of hydrodynamic oil layer in the bearings, support flexibility, Simple model with one concentrated mass at the center **6 Hours**

3. **Turbo rotor System Stability by Transfer Matrix Formulation:** General turbo rotor system, development of element transfer matrices, the matrix differential equation, effect of shear and rotary inertia, the elastic rotors supported in bearings, numerical solutions. **10 Hours**

4. **Turbo rotor System Stability by Finite Element Formulation:** General turbo rotor system, generalized forces and co-ordinates system assembly element matrices, Consistent mass matrix formulation, Lumped mass model, linearized model for journal bearings, System dynamic equations Fix stability analysis non dimensional stability analysis, unbalance response and Transient analysis. **14 Hours**

5. **Blade Vibration:** Centrifugal effect, Transfer matrix and Finite element, approaches. **8 Hours**

NOTE: the students are advised to prepare the report in the form of assignment to understand the subject and its relevance in the industry.

Reference Books:

1. Cameron, "Principles of Lubrication", Longman Publishing Group, 1986
2. Bolotin, "Nonconservative problems of the Theory of elastic stability", Macmillan, 1963
3. Peztel, Lockie, "Matrix Methods in Elasto Mechanic s", McGraw-Hill, 1963.
4. Timoshenko, "Vibration Problems in Engineering", Ox ford City Press, 2011
5. Zienkiewicz, "The finite element method in engineering science", McGraw-Hill, 1971

Course Outcomes:

Upon completion of this course, the student will be able to

CO1	Model a rotating machine element theoretically for rotor dynamic analysis.
CO2	Analyze Free and Forced lateral response of simple rotor models and of more complex systems including shafts, bearings, seals and stators.
CO3	Formulate Finite element and carry out analysis for Turborotor System Stability.
CO4	Apply Finite element approach to blade vibration.

SCHEME OF EXAMINATION (QUESTION PAPER PATTERN)

1. Seven FULL questions to be set.
2. Five FULL questions to be answered.
3. Chapter-2, Chapter-3, Chapter-5, are compulsory, with one question from each chapter
4. Chapter-1 and Chapter-4: two questions to be set with choice.

FINITE ELEMENT METHODS FOR HEAT TRANSFER AND FLUID FLOW ANALYSIS

Course Code	**:**	**16MMD253**		**CIE Marks**	**:**	**50**
Hrs/Week	**:**	**L: T: P: 4:0:0**		**SEE Marks**	**:**	**50**
Credits	**:**	**04**		**SEE Duration**	**:**	**3 hours**

Course Objective:
The student will learn finite element formulation of various modes of heat transfer and fluid flow and to solve numerical examples.

Course Content: Chapters/ Units

1. **Introduction to Heat Transfer and Fluid Mechanics:** Mathematical Preliminaries, Governing equations of a continuum, Governing equation in terms of primitive variables, porous equations, low speed compressible flow equations, auxiliary transport equations, chemically reacting systems, boundary conditions, change of phase, enclosure radiation. 2.
   Finite Element Methods: Introduction, model differential equation, finite element approximations, interpolation functions, library of finite elements, modeling considerations, assembly of elements, numerical integration, discussion of results with some practical examples, time dependent problems.
   12 Hours

2. **Steady State Conduction Heat Transfer:** Introduction, one dimensional linear, quadratic element. Homogeneous, composite wall with uniform and varying cross-sectional area. Radial heat flow in a cylinder. Conduction –convection systems. Numerical examples.
   Conduction Heat Transfer: Interpolation functions for tetrahedral, hexahedral, pyramid and prism elements. Numerical integration, computation of surface flux, semi-discrete finite element model, solution of nonlinear equations for transient problems. Radiation algorithms. Variable properties.
   12 Hours

3. **Advanced topic in Conduction:** specialty elements, computation of boundary conditions, bulk nodes, reactive materials, material motions Example problems on conduction, radiation, temperature dependent conductivity, anisotropic conduction, brazing and welding, investment casting. **8 Hours**

4. **Flows of Viscous Incompressible Fluids:** Governing equation, mixed finite element model, penalty finite element models. Finite element models of porous flow
   Computational consideration: Interpolation functions for triangular, quadrilateral, tetrahedral and hexahedral elements. Evaluation of element matrices in penalty model, pressure calculation and traction boundary conditions. Numerical examples. **10 Hours**

5. **Coupled Fluid Flow and Heat Transfer:** Introduction to non-isothermal incompressible flows, governing equations and boundary condition. Mixed, penalty finite element model. Finite element model for porous flow. Non-isothermal low speed compressible flows: governing equation, boundary conditions, mixed finite element model and solution methods. Convection with change of phase, convection with enclosure radiation, turbulent heat transfer, chemically reacting systems. Numerical examples. **10 Hours**

NOTE: the students are advised to prepare the report in the form of assignment to understand the subject and its relevance in the industry

Text Books:

1. J N Reddy, David K. Gartling, "The finite element method in heat transfer and flu id dynamics", CRC, 2004.
2. Roland Wynne Lewis, Perumal Nithiarasu, K. N. Seetharamu," Fundamentals of the finite element method for heat and fluid flow"
   John Wiley, 2004

Reference Books:

1. Ching Jen Chen, R. A. Bernatz, "Finite analytic method in flows and heat transfer", Taylor & Francis.
2. Gianni Comini, Stefano Del Giudice, Carlo Nonino, "Finite Element Analysis in Heat Transfer: Basic Formulation and Linear problems" Taylorand Francis, 1994.

Course Outcomes:

Upon completion of this course, the student will be able to

CO1	This course enables the student to use numerical methods for solving problems of fluid flow and heat transfer.
CO2	Analyze of the continuum mechanics problems like fluid flow, heat transfer.
CO3	Analyze of incompressible and compressible fluids.
CO4	Analyze modes of conduction in various mechanical systems

SCHEME OF EXAMINATION (QUESTION PAPER PATTERN)

1. Seven FULL questions to be set.
2. Five FULL questions to be answered.
3. Chapter-3, Chapter-4, Chapter-5, are compulsory, with one question from each chapter
4. Chapter-1 and Chapter-2: two questions to be set with choice.

Design Engineering Laboratory - Lab 2

Course Code	**:**	**16MMDL26**		**CIE Marks**	**:**	**50**
Hrs/Week	**:**	**L: T: P: 0:0:3**		**SEE Marks**	**:**	**50**
Credits	**:**	**02**		**SEE Duration**	**:**	**3 hours**

Note:

1) These are independent laboratory exercises
2) A student may be given one or two problems stated herein
3) Student must submit a comprehensive report on the problem solved and give a Presentation on the same for Internal Evaluation
4) Any one of the exercises done from the following list has to be asked in the Examination for evaluation.

Course Content:

Experiment #1 Structural Analysis
Part A: FE Modeling of a stiffened Panel using a commercial preprocessor.
Part B: Buckling, Bending and Modal analysis of stiffened Panels.
Part C: Parametric Studies.

Experiment #2 Design Optimization
Part A: Shape Optimization of a rotating annular disk.
Part B: Weight Minimization of a Rail Car Suspension Spring.
Part C: Topology Optimization of a Bracket.

Experiment #3 Thermal analysis
Part A: Square Plate with Temperature Prescribed on one edge and Opposite edge insulated.
Part B: A Thick Square Plate with the Top Surface exposed to a Fluid at high temperature, Bottom Surface at room temperature, Lateral Surfaces Insulated.

Experiment #4 Thermal Stress Analysis
Part A: A Thick-Walled Cylinder with specified Temperature at inner and outer Surfaces.
Part B: A Thick-Walled Cylinder filled with a Fluid at high temperature and Outer Surface exposed to atmosphere.

Experiment#5 CFD Analysis
Part A: CFD Analysis of a Hydro Dynamic Bearing using commercial code.
Part B: Comparison of predicted Pressure and Velocity distributions with Target solutions.
Part C: Experimental Investigations using a Journal Bearing Test Rig.
Part D: Correlation Studies.

Experiment #6 Welded Joints.
Part A: Fabrication and Testing.
Part B: FE Modeling and Failure Analysis.
Part C: Correlation Studies.

Experiment #7 Bolted Joints.

Part A: Fabrication and Testing.

Part B: FE Modeling and Failure Analysis.

Part C: Correlation Studies.

Experiment #8 Adhesive Bonded Joints.

Part A: Fabrication and Testing.

Part B: FE Modeling and Failure Analysis.

Part C: Correlation Studies.

RESEARCH METHODOLOGY

Course Code	**:**	**RM 27**		**CIE Marks**	**:**	**50**
Hrs/Week	**:**	**L: T: P: 2:0:0**		**SEE Marks**	**:**	**50**
Credits	**:**	**02**		**SEE Duration**	**:**	**3 hours**

Course Learning Objectives: Students are expected to

- Have a basic understanding of the underlying principles of quantitative and qualitative research
- Identify the overall process of designing a research study from its inception to its report.
- Choose the most appropriate research method to address a particular research question
- Gain a overview of a range of quantitative and qualitative approaches to data analysis

1. **Overview of Research:** Research and its types, identifying and defining research problem and introduction to different research designs. Essential constituents of Literature Review. Basic principles of experimental design, Primary data and Secondary Data, methods of primary data collection, classification of secondary data, designing questionnaires and schedules. **8 Hours**

2. **Sampling Methods:** Probability sampling: simple random sampling, systematic sampling, stratified sampling, cluster sampling and multistage sampling. Non-probability sampling: convenience sampling, judgment sampling, quota sampling. Sampling distributions. **6 Hours**

3. **Processing and analysis of Data:** Statistical measures and their significance: Central tendencies, variation, skewness, Kurtosis, time series analysis, correlation and regression, Testing of Hypotheses: Parametric (t and Chi Square). **6 Hours**

4. **Essential of Report writing and Ethical issues**: Significance of Report Writing, Different Steps in Writing Report, Layout of the Research Report, Ethical issues related to Research, Plagiarism and self- Plagiarism, Publishing. **6 Hours**

Reference Books:

1. Krishnaswami, K.N., Sivakumar, A. I. and Mathirajan, M., Management Research Methodology, Pearson Education: New Delhi.
2. Kothari C.R., Research Methodology Methods and techniques by, New Age International Publishers, 2nd edition
3. Levin, R.I. and Rubin, D.S., Statistics for Management, 7th Edition, Pearson Education: New Delhi.

Course Outcome:

At the end of the course students will:

CO1	Describe a range of quantitative and qualitative research designs and identify the advantages and disadvantages associated with these designs
CO2	Choose appropriate quantitative or qualitative method to collect data
CO3	Analyze and test the given data using appropriate methods
CO4	Design an appropriate mixed-method research study to answer a research question

MINI PROJECT/ INDUSTRIAL VISIT/ FIELD WORK

Course Code	**:**	**16MMDM28**		**CIE Marks**	**:**	**50**
Hrs/Week	**:**	**L: T: P: S 0:0:0:3**		**SEE Marks**	**:**	**50**
Credits	**:**	**02**		**SEE Duration**	**:**	**3 hours**

- **Industrial Visit**: At the end of second CIE the industrial visit will be arranged in the domain field, each student is required to submit the report of the visit.
- Report submissions and final Evaluation is to be carried out by the Internal Guide of the college and a senior faculty along with HOD.

OR

- **Seminar**: At the end of second CIE each student is required to present the seminar of his/her interested field (Related to design subjects).
- Report submissions and final Evaluation is to be carried out by the Internal Guide of the college and a senior faculty along with HOD.

Semester III

INTERNSHIP

Internship: The student shall undergo internship for 16 weeks.

Preliminary Report submission and Evaluation after 8th week of Internship to be carried out by the Internal Guide of the college and a senior faculty for 100 marks

Final Report submission and Evaluation after 16th week of Internship to be carried out by the Internal Guide of the college and a senior faculty. Report Evaluation to be completed within two weeks of submission for 100 marks.

Viva-Voce on Internship - To be conducted by the Internship Guide (from the college) and the External Guide / Examiner within 2 weeks of Submission with a senior faculty / HOD as chairman for 100 marks

Project Phase: I

Problem formulation and submission of **synopsis** within 8 weeks from the commencement of 3rd semester, which shall be evaluated for 50 marks by the committee constituted for the purpose by the Head of the Department comprising the guide, senior faculty of the department with HOD as Chairman.

Literature survey and progress done after 16 weeks shall be evaluated by guide and external examiner with senior faculty / HOD as chairman for 100 marks.

IV Semester

Project Phase-II - Internal Evaluation of progress in Project work shall be evaluated after 8 weeks for 100 marks by the committee constituted for the purpose by the Head of the Department comprising the guide and senior faculty of the department with HOD as Chairman.

Project Phase-III - Internal Evaluation of Project Demonstration, which shall be evaluated after 15 weeks for 100 marks by the committee constituted for the purpose by the Head of the Department.

Final Evaluation of Project Work and Viva-voce.

Final evaluation of project to be carried out after 16 weeks from the date of commencement of 4^{th} semester.

The Internal Examiner (the project guide with a teaching experience of at least three years) and External Examiner with HOD as chairman will complete the final evaluation of Project.

Internal and External Examiners shall carry out the evaluation for 100 Marks each and the average of these marks shall be the final marks of the Project Evaluation.

Viva – Voce: The Viva-Voce shall be conducted jointly by Internal Examiner and External Examiner with HOD as chairman for 100 Marks.

FRACTURE MECHANICS

Course Code	**:**	**16MMD41**		**CIE Marks**	**:**	**50**
Hrs/Week	**:**	**L: T: P: 4:0:0**		**SEE Marks**	**:**	**50**
Credits	**:**	**04**		**SEE Duration**	**:**	**3 hours**

Course Objective:

Fracture mechanics provides a methodology for prediction, prevention and control of fracture in materials, components and structures. It provides a background for damage tolerant design. It quantifies toughness as materials resistance to crack propagation.

Course Content: Chapters/ Units

1. **Fracture mechanics principles:** Introduction and historical review, Sources of micro and macro cracks. Stress concentration due to elliptical hole, Strength ideal materials, Griffith's energy balance approach. Fracture mechanics approach to design. NDT and Various NDT methods used in fracture mechanics, Numerical problems. The Airy stress functions. Complex stress function. Solution to crack problems. Effect of finite size. Special cases, Elliptical cracks, Numerical problems. **13 Hours**

2. Plasticity effects, Irwin plastic zone correction. Dugdale approach. The shape of the plastic zone for plane stress and plane strain cases, Plastic constraint factor. The Thickness effect, numerical problems.
   Determination of Stress intensity factors and plane strain fracture toughness: Introduction, analysis and numerical methods, experimental methods, estimation of stress intensity factors. Plane strain fracture toughness test, The Standard test. Size requirements. Non-linearity. Applicability. **13Hours**

3. The energy release rate, Criteria for crack growth. The crack resistance (R curve). Compliance, J integral. Tearing modulus. Stability.
   Elastic plastic fracture mechanics: Fracture beyond general yield. The Crack-tip opening displacement. The Use of CTOD criteria. Experimental determination of CTOD. Parameters affecting the critical CTOD. Use of J integral. Limitation of J integral. **12 Hours**

4. **Dynamics and crack arrest:** Crack speed and kinetic energy. Dynamic stress intensity and elastic energy release rate. Crack branching. Principles of crack arrest. Crack arrest in practice. Dynamic fracture toughness**.** **6 Hours**

5. **Fatigue crack propagation and applications of fracture mechanics:** Crack growth and the stress intensity factor. Factors affecting crack propagation. variable amplitude service loading, means to provide fail-safety, required information for fracture mechanics approach, Mixed mode (combined) loading and design criteria. **8 Hours**

NOTE: the students are advised to prepare the report in the form of assignment to understand the subject and its relevance in the industry

Text Books:

1. David Broek, “Elementary Engineering Fracture Mechanics”, Springer Netherlands,2011
2. Anderson, “Fracture Mechanics-Fundamental and Application”, T.L CRC press1998.

Reference Books:

1. Karen Hellan, “Introduction to fracture mechanics”, McGraw Hill, 2^{nd} Edition
2. S.A. Meguid, “Engineering fracture mechanics” Elsevier Applied Science, 1989
3. Jayatilaka, “Fracture of Engineering Brittle Materials”, Applied Science Publishers, 1979
4. Rolfe and Barsom, “Fracture and Fatigue Control in Structures”, Prentice Hall, 1977
5. Knott, “Fundamentals of fracture mechanisms”, Butter worth’s, 1973

Course Outcome:

At the end of the course students will:

CO1	Develop fundamental understanding of the effects of crack like defects on the performance of aerospace, civil, and mechanical engineering structures.
CO2	Select appropriate materials for engineering structures to ensure damage tolerance.
CO3	Employ modern numerical methods to determine critical crack sizes and fatigue crack propagation rates in engineering structures.
CO4	Gain appreciation of the status of academic research in field of fracture mechanics.

SCHEME OF EXAMINATION (QUESTION PAPER PATTERN)

1. Seven FULL questions to be set.
2. Five FULL questions to be answered.
3. Chapter-3, Chapter-4, Chapter-5, are compulsory, with one question from each chapter
4. Chapter-1 and Chapter-2: two questions to be set with choice.

ELECTIVE-I

COMPUTATIONAL FLUID DYNAMICS

Course Code	**:**	**16MMD421**		**CIE Marks**	**:**	**50**
Hrs/Week	**:**	**L: T: P: 4:0:0**		**SEE Marks**	**:**	**50**
Credits	**:**	**04**		**SEE Duration**	**:**	**3 hours**

Course Objective:
This course would create awareness about the theory behind fluid dynamics computations as applied in analysis tools.

Course Content: Chapters/ Units

1. Basic Concepts - Dimensionless form of equations; Simplified mathematical models; Hyperbolic, Parabolic & Elliptic systems; Properties of numerical solutions (Consistency, Stability, Conservation, Convergence and Accuracy). **8 Hours**

2. Finite Difference Methods - Discretization; Boundary conditions; error propagation; Introduction to spectral methods; examples. **10 Hours**

3. Finite volume method - Surface & volume integrals; Interpolation & differentiation; Boundary conditions; Examples. **10 Hours**

4. Gaussian Elimination; LU decomposition; Tridiagonal Systems; Iterative methods; convergence; ADI & other splitting methods. Multi-grid method - Coupled equations; Simultaneous solutions, sequential solutions & under relaxation. Nonlinear systems **12 Hours**

5. Initial value problem & Boundary value problems; Implicit & Explicit Schemes; 2D and 3D examples. Heat and Mass transfer Problems; Multi Phase Flows. **12 Hours**

NOTE: the students are advised to prepare the report in the form of assignment to understand the subject and its relevance in the industry

Text Books:

1. Computational Methods for Fluid Dynamics, 3rd edition - J.H. Ferziger& M. Peric, Springer, 2002.
2. Numerical Solutions of Partial Differential Equations, Finite Difference methods, 3rd ed., - G.D. Smith, Oxford University Press. 1986.

Reference Books:

1. **Computational Fluid Dynamics -** T. J. Chung, Cambridge Univ. Press, 2002.
2. **Partial Differential Equations for Scientists and Engineers -** Farlow, John Wiley, 1982.

Course Outcome:

The student will be able to analyze and obtain numerical solutions to fluid dynamics problems

CO1	The course will equip the students with the necessary knowledge to use computational techniques related to flow mechanics.
CO2	Understand and apply finite difference, finite volume and finite element methods to fluid flow problems
CO3	Understand and apply compressible flow solvers
CO4	Understand the issues surrounding two phase flow modeling

SCHEME OF EXAMINATION (QUESTION PAPER PATTERN)

1. Seven FULL questions to be set.
2. Five FULL questions to be answered.
3. Chapter-1, Chapter-2, Chapter-3, are compulsory, with one question from each chapter
4. Chapter-4 and Chapter-5: two questions to be set with choice.

SMART MATERIALS AND STRUCTURES

Course Code	**:**	**16MMD422**		**CIE Marks**	**:**	**50**
Hrs/Week	**:**	**L: T: P: 4:0:0**		**SEE Marks**	**:**	**50**
Credits	**:**	**04**		**SEE Duration**	**:**	**3 hours**

Course Objective:
Knowledge of smart materials and structures is essential designing mechanical systems for advanced engineering applications, the course aims at training students in smart materials and structures application and analysis

Course Content: Chapters/ Units

1. **Smart Structures**: Types of Smart Structures, Potential Feasibility of Smart Structures, Key Elements of Smart Structures, Applications of Smart Structures. Piezoelectric materials, Properties, piezoelectric Constitutive Relations, Depoling and Coersive Field, field strain relation. Hysteresis, Creep and Strain Rate effects, Inchworm Linear Motor.
   Beam Modeling: Beam Modeling with induced strain Rate effects, Inchworm Linear Motor Beam Modeling with induced strain Actuation-single Actuators, dual Actuators, Pure Extension, Pure Bending harmonic excitation, Bernoulli-Euler beam Model, problems, Piezoelectric Applications.
   12 Hours

2. **Shape memory Alloy:** Experimental Phenomenology, Shape Memory Effect, Phase Transformation, Tanaka's Constitutive Model, testing of SMA Wires, Vibration Control through SMA, Multiplexing. Applications Of SMA and Problems.
   ER and MR Fluids: Mechanisms and properties, Fluid Composition and behavior, The Bingham Plastic and Related Models, Pre-Yield Response. Post-Yield flow applications in Clutches, Dampers and Others. **14 Hours**

3. **Vibration Absorbers:** series and Parallel Damped Vibrations (Overview), Active Vibration Absorbers, Fiber Optics, Physical Phenomena, Characteristics, Sensors, Fiber Optics in Crack Detection, applications.
   Control of Structures: Modeling, Control Strategies and Limitations, Active Structures in Practice. **14 Hours**

4. **MEMS** – Mechanical Properties of MEMS Materials, Scaling of Mechanical Systems, Fundamentals of Theory, The Intrinsic Characteristics of MEMS, Miniaturization, Microelectronics Integration. **6 Hours**

5. **Devices:** Sensors and Actuators, Conductivity of Semiconductors, Crystal Planes and Orientation, (Stress and Strain Relations, Flexural Beam Bending Analysis Under Simple Loading Conditions), Polymers in MEMS, Optical MEMS Applications. **6 Hours**

NOTE: the students are advised to prepare the report in the form of assignment to understand the subject and its relevance in the industry

TEXT BOOKS:

1. Smart Materials and Structures - M. V. Gandhi and B. So, Thompson, Chapman and Hall, London; New York, 1992 (ISBN: 0412370107).
2. Smart Structures and Materials - B. Culshaw, Artech House, Boston, 1996 (ISBN :0890066817).
3. Smart Structures: Analysis and Design - A. V. Srinivasan, Cambridge University Press, Cambridge; New York, 2001 (ISBN: 0521650267).

REFERENCE BOOKS:

1. Electro ceramics: Materials, Properties and Applications - A. J. Moulson and J. M. Herbert. John Wiley & Sons, ISBN: 0471497429
2. Piezoelectric Sensories: Force, Strain, Pressure, Acceleration and Acoustic Emission Sensors. Materials and Amplifiers, Springer, Berlin; New York, 2002 (ISBN: 3540422595).
3. Piezoelectric Actuators and Wtrasonic Motors - K. Uchino, Kluwer Academic Publishers, Boston, 1997 (ISBN: 0792398114).
4. Handbook of Giant Magneto strictive Materials - G. Engdahl, Academic Press, San Diego, Calif.; London, 2000 (ISBN: 012238640X).
5. Shape Memory Materials - K. Otsuka and C. M. Wayman, Cambridge University Press, Cambridge; New York, 199~ (ISBN: 052144487X).

Course Outcome:

At the completion of this course, students will be able to:

CO1	Understand the behavior and applicability of various smart materials.
CO2	Design Simple models for smart structures and materials
CO3	Perform simulation of smart structures and material application.
CO4	Conduct experiments to verify the predictions.

<u>SCHEME OF EXAMINATION (QUESTION PAPER PATTERN)</u>

1. Seven FULL questions to be set.
2. Five FULL questions to be answered.
3. Chapter-1, Chapter-4, Chapter-5, are compulsory, with one question from each chapter
4. Chapter-2 and Chapter-3: two questions to be set with choice.

DESIGN OPTIMIZATION

Course Code	**:**	**16MMD423**		**CIE Marks**	**:**	**50**
Hrs/Week	**:**	**L: T: P: 4:0:0**		**SEE Marks**	**:**	**50**
Credits	**:**	**04**		**SEE Duration**	**:**	**3 hours**

Course Objective:
It aids the students to acquire the basics of optimum design, Classical Optimization Techniques, Non - linear Programming, Unconstrained Optimization Techniques, Integer Programming and Dynamic Programming.

Course Content: Chapters/ Units

Chapters / Units:

1. **Engineering Design Practice:** Evolution of Design Technology, Introduction to Design and the Design Process, Design versus Analysis, Role of Computers in Design Cycle, Impact of CAE on Design, Numerical Modeling with FEA and Correlation with Physical Tests.
   Applications of Optimization in Engineering Design: Automotive, Aerospace and General Industry Applications, Optimization of Metallic and Composite Structures, Minimization and Maximization Problems, MDO and MOO. **10 Hours**

2. **Optimum Design Problem Formulation**: Types of Optimization Problems, The Mathematics of Optimization, Design Variables and Design Constraints, Feasible and Infeasible Designs, Equality and Inequality Constraints, Discrete and Continuous Optimization, Linear and Non-Linear Optimization.
   Optimization Theory – Fundamental Concepts, Global and Local Minimum, Gradient Vector and Hessian Matrix, Concept of Necessary and Sufficient Conditions, Constrained and Unconstrained Problems, Lagrange Multipliers and Kuhn Tucker Conditions. **12 Hours**

3. **Sensitivity Analysis, Linear and** Non-Linear Approximations. Gradient Based Optimization Methods – Dual and Direct.
   Optimization Disciplines: Conceptual Design Optimization and Design Fine Tuning, Combined Optimization, Optimization of Multiple Static and Dynamic Loads, Transient Simulations, Equivalent Static Load Methods. **10 Hours**

4. **Manufacturability in Optimization Problems:** Design for Manufacturing, Manufacturing Methods and Rules, Applying Manufacturing Constraints to Optimization Problems.
   Design Interpretation: Unbound Problems, Over Constrained Problems, Problems with No of Multiple Solutions, Active and Inactive Constraints, Constraint Violations and Constraint Screening, Design Move Limits, Local and Global Optimum. **12 Hours**

5. **Dynamic Programming:** Introduction, Multistage decision processes, Principle of optimality, Computational Procedure in dynamic programming, Initial value problem, Examples. **8 Hours**

Text Books:

1. S.S. Rao, Engineering Optimization: Theory and Practice, John Wiley, 2009
2. JasbirArora, Introduction to Optimum Design, McGraw Hill, 2011.

Reference Books:

1. Optimization and Probability in System Engg - Ram, Van Nostrand.
2. Optimization methods - K. V. Mital and C. Mohan, New age International Publishers, 1999.
3. Optimization methods for Engg. Design - R.L Fox, Addison – Wesley, 1971.

Course Outcome:

At the completion of this course, students will be able to:

CO1	It provides the student with knowledge required to optimize an existing design with single or multiple objective functions.
CO2	Skills acquired through commercial optimization programs
CO3	Acquire the knowledge of engineering system design

<u>SCHEME OF EXAMINATION (QUESTION PAPER PATTERN)</u>

1. Seven FULL questions to be set.
2. Five FULL questions to be answered.
3. Chapter-1, Chapter-3, Chapter-5, are compulsory, with one question from each chapter
4. Chapter-2 and Chapter-4: two questions to be set with choice.

DR AMBEDKAR INSTITUTE OF TECHONOLOGY

DEPARTMENT OF MECHNICAL ENGINEERING

SCHEME AND SYLLABUS

FOR

M. Tech MACHINE DESIGN

YEAR 2018-19

PROGRAM EDUCATIONAL OBJECTIVES

PEO1--Graduates will have knowledge in the discipline of Machine Design with hands on skill in using modern engineering tools to address real world engineering problems and be socially responsible.

PEO2– Graduates shall be successful in their career as analysts and designers of structural components of conventional and advanced materials, participating in a team or individually in an industry, research or academia.

PEO3– Graduates shall be proficient in their communication, presentation and will be prepared to engage in the process of life-long learning through professional development and research.

PROGRAM OUTCOMES

PO No.	Program Outcomes (PO)
PO1	Acquire in-depth knowledge of specific discipline or professional area, including wider and global perspective, with an ability to discriminate, evaluate, analyze and synthesize existing and new knowledge, and integration of the same for enhancement of knowledge.
PO2	Analyze complex engineering problems critically, apply independent judgment for synthesizing information to make intellectual and/or creative advances for conducting research in a wider theoretical, practical and policy context
PO3	Think laterally and originally, conceptualize and solve engineering problems, evaluate a wide range of potential solutions for those problems and arrive at feasible, optimal solutions after considering public health and safety, cultural, societal and environmental factors in the core areas of expertise.
PO4	Extract information pertinent to unfamiliar problems through literature survey and experiments, apply appropriate research methodologies, techniques and tools, design, conduct experiments, analyze and interpret data, demonstrate higher order skill and view things in a broader perspective, contribute individually/in group(s) to the development of scientific/technological knowledge in one or more domains of engineering.
PO5	Create, select, learn and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modeling, to complex engineering activities with an understanding of the limitations.
PO6	Possess knowledge and understanding of group dynamics, recognize opportunities and contribute positively to collaborative-multidisciplinary scientific research, demonstrate a capacity for self-management and teamwork, decision-making based on open-mindedness, objectivity and rational analysis in order to achieve common goals and further the learning of themselves as well as others.
PO7	Demonstrate knowledge and understanding of engineering and management principles and apply the same to one’s own work, as a member and leader in a team, manage projects efficiently in respective disciplines and multidisciplinary environments after consideration of economic and financial factors.
PO8	Communicate with the engineering community, and with society at large, regarding complex engineering activities confidently and effectively, such as, being able to comprehend and write effective reports and design documentation by adhering to appropriate standards, make effective presentations, and give and receive clear instructions.
PO9	Recognize the need for, and have the preparation and ability to engage in life-long learning independently, with a high level of enthusiasm and commitment to improve knowledge and competence continuously.
PO10	Acquire professional and intellectual integrity, professional code of conduct, ethics of research and scholarship, consideration of the impact of research outcomes on professional practices and an understanding of responsibility to contribute to the community for sustainable development of society.
PO11	Observe and examine critically the outcomes of one’s actions and make corrective

BATCH **2018-19** **MACHINE DESIGN**

FIRST SEMSTER			L	T	P	C
1	18MMD11	ADVANCED MECHANICS OF SOLIDS	4	0	0	4.0
2	18MMD12	FINITE ELEMENT METHOD	3	0	2	4.0
3	18MMD131	EXPERIMENTAL MECHANICS	3	0	2	4.0
4	18MMD132	ROBUST DESIGN	4	0	0	
5	18MMD141	DYNAMICS AND MACHINE DESIGN	4	0	0	4.0
6	18MMD142	DESIGN FOR MANUFACTURE	4	0	0	
7	18MMD151	MECHATRONICS SYSTEM DESIGN	4	0	0	4.0
8	18MMD152	AUTOMOBILE SYSTEM DESIGN	4	0	0	
9	18MMD16	INDUSTRIAL VISIT		0	2	2.0
FIRST SEMESTER END CREDITS						22.0

SECOND SEMSTER			L	T	P	C
1	18MMD21	ADVANCED MACHINE DESIGN	4	0	0	4.0
2	18MMD22	ADVANCED THEORY OF VIBRATIONS	3	0	2	4.0
3	18MMD231	TRIBOLOGY AND BEARING DESIGN	4	0	0	4.0
4	18MMD232	DESIGN OPTIMIZATION	4	0	0	
5	18MMD241	COMPOSITE MATERIALS TECHONOLOGY	4	0	0	4.0
6	18MMD242	FINITE ELEMENT METHODS FOR HEAT TRANSFER	4	0	0	
7	18MMD251	THEORY OF PLASTICITY	4	0	0	4.0
8	18MMD252	ROTOR DYNAMICS	4	0	0	
9	RM27	RESEARCH METHODOLOGY	2	0	0	2.0
SECOND SEMESTER END CREDITS						22.0
FIRST YEAR CREDITS						44.0
CUMULATIVE CREDITS AT END OF 1st YEAR						44.0

BATCH **2018-19** **MACHINE DESIGN**

THIRD SEMSTER			L	T	P	C
1	18MMD31	FRACTURE MECHANICS	3	0	0	3.0
2	18MMD32X	ELECTIVE -1	3	0	0	3.0
3	18MMD33X	ELECTIVE -2	3	0	0	3.0
4	18MMDI34	INTERNSHIP	0	0	6	6.0
5	18MMDL35	MODELING AND ANALYSIS LAB	0	0	2	2.0
6	18MMDS36	TECHNICAL SEMINAR	0	0	1	1.0
7	18MMDP37	PROJECT PHASE -1	0	2	0	2.0
THIRD SEMESTER END CREDITS						20.0

ELECTIVE 1			ELECTIVE-2		
SL.NO	NAME OF THE SUBJECT	Subject code	SL.NO	NAME OF THE SUBJECT	Subject Code
1	SMART MATERIALS AND STRUCTURES	18MMD321	1	COMPUTER APPLICATIONS IN DESIGN	18MMD331
2	STATISTICAL MODELLING& EXPERIMENTAL DESIGN	18MMD322	2	ADVANCE SYSTEM DESIGN	18MMD332
3	OPTIMIZATION TECHNIQUES	18MMD323	3	DESIGN OF HYDRAULICS AND PNEUMATICS	18MMD333
4	THEORY OF PLATES AND SHELLS	18MMD324	4	COMPUTATIONAL METHODS IN ENGINEERING ANALYSIS	18MMD334

FOURTH SEMSTER			L	T	P	C
1	18MMDP41	PROJECT WORK PHASE II – MIDTERM INTERNAL EVALUATION	0	0	2	2.0
2	18MMDP42	PROJECT WORK EVALUATION AND VIVA VOCE	0	0	22	22
FOURTH SEMESTER END CREDITS						24.0
SECOND YEAR CREDITS						44.0
CUMULATIVE CREDITS AT END OF 2nd YEAR						88.0

1ST SEMESTER

ADMISSION YEAR:2018-19 **ACADEMIC YEAR: 2018-19**

COURSE TITLE: ADVANCED MECHANICS OF SOLIDS		
Sub Code:18MMD11	**No of Credits: L-T-P-SS 4:0:0:0 =4**	**No. of lecture hours/week: 04**
Exam Duration: 3 hours	**CIE Marks: 50**	**Exam Marks: 50**
Pre-requisites	**MOM, DESIGN OF MACHINE ELEMENTS.**	

COURSE OBJECTIVES:

To study the basic concept of stresses, stress distribution, elastic constants when the material is subjected to loading within the elastic limits. Study the stress distribution in plane, polar and cylindrical coordinate systems. Analyze the material or component subjected to torsion of circular and non-circular shafts (elliptical, triangular bars) Study the thermo-elastic properties of the material at elevated temperatures.

#	**CONTENTS**	**Hrs**
UNIT-1	**INTRODUCTION TO STRESS:** Definition and Notation for forces and stresses. Components of stresses, equations of Equilibrium, Specification of stress at a point. Principal stresses and shear stresses and Mohr's diagram in three dimensions. Boundary conditions. Stress transformation, Stress components on an arbitrary plane, Stress invariants, Octahedral stresses, Decomposition of state of stress.	08
UNIT-2	**INTRODUCTION TO STRAIN**: Deformation, Strain Displacement relations, Strain components, The state of strain at a point, Principal strain, Strain transformation, Compatibility equations, Cubical dilatation. **STRESS-STRAIN RELATIONS AND THE GENERAL EQUATIONS OF ELASTICITY**: Generalized Hooke's; law in terms of engineering constants. Formulation of elasticity Problems. Existence and uniqueness of solution, Saint -Venant's principle, Principle of super position and reciprocal theorem.	10
UNIT-3	**ENERGY METHODS**: Work done by forces and elastic strain energy stored, Begg's Deformeter, First theorem of Castigliano, Theorem of virtual work, Kirchhoff's theorem.	10
UNIT-4	**TWO DIMENSIONAL PROBLEMS IN CARTESIAN CO-ORDINATES:** Airy's stress function, investigation for simple beam problems. Bending of a narrow cantilever beam under end load, simply supported beam with uniform load, Use of Fourier series to solve two dimensional problems. **TORSION OF PRISMATIC BARS:** Torsion of Circular and elliptical cross section bars, Membrane analogy, Torsion of thin-walled closed tubes.	14

UNIT-5	**TWO DIMENSIONAL PROBLEMS IN POLAR CO-ORDINATES:** General equations, stress distribution symmetrical about an axis, thick cylinder, shrink fit, Strain components in polar co-ordinates, Rotating disk and cylinder, Thermal stresses in thin discs, Stress concentration around a circular hole in an infinite plate. Thermo-elastic stress –strain relations.	**14**

TEXT BOOKS:

1. **Advanced Mechanics of solids**, L. S. Srinath, Tata Mc. Graw Hill, 2003
2. **Theory of Elasticity,** S. P. Timoshenko and J. N Gordier, McGraw Hill International, 3rd edition, 1972

REFERENCES BOOKS:

1. **Theory of Elasticity,** Dr. Sadhu Singh, Khanna Publications, 1988
2. **Elasticity, Theory, Applications &Numericals,** Martin H Sadd, Elsevier. 2005
3. **Applied Elasticity,** Seetharaman & Govindaraju, Interline Publishing
4. **Applied Elasticity,** C.T. WANG Sc. D. Mc. Graw Hill Book Co.1953.

REMINDER

BREAK-UP OF COURSE CONTENTS FOR;
CIE-1: UNIT 1 (100%) + UNIT 2 (100%)
CIE-2: UNIT 3 (100%) + UNIT 4 (FIRST 50%)
CIE-3: UNIT 4 (NEXT 50%) + UNIT 5 (100%)
(Irrespective of portions covered due to whatever might be the reason)

QUESTION PAPER PATTERN (SEE)

Q. No	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**
Unit	**1**		**2**		**3**		**4**		**5**	

SCHEME OF EXAMINATION (SEE)

1. Ten Full Questions to be set.
2. Five full Questions to be answered.
3. Students shall answer Q1 or Q2 from Unit-1, Q3 or Q4 from Unit-2, Q5 or Q6 from Unit-3, Q7 or Q8 from Unit-4, Q9 or Q10 from Unit-5 with two questions from each Unit.
4. Each question shall contain maximum of 2 subdivisions
5. Each main question carries equal Marks.

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO1	Apply basic concepts in continuum mechanics of solids viz. Stress and strain tensors, equilibrium, compatibility and constitutive equations and methods of solution to elasticity problems
CO 2	Evaluate stresses and displacements in simple solids such as pressurized cylinders, shrink fitted cylinders, rotating disc and shaft, plate with hole and non-circular shafts and thin tubes under torsion.
CO 3	Use MATLAB or equivalent software to evaluate and plot particular solutions.
CO 4	Apply the principles of plastic deformation to estimate yielding in simple engineering structures.

CO 5	Apply principles of continuum mechanics to design a structure or component to achieve desired performance under realistic constraints.

MAPPING OF COs WITH POs

COs/POs	po1	po2	po3	po4	po5	po6	po7	po8	po9	po10	po11	po12
CO1	3	3	3	2	2	3	3	2	3	3	1	2
CO2	2	3	3	2	2	1	3	2	3	3	3	2
CO3	3	3	3	2	3	2	3	1	3	2	3	2
CO4	3	3	2	2	3	2	3	1	2	2	3	3

ADMISSION YEAR :2018-19 **ACADEMIC YEAR: 2018-19**

COURSE TITLE:	**FINITE ELEMENT METHOD**	
Sub Code:18MMD12	**No of Credits: L-T-P-SS 3:0:0:1 =4**	**No. of lecture hours/week: 04**
Exam Duration: 3 hours	**CIE Marks: 50**	**Exam Marks: 50**
Pre-requisites	**Engineering Mechanics, Design of Machine Elements**	

COURSE OBJECTIVES:

This course enables the student to identify failure modes and evolve design by analysis methodology. Design against fatigue failure is given explicit attention. **To** impart structures analysis for stress, strain & dynamic loading knowledge. To enable formulation of the design problems into FEA. To comprehend the basic concepts and enhance capabilities for solving complex problems. To introduce the concepts of elastic and static analysis problems.

#	CONTENTS	Hrs
UNIT-1	**MATHEMATICS FOR FEM**: Significant figures, accuracy and precision, error definitions, round off errors and truncation errors. Mathematical modeling. **SYSTEM OF LINEAR ALGEBRAIC EQUATIONS AND EIGEN VALUE PROBLEMS:** Gauss Elimination Method, Gauss-Jordan Elimination Method, Triangularization method, Cholesky Method, Partition method, Iteration Methods. Eigen values and Eigen Vectors: Bounds on Eigen Values, Jacobi method for symmetric matrices.	08
UNIT-2	**Introduction to Finite Element Method:** Basic Steps in Finite Element Method to solve mechanical engineering (Solid, Fluid and Heat Transfer) Galerkin approach, Displacement Approach: Admissible Functions, Convergence Criteria: Conforming and Non-Conforming elements, C_o C_1 and C_n Continuity Elements. Basic Equations, Element Characteristic Equations, Assembly Procedure, Boundary and Constraint Conditions	08
UNIT-3	**Solid Mechanics: One-Dimensional Finite Element Formulations and Analysis** – Bars-uniform, varying and stepped cross section-Basic (Linear) and Higher Order Elements Formulations for Axial, Torsional and Temperature Loads with problems. Beams- Basic (Linear) Element Formulation-for uniform, varying and stepped cross section- for different loading and boundary conditions with problems.	08
UNIT-4	**FINITE ELEMENT FORMULATIONS FOR STRUCTURAL MECHANICS PROBLEMS:** Basics of plates and shell theories: Classical thin plate Theory, Shear deformation Theory and Thick Plate theory. Finite Element Formulations for triangular and quadrilateral Plate elements. Finite element formulation of flat, curved, cylindrical and conical Shell elements **TWO-DIMENSIONAL FINITE ELEMENT FORMULATIONS FOR SOLID MECHANICS PROBLEMS**: Triangular Membrane (TRIA 3, TRIA 6, TRIA 10) Element, Four-Noded Quadrilateral Membrane (QUAD 4, QUAD 8) Element Formulations for in-plane loading with sample problems. Triangular and Quadrilateral, Axis-symmetric basic and higher order Elements formulation for axis-symmetric loading only with sample	14

	problems.	
UNIT-5	**THREE-DIMENSIONAL FINITE ELEMENT FORMULATIONS FOR SOLID MECHANICS PROBLEMS:** Finite Element Formulation of Tetrahedral Element (TET 4, TET 10), Hexahedral Element (HEXA 8, HEXA 20), for different loading conditions. Serendipity and Lagrange family Elements. **DYNAMIC ANALYSIS:** Finite Element Formulation for point/lumped mass and distributed masses system, Finite Element Formulation of one-dimensional dynamic analysis: bar, truss, frame and beam element. Finite Element Formulation of Two-dimensional dynamic analysis: triangular membrane and axisymmetric element, quadrilateral membrane and axisymmetric element. Evaluation of eigen values and eigen vectors applicable to bars, shaft, beams, plane and space frame.	14

Text Books:

1. **S.S. SASTRY**, Introductory Methods of Numerical Analysis, PHI, 2005.
2. **STEVEN C. CHAPRA, RAYMOND P. CANALE**, Numerical Methods for Engineers, Tata McGraw Hill, 4th Ed, 2002.
3. **M K JAIN, S.R.K IYENGAR, R K. JAIN**, Numerical methods for Scientific and engg computation, New Age International, 2003.
4. **T. R. CHANDRUPATLA AND A. D. BELEGUNDU**, Introduction to Finite Elements in Engineering, Prentice Hall, 3rd Ed, 2002.
5. **LAKSHMINARAYANA H. V.**, Finite Elements Analysis– Procedures in Engineering, Universities Press, 2004.

Reference Books:

1. **RAO S. S.**, Finite Elements Method in Engineering- 4th Edition, Elsevier, 2006
2. **P. SESHU**, Textbook of Finite Element Analysis, PHI, 2004.
3. **BATHE K. J**., Finite Element Procedures, Prentice-Hall, 2006.
4. **COOK R. D.**, Finite Element Modeling for Stress Analysis, Wiley,1995.
5. **DAVID. C. LAY**, Linear Algebra and its applications, 3rd edition, Pearson Education, 2002

SYLLABUS COVERAGE FOR CIE-1, 2, 3
CIE-1: UNIT-1 (100%) + UNIT- 2 (50%)
CIE-2: UNIT-2 (50%) + UNIT -3 (Firs100%)
CIE-3: UNIT- 4 (100%) + UNIT- 5 (100%)

QUESTION PAPER PATTERN (SEE)

Q. No	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**
Unit	**1**		**2**		**3**		**4**		**5**	

SCHEME OF EXAMINATION (SEE)

1. Ten Full Questions to be set.

2. Five full Questions to be answered.
3. Students shall answer Q1 or Q2 from Unit-1, Q3 or Q4 from Unit-2, Q5 or Q6 from Unit-3, Q7 or Q8 from Unit-4, Q9 or Q10 from Unit-5 with two questions from each Unit.
4. Each question shall contain maximum of 2 subdivisions
5. Each main question carries equal Marks.

COURSE OUTCOMES: Learners will able to

CO1	Model some simple mathematical models of physical Applications. Develop governing equation for a mechanical system and apply principles of variation and integral formulation to formulate finite element equations.
CO2	Formulate and perform one dimensional, two-dimensional structural analysis using bar, beam, triangular and quadrilateral elements.
CO3	Formulate axisymmetric triangular element and analyze problems on solids of revolution.
CO4	Formulate mass matrices and compute eigen values and eigen vectors for a 1- D and 2D analysis of mechanical system.

MAPPING OF COs WITH POs

COs/POs	po1	po2	po3	po4	po5	po6	po7	po8	po9	po10	po11	po12
CO1	3	3	3	2	2	3	3	2	3	3	1	2
CO2	2	3	3	2	2	1	3	2	3	3	3	2
CO3	3	3	3	2	3	2	3	1	3	2	3	2
CO4	3	3	2	2	3	2	3	1	2	2	3	3

ADMISSION YEAR :2018-19 **ACADEMIC YEAR: 2018-19**

EXPERIMENTAL MECHANICS

Course Code	**:**	**18MMD131**		**CIE Marks**	**:**	**50**
Hrs./Week	**:**	**L: T: P: 3:1:0**		**SEE Marks**	**:**	**50**
Credits	**:**	**04**		**SEE Duration**	**:**	**3 hours**

Course Objective:
This course aims at a comprehensive study of mechanics of solids. The objective of this course is to familiarize the student with state-of-the-art experimental techniques namely strain gauges, photo elasticity, moiré interferometry, brittle coating, moiré fringes and holography.

Course Content: Chapters/ Units

1. **Introduction**: Definition of terms, calibration, standards, dimension and units, generalized measurement system, Basic concepts in dynamic measurements, system response, distortion, impedance matching, experiment planning.
   Analysis of Experimental Data: Cause and types of experimental errors, error analysis. Statistical analysis of experimental data- Probability distribution, gaussian, normal distribution. **8 Hours**

2. **Force, Torque and Strain Measurement:** Mass balance measurement, Elastic Element for force measurement, torque measurement. Strain Gages -Strain sensitivity of gage metals, Gage construction, Gage sensitivity and gage factor, Performance characteristics, Environmental effects Strain, gage circuits, Potentiometer, Wheat Stone's bridges, Constant current circuits. Strain Analysis Methods-Two element and three element, rectangular and delta rosettes, Correction for transverse strains effects, stress gage - plane shear gage, Stress intensity factor gage. **8 Hours**

3. **Stress Analysis:** Two-Dimensional Photo elasticity **-** Nature of light, - wave theory of light, - optical interference - Polariscopes stress optic law - effect of stressed model in plane and circular Polariscopes, Isoclinic, isochromatic fringe order determination. Calibration Photo elastic model materials. Model to prototype scaling**.** . **8 Hours**

4. **Three-Dimensional Photo elasticity:** Stress freezing method, General slice, Effective stresses, Stresses separation, Shear deference method, Oblique incidence method Secondary principal stresses, Scattered light photo elasticity, Principals, Polari scope and stress data analyses**.**
   Holography: Introduction, Equation for plane waves and spherical waves, Intensity, Coherence, Spherical radiator as an object (record process), Hurter, Driffield curves, Reconstruction process, Holographic interferometry, Realtime. and double exposure methods, Displacement measurement, Isopaches **14 Hours**

5. **Coating Methods:** a) Photo elastic Coating Method-Birefringence coating techniques Sensitivity Reinforcing and thickness effects - data reduction - Stress separation techniques Photo elastic strain gauges. b) Brittle Coatings Method: Brittle coating technique Principles data analysis - coating materials, Coating techniques. c) Moire Technique - Geometrical approach, Displacement approach-sensitivity of Moire data reduction, In plane and out plane Moire methods, Moire photography, Moire grid production. **14 Hours**

NOTE: the students are advised to prepare the lab report in the form of assignment to understand the subject and its relevance in the industry

Text Books:

1. **Holman,** “Experimental Methods for Engineers” 7th Edition, Tata McGraw-Hill Companies, Inc, New York, 2007.
2. **R. S. Sirohi, H. C. Radha Krishna,** “Mechanical measurements” New Age International Pvt. Ltd., New Delhi, 2004
3. **Experimental Stress Analysis** - Srinath, Lingaiah, Raghavan, Gargesa, Ramachandra and Pant, Tata McGraw Hill, 1984.
4. **Instrumentation, Measurement and Analysis -**Nakra & Chaudhry, B C Nakra K Chaudhry, Tata McGraw-Hill Companies, Inc, New York, Seventh Edition, 2006.

Reference Books:

1. **Measurement Systems Application and Design -** Doeblin E. A., 4th (S.I.) Edition, McGraw Hill, New York. 1989
2. **Design and Analysis of Experiments -** Montgomery D.C., John Wiley & Sons, 1997.
3. **Experimental Stress Analysis** - Dally and Riley, McGraw Hill, 1991.
4. **Experimental Stress Analysis -** Sadhu Singh, Khanna publisher, 1990.
5. **Photoelasticity Vol I and Vol II -** M.M.Frocht,. John Wiley and sons, 1969.
6. **Strain Gauge Primer -** Perry and Lissner, McGraw Hill, 1962.

Course Outcomes:

Upon completion of this course, the student will be able to

CO1	Understand functional requirements of a generalized measurement system and identify suitable components for an application.
CO2	Use concepts of Data Acquisition, Processing and apply the same for interpretation and analysis of experimental data.
CO3	Determine stresses and strains in a structure using different methods such as strain gages, photo-elasticity, brittle coating and holography.
CO4	Identify and apply suitable experimental stress analysis to practical problems

SYLLABUS COVERAGE FOR CIE-1, 2, 3

CIE-1: UNIT-1 (100%) + UNIT- 2 (50%)
CIE-2: UNIT-2 (50%) + UNIT -3 (Firs100%)
CIE-3: UNIT- 4 (100%) + UNIT- 5 (100%)

QUESTION PAPER PATTERN (SEE)

Q. No	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Unit	1		2		3		4		5	

SCHEME OF EXAMINATION (SEE)

1. Ten Full Questions to be set.
2. Five full Questions to be answered.
3. Students shall answer Q1 or Q2 from Unit-1, Q3 or Q4 from Unit-2, Q5 or Q6 from Unit-3, Q7 or Q8 from Unit-4, Q9 or Q10 from Unit-5 with two questions from each Unit.
4. Each question shall contain maximum of 2 subdivisions
5. Each main question carries equal Marks.

MAPPING OF COs WITH POs

COs/POs	po1	po2	po3	po4	po5	po6	po7	po8	po9	po10	po11	po12
CO1	3	3	3	2	2	3	3	2	3	3	1	2
CO2	2	3	3	2	2	1	3	2	3	3	3	2
CO3	3	3	3	2	3	2	3	1	3	2	3	2
CO4	3	3	2	2	3	2	3	1	2	2	3	3

ADMISSION YEAR :2018-19 **ACADEMIC YEAR: 2018-19**

ROBUST DESIGN

Sub Code: 18MMD132	**No of Credits: L-T-P-SS 4:0:0:0=4**	**No. of lecture hours/week :04**
Exam Duration: 3 hours	**CIE Marks: 50**	**Exam Marks :50**
Pre-requisites	Mom, Design of Machine Elements**.**	

COURSE OBJECTIVES:
To study the basic concept of stresses, stress distribution, elastic constants when the material is subjected to loading within the elastic limits.

#	CONTENTS	Hrs
UNIT-1	**QUALITY BY EXPERIMENTAL DESIGN**: Quality, western and Taguchi quality philosophy, Elements of cost, Noise factors causes of variation, Quadratic loss function and variation of quadratic loss functions. **ROBUST DESIGN:** Steps in robust design: parameter design and tolerance design, reliability improvement through experiments, illustration through numerical examples.	08
UNIT-2	**EXPERIMENTAL DESIGN:** Classical experiments: factorial experiments, terminology, factors. Levels, Interactions, Treatment combination, randomization, 2-level experimental design for two factors and three factors. 3-level experiment deigns for two factors and three factors, factor effects, factor interactions, Fractional factorial design, Saturated design, Central composite designs, Illustration through numerical examples.	08
UNIT-3	**Measures of Variability:** Measures of variability, Concept of confidence level, Statistical distributions: normal, log normal and Weibull distributions. Hypothesis testing, Probability plots, choice of sample size illustration through numerical examples. Analysis and interpretation of experimental data: Measures of variability, Ranking method, column effect method and plotting method, Analysis of variance (ANOVA), in factorial experiments: YATE's algorithm for ANOVA, Regression analysis, Mathematical models from experimental data, illustration through numerical examples.	08
UNIT-4	**TAGUCHI'S ORTHOGONAL ARRAYS:** Types orthogonal arrays, Selection of standard orthogonal arrays, Linear graphs and interaction assignment, dummy level technique, Compound factor method, modification of linear graphs, Column merging method, branching design, Strategies for constructing orthogonal arrays. Signal to Noise ratio (S-N Ratios) : Evaluation of sensitivity to noise, Signal to noise ratios for static problems, Smaller – the – better types, Nominal – the –better – type, larger – the better – type. Signal to noise ratios for dynamic problems, Illustrations through numerical examples.	14

UNIT-5	**PARAMETER DESIGN AND TOLERANCE DESIGN:** Parameter and tolerance design concepts, Taguchi's inner and outer arrays, Parameter design strategy, Tolerance deign strategy, Illustrations through numerical examples. **RELIABILITY IMPROVEMENT THROUGH ROBUST DESIGN**: Role of S-N ratios in reliability improvement; Case study; illustrating the reliability improvement of routing process of a printed wiring board using robust design concepts .	**14**

Text Books:

1.**Madhav S. Phadake,** "Quality Engineering using Robust Design", Prentice Hall,1989.

2.**Douglas Montgomery,** "Design and analysis of experiment", Willey India Pvt. Ltd.,2007.

3.**Phillip J. Ross, Taguchi**, "Techniques for Quality Engineering" McGraw Hill Int.Ed.,1996.

Reference Books:

1. **Thomas B. Barker,** "Quality by Experimental Design" , Marcel Dekker IncASQC Quality Press,1985.
2. **C.F. Jeff Wu**, ichael Hamada, "Experiments planning, analysis and parameter design optimization", John Wiley Ed., 2002.
3. **W.L. Condra, Marcel Dekker**, "Reliability improvement by Experiments", Marcel Dekker Inc ASQC Quality Press, 1985.

SYLLABUS COVERAGE FOR CIE-1, 2, 3

CIE-1: UNIT-1 (100%) + UNIT- 2 (50%)
CIE-2: UNIT-2 (50%) + UNIT -3 (Firs100%)
CIE-3: UNIT- 4 (100%) + UNIT- 5 (100%)

QUESTION PAPER PATTERN (SEE)

Q. No	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**
Unit	**1**		**2**		**3**		**4**		**5**	

SCHEME OF EXAMINATION (SEE)

1. Ten Full Questions to be set.
2. Five full Questions to be answered.
3. Students shall answer Q1 or Q2 from Unit-1, Q3 or Q4 from Unit-2, Q5 or Q6 from Unit-3, Q7 or Q8 from Unit-4, Q9 or Q10 from Unit-5 with two questions from each Unit.
4. Each question shall contain maximum of 2 subdivisions
5. Each main question carries equal Marks.

COURSE OUTCOMES:

Learners will able to

CO1	Apply Design of Experiments (DOE) techniques to various methods of design.
CO 2	Analyze and evaluate design parameters using different design strategies.
CO 3	Illustrate through numerical examples improvements in design parameters.
CO 4	Perform case studies involving identification of parameters, analysis of experimental data in a robust design.

MAPPING OF COs WITH Pos

COs/POs	po1	po2	po3	po4	po5	po6	po7	po8	po9	po10	po11	po12
CO1	3	3	3	2	2	3	3	2	3	3	1	2
CO2	2	3	3	2	2	1	3	2	3	3	3	2
CO3	3	3	3	2	3	2	3	1	3	2	3	2
CO4	3	3	2	2	3	2	3	1	2	2	3	3

ADMISSION YEAR :2018-19 **ACADEMIC YEAR: 2018-19**

COURSE TITLE: ADVANCED DESIGN OF MECHANISM		
Sub Code: 18MMD141	**No of Credits: L-T-P-SS 4:0:0:0 =4**	**No. of lecture hours/week: 04**
Exam Duration: 3 hours	**CIE Marks: 50**	**Exam Marks: 100**
Pre-requisites	**Engineering mechanics, MOM, Material science and metallurgy**	

COURSE OBJECTIVES:

To include dynamics considerations in the design of mechanisms for engineering applications is the objective of this course. To study basic principles of machine design. To acquaint with the concepts of strength design related to various components. To familiarize with use of design data books & various codes of practice. To make conversant with preparation of working drawings based on designs and enable the students to have high ethical standards in terms of team work to be a good design engineer

#	CONTENTS	Hrs
UNIT-1	**GEOMETRY OF MOTION:** Introduction, analysis and synthesis, Mechanism terminology, planar, Spherical and spatial mechanisms, mobility, Grashoffs law, Equivalent mechanisms, Unique mechanisms, Kinematic analysis of plane mechanisms: Auxiliary point method using rotated velocity vector, Hall - Ault auxiliary point method, Goodman's indirect method.	08
UNIT-2	**GENERALIZED PRINCIPLES OF DYNAMICS:** Virtual work, principle of virtual work, Equilibrium and stability, Kinetic energy of a system, Angular momentum, Generalized momentum. Lagrange's Equation: Lagrange's equation from D'Alembert's principles, Examples, Hamilton’s equations, Hamilton’s principle, Lagrange's, equation from Hamilton’s principle, Derivation of Hamilton’s equations, Examples.	08
UNIT-3	**SPATIAL MECHANISMS**: Introduction, Position analysis problem, Velocity and acceleration analysis, Eulerian angles.	08
UNIT-4	**SYSTEM DYNAMICS:** Gyroscopic action in machines, Euler's equation of motion, Phase Plane representation, Phase plane Analysis, Response of Linear Systems to transient disturbances. Synthesis of Linkages: Type, number, and dimensional synthesis, Function generation, Path generation and Body guidance, Precision positions, Structural error, Chebyshev spacing, two position synthesis of slider crank mechanisms, Crank-rocker mechanisms with optimum transmission angle Motion Generation: Poles and relative poles, Location of poles and relative poles, pooled, Curvature, Inflection circle.	12
UNIT-5	**GRAPHICAL METHODS OF DIMENSIONAL SYNTHESIS:** Two position synthesis of crank and rocker mechanisms, three position synthesis, four position synthesis (point precision reduction) Overlay method, Coupler curve synthesis, Cognate linkages. Ana1ytical Methods of Dimensional Synthesis: Freudenstein's equation for four bar mechanism and slider crank mechanism, Examples, Bloch's method of synthesis, Analytical synthesis using complex algebra.	12

Text Books:

1. **GREENWOOD,** "Classical Dynamics", Prentice Hall of India, 1988.
2. **K.J. Waldron & G.L. Kinzel, "Kinematics, Dynamics and Design of Machinery",** Wiley India, 2007.

References Books:

1. **J E SHIGLEY**, "Theory of Machines and Mechanism" -McGraw-Hill, 1995
2. **A.G. AMBEKAR,** "Mechanism and Machine Theory", PHI, 2007.
3. **GHOSH AND MALLICK**, "Theory of Mechanism and Mechan ism", East West press 2007.
4. **DAVID H. MYSZKA,** "Machines and Mechanisms", Pearson Education, 2005.

SYLLABUS COVERAGE FOR CIE-1, 2, 3

CIE-1: UNIT-1 (100%) + UNIT- 2 (50%)
CIE-2: UNIT-2 (50%) + UNIT -3 (Firs100%)
CIE-3: UNIT- 4 (100%) + UNIT- 5 (100%)

QUESTION PAPER PATTERN (SEE)

Q. No	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**
Unit	**1**		**2**		**3**		**4**		**5**	

SCHEME OF EXAMINATION (SEE)

1. Ten Full Questions to be set.
2. Five full Questions to be answered.
3. Students shall answer Q1 or Q2 from Unit-1, Q3 or Q4 from Unit-2, Q5 or Q6 from Unit-3, Q7 or Q8 from Unit-4, Q9 or Q10 from Unit-5 with two questions from each Unit.
4. Each question shall contain maximum of 2 subdivisions
5. Each main question carries equal Marks.

COURSE OUTCOMES: Learners will able to

CO1	The knowledge of dynamics considerations in mechanism design is essential to use commercial multi body dynamics software in mechanical engineering design.
CO2	Carry out mobility analysis of mechanism and perform velocity and acceleration of complex planer mechanism.
CO3	Synthesize mechanisms for function generation and path generation.
CO4	Analyze the Dynamics of Mechanical systems using D'Alembert's, Lagrange's, and Hamilton's Principles.
CO5	Demonstrate the skills to use software to analyze mechanisms, synthesis of linkages.

MAPPING OF COs WITH POs

COs/POs	po1	po2	po3	po4	po5	po6	po7	po8	po9	po10	po11	po12
CO1	3	3	3	3	2	2	3	2	3	1	3	3
CO2	2	3	3	2	3	3	3	1	2	3	3	2
CO3	3	3	2	3	3	3	1	3	3	2	3	2
CO4	3	3	2	3	3	2	3	2	1	2	3	3

ADMISSION YEAR :2018-19 **ACADEMIC YEAR: 2018-19**

COURSE TITLE: DESIGN FOR MANUFACTURE		
Sub Code: 18MMD142	**No of Credits: L-T-P-SS 4:0:0:0 =4**	**No. of lecture hours/week: 04**
Exam Duration: 3 hours	**CIE Marks: 50**	**Exam Marks: 50**
Pre-requisites	**metrology & Measurements, Design Of Machine Elements.**	

COURSE OBJECTIVES:

To educate students a clear understanding of factors to be considered in designing parts and components with focus on manufacturability**.** To study Effect of material properties on mechanical design. To acquaint with the concepts of Tolerance. To Design the components with casting consideration. Emphasis on various types of limit gauges for both hole and shaft.

#	CONTENTS	Hrs
UNIT-1	**EFFECT OF MATERIALS AND MANUFACTURING PROCESS ON DESIGN:** Major phases of design. Effect of material properties on design, Effect of manufacturing processes on design. Material selection process cost per unit property, Weighted properties and limits on properties methods.	08
UNIT-2	**TRUE POSITIONAL THEORY:** Comparison between co-ordinate and convention method of feature location. Tolerance and true positioning tolerance virtual size concept, Floating and fixed fasteners. Projected tolerance zone. Assembly with gasket, zero position tolerance. Functional gauges, Paper layout gauging.	10
UNIT-3	**SELECTIVE ASSEMBLY:** interchangeable part manufacture and selective assembly, deciding the number of groups -model-1: group tolerance of mating parts equal, model total and group tolerances of shaft equal. control of axial play-introducing secondary machining operations, laminated shims, examples. Datum features: functional datum, datum for manufacturing, changing the datum. examples	10
UNIT-4	**DESIGN CONSIDERATIONS:** Design of components with casting consideration. Pattern, Mould, and Parting line. Cored holes and Machined holes. Identifying the possible and probable parting line. Casting requiring special sand cores. Designing to obviate sand cores. Component Design: Component design with machining considerations link design for turning components-milling, Drilling and other related processes including finish-machining operations.	12
UNIT-5	**Design of Gauges:** Design of gauges for checking components in assemble with emphasis on various types of limit gauges for both hole and shaft. **TOLERANCE ANALYSIS:** Process capability, mean, variance, skewness, kurtosis, Process capability metrics, Cp, Cpk, Cost aspects, Feature tolerances, Geometries tolerances, Geometric tolerances, Surface finish, Review of relationship between attainable tolerance grades and different machining process. Cumulative effect of tolerance- Sure fit law and truncated normal law.	12

Text Books:

1**. HARRY PECK**, “Designing for Manufacturing”, Pitman Publications, 1983.

2. **DIETER,** “Machine Design” - McGraw-Hill Higher Education, -2008.

3. **R.K. JAIN**, "Engineering Metrology", Khanna Publishers, 1986.

4. **GEOFFREY BOOTHROYD, PETER DEWHURST, WINSTON KNIGHT**, “Product design for manufacture and assembly”, Merce Dekker. Inc. CRC Press, Third Edition

5. **MATERIAL SELECTION AND DESIGN**, Vol. 20 - ASM Hand book.

SYLLABUS COVERAGE FOR CIE-1, 2, 3

CIE-1: UNIT-1 (100%) + UNIT- 2 (50%)
CIE-2: UNIT-2 (50%) + UNIT -3 (First100%)
CIE-3: UNIT- 4 (100%) + UNIT- 5 (100%)

QUESTION PAPER PATTERN (SEE)

Q. No	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**
Unit	**1**		**2**		**3**		**4**		**5**	

SCHEME OF EXAMINATION (SEE)

1. Ten Full Questions to be set.
2. Five full Questions to be answered.
3. Students shall answer Q1 or Q2 from Unit-1, Q3 or Q4 from Unit-2, Q5 or Q6 from Unit-3, Q7 or Q8 from Unit-4, Q9 or Q10 from Unit-5 with two questions from each Unit.
4. Each question shall contain maximum of 2 subdivisions
5. Each main question carries equal Marks.

COURSE OUTCOMES:

Upon completion of this course, the student will be able to

CO1	Understand the role of manufacture and assembly in development of mechanical parts and their assemblies.
CO2	Apply manufacturing considerations in the design and development of components made of casting and machining.
CO3	Apply geometrical dimensioning and tolerances issues in mechanical design.

MAPPING OF COs WITH POs

COs/POs	**po1**	**po2**	**po3**	**po4**	**po5**	**po6**	**po7**	**po8**	**po9**	**po10**	**po11**	**po12**
CO1	3	3	3	3	2	2	3	2	3	1	3	3
CO2	2	3	3	2	3	3	3	1	2	3	3	2
CO3	3	3	2	3	3	3	1	3	3	2	3	2
CO4	3	3	2	3	3	2	3	2	1	2	3	3

ADMISSION YEAR :2018-19 **ACADEMIC YEAR: 2018-19**

COURSE TITLE: MECHATRONICS SYSTEMS DESIGN		
Sub Code: 18MMD151	**No of Credits: L-T-P-SS 4:0:0:0 =4**	**No. of lecture hours/week: 04**
Exam Duration: 3 hours	**CIE Marks: 50**	**Exam Marks: 50**
Pre-requisites	BASIC ELECTRONICS, BASIC ELECTRICALS, MATERIAL SCIENCE AND METROLOGY	

COURSE OBJECTIVES:

To educate the student regarding integration of mechanical, electronic, electrical and computer systems in the design of CNC machine tools, Robots etc. To provide students with an understanding of the Mechatronic Design Process, actuators, Sensors, transducers, Signal Conditioning, MEMS and Microsystems and also the Advanced Applications in Mechatronics

#	CONTENTS	Hrs
UNIT-1	**Introduction:** Definition and Introduction to Mechatronic Systems. Modeling &Simulation of Physical systems Overview of Mechatronic Products and their functioning, measurement systems. Control Systems, simple Controllers.	08
UNIT-2	**Study of Sensors and Transducers:** Pneumatic and Hydraulic Systems, Mechanical Actuation System, Electrical Actual Systems, Real time interfacing and Hardware components for Mechatronics.	08
UNIT-3	**Electrical Actuation Systems:** Electrical systems, Mechanical switches, Solid state switches, solenoids, DC & AC motors, Stepper motors. **System Models:** Mathematical models: - mechanical system building blocks, electrical system building blocks, thermal system building blocks, electromechanical systems, hydro-mechanical systems, pneumatic systems.	08
UNIT-4	**Signal Conditioning:** Signal conditioning, the operational amplifier, Protection, Filtering, Wheatstone Bridge, Digital signals, Multiplexers, Data Acquisition, Introduction to digital system processing, pulse-modulation. **MEMS and Microsystems:** Introduction, Working Principle, Materials for MEMS and Microsystems, Micro System fabrication process, Overview of Micro Manufacturing, Micro system Design, and Micro system Packaging.	14
UNIT-5	**Data Presentation Systems:** Basic System Models, System Models, Dynamic Response of system. **Advanced Applications in Mechatronics:** Fault Finding, Design, Arrangements and Practical Case Studies, Design for manufacturing, User-friendly design	14

NOTE: the students are advised to prepare the report in the form of assignment to understand the subject and its relevance in the industry

Text Books:

1. W. Bolton, “Mechatronics” - Addison Wesley Longman Publication, 1999
2. HSU “MEMS and Microsystems design and manufacture”- Tata McGraw-Hill Education, 2002

Reference Books:

1. Kamm, “Understanding Electro-Mechanical Engineering an Introduction to Mechatronics”- IEEE Press, 1 edition ,1996
2. Shetty and Kolk “Mechatronics System Design”- Cengage Learning, 2010
3. Mahalik “Mechatronics”- Tata McGraw-Hill Education, 2003
4. HMT “Mechatronics”- Tata McGraw-Hill Education, 199 8
5. Michel.B. Histand& David. Alciatore, “Introduction to Mechatronics & Measurement Systems”–. Mc Graw Hill, 2002
6. “Fine Mechanics and Precision Instruments”- Pergamon Press, 1971.

SYLLABUS COVERAGE FOR CIE-1, 2, 3

CIE-1: UNIT-1 (100%) + UNIT- 2 (50%)
CIE-2: UNIT-2 (50%) + UNIT -3 (First100%)
CIE-3: UNIT- 4 (100%) + UNIT- 5 (100%)

QUESTION PAPER PATTERN (SEE)

Q. No	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Unit	1		2		3		4		5	

SCHEME OF EXAMINATION (SEE)

1. Ten Full Questions to be set.
2. Five full Questions to be answered.
3. Students shall answer Q1 or Q2 from Unit-1, Q3 or Q4 from Unit-2, Q5 or Q6 from Unit-3, Q7 or Q8 from Unit-4, Q9 or Q10 from Unit-5 with two questions from each Unit.
4. Each question shall contain maximum of 2 subdivisions
5. Each main question carries equal Marks.

Course Outcome:

At the completion of this course, students will be able to:

CO1	Appreciate multi-disciplinary nature of modern engineering systems.
CO2	Model and analyze mechanical and electrical systems and their connection.
CO3	Be able to integrate mechanical, electronics, control and computer engineering in the design of mechatronics systems.
CO4	Address issues of design, fabrication, and packaging issues of Microsystems.

MAPPING OF COs WITH POs

COs/POs	po1	po2	po3	po4	po5	po6	po7	po8	po9	po10	po11	po12
CO1	3	3	3	3	2	2	3	2	3	1	3	3
CO2	2	3	3	2	3	3	3	1	2	3	3	2
CO3	3	3	2	3	3	3	1	3	3	2	3	2
CO4	3	3	2	3	3	2	3	2	1	2	3	3

AUTOMOBILE SYSTEM DESIGN

Course Code	**:**	**18MMD152**		**CIE Marks**	**:**	**50**
Hrs./Week	**:**	**L: T: P: 4:0:0**		**SEE Marks**	**:**	**50**
Credits	**:**	**04**		**SEE Duration**	**:**	**3 hours**

Course Objective:
This course would facilitate understanding of the stages involved in automobile system design. The student will be exposed to industrial practices in design of various systems of an automobile.

Course Content: Chapters/ Units

1. **Body Shapes**: Aerodynamic Shapes, drag forces for small family cars.
   Fuel Injection: Spray formation, direct injection for single cylinder engines (both SI & CI), energy audit. **08 Hours**

2. **Design of I.C. Engine** I: Combustion fundamentals, combustion chamber design, cylinder head design for both SI & C. I. Engines. 0**8 Hours**

3. Design of I.C. Engine II: Design of crankshaft, camshaft, connecting rod, piston & piston rings for small family cars (max up to 3cylinders). 08 **Hours**

4. Transmission System: Design of transmission systems – gearbox (max of 4-speeds), differential.
Suspension System: Vibration fundamentals, vibration analysis (single & two degree of freedom, vibration due to engine unbalance, application to vehicle suspension. **14 Hours**

5. Cooling System: Heat exchangers, application to design of cooling system (water cooled).
Emission Control: Common emission control systems, measurement of missions, exhaust gas emission testing. **14 Hours**

NOTE: the students are advised to prepare the report in the form of assignment to understand the subject and its relevance in the industry

Text Books:

1. **Design of Automotive Engines**, **-** A. Kolchin& V. Demidov, MIR Publishers, Moscow
2. **The motor vehicle, Newton steeds &Garratte -** Iliffee& sons Ltd., London
3. **I.C. Engines -** Edward F Obert, International text book company.

Reference Books:

1. **Introduction to combustion** - Turns
2. **Automobile Mechanic -**, N.K. Giri, Khanna Publications, 1994
3. **I.C. Engines** - Maleev, McGraw Hill book company, 1976
4. **Diesel engine design** – Heldt P.M., Chilton company New York.
5. **Problems on design of machine elements -** V.M. Faires & Wingreen, McMillan Company., 1965
6. **Design of I.C. Engines -** John Heywood, TMH

Course Outcome:

Upon completion of this course, the student will be able to

CO1	The student will be able to apply the knowledge in creating a preliminary design of automobile sub systems.
CO2	Students are exposed to aerodynamic analysis of the auto mobiles.
CO3	Students are exposed to engine performances, combustion analysis and exhaust gas analysis to meet the BIS standards (10000 series).

SYLLABUS COVERAGE FOR CIE-1, 2, 3

CIE-1: UNIT-1 (100%) + UNIT- 2 (50%)
CIE-2: UNIT-2 (50%) + UNIT -3 (First100%)
CIE-3: UNIT- 4 (100%) + UNIT- 5 (100%)

QUESTION PAPER PATTERN (SEE)

Q. No	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**
Unit	**1**		**2**		**3**		**4**		**5**	

SCHEME OF EXAMINATION (SEE)

1. Ten Full Questions to be set.
2. Five full Questions to be answered.
3. Students shall answer Q1 or Q2 from Unit-1, Q3 or Q4 from Unit-2, Q5 or Q6 from Unit-3, Q7 or Q8 from Unit-4, Q9 or Q10 from Unit-5 with two questions from each Unit.
4. Each question shall contain maximum of 2 subdivisions
5. Each main question carries equal Marks.

INDUSTRIAL VISIT

Course Code	**:**	**18MMDM16**		**CIE Marks**	**:**	**50**
Hrs./Week	**:**	**L: T: P: S 0:0:0:3**		**SEE Marks**	**:**	**50**
Credits	**:**	**02**		**SEE Duration**	**:**	**3 hours**

- **Industrial Visit**: At the end of second CIE the industrial visit will be arranged in the domain field, each student is required to submit the report of the visit.
- Report submissions and final Evaluation is to be carried out by the Internal Guide of the college and a senior faculty along with HOD.

II Semester

ADMISSION YEAR :2018-19 **ACADEMIC YEAR: 2018-19**

COURSE TITLE:	ADVANCED MACHINE DESIGN	
Sub Code: 18MMD21	No of Credits: L-T-P-SS 4:0:0:0 =4	No. of lecture hours/week: 04
Exam Duration: 3 hours	CIE Marks: 50	Exam Marks: 50
Pre-requisites	Engineering Mechanics, MoM, Design of Machine Elements	

COURSE OBJECTIVES:

To study Role of failure prevention analysis in mechanical design. To acquaint with the concepts of damage fraction and accumulation in various damage theories. To study Role of surface failure in mechanical design. Enable the students to have high ethical standards in terms of team work to be a good design engineer.

#	CONTENTS	Hrs
UNIT-1	**INTRODUCTION:** Role of failure prevention analysis in mechanical design, Modes of mechanical failure, Review of failure theories for ductile and brittle materials including Mohr's theory and modified Mohr's theory, Numerical examples. **FATIGUE OF MATERIALS:** Introductory concepts, High cycle and low cycle fatigue, Fatigue design models, Fatigue design methods, Fatigue design criteria, Fatigue testing, Test methods and standard test specimens.	08
UNIT-2	**FATIGUE FROM VARIABLE AMPLITUDE LOADING:** Spectrum loads and cumulative damage, Damage quantification and the concepts of damage fraction and accumulation, Cumulative damage theories, Load interaction and sequence effects, Cycle counting methods, Life estimation using stress life approach.	08
UNIT-3	**SURFACE FAILURE:** Introduction, Surface geometry, Mating surface, Friction, Adhesive wear, Abrasive wear, Corrosion wear, Surface fatigue spherical contact, cylindrical contact, General contact, Dynamic contact stresses, Surface fatigue strength	08
UNIT-4	**STESS-LIFE (S-N) APPROACH:** S-N curves, Statistical nature of fatigue test data, General S-N behavior, Mean stress effects, Different factors influencing S-N behavior, S-N curve representation and approximations, Constant life diagrams, Fatigue life estimation using S-N approach. **STRAIN-LIFE(E-N) APPROACH:** Monotonic stress-strain behavior, Strain controlled test methods, Cyclic stress-strain behavior, Strain based approach to life estimation, Determination of strain life fatigue properties, Mean stress effects, Effect of surface finish, Life estimation by ε-N approach.	14

UNIT-5	**LEFM APPROACH:** LEFM concepts, Crack tip plastic zone, Fracture toughness, Fatigue crack growth, Mean stress effects, Crack growth life estimation. Notches and their effects: Concentrations and gradients in stress and strain, S-N approach for notched membranes, mean stress effects and Haigh diagrams, Notch strain analysis and the strain – life approach, Neuber's rule, Glinka's rule, applications of fracture mechanics to crack growth at notches.	14

Text Books:

1. **Ralph I. Stephens, Ali Fatemi, Robert, Henry o. Fuchs,** "Metal Fatigue in engineering", John Wiley New York, Second edition. 2001.
2. **Failure of Materials in Mechanical Design**, Jack. A. Collins, John Wiley, New York 1992.
3. **Robert L. Norton, "Machine Design",** Pearson Education India, 2000

Reference Books:

1. **S. Suresh, "Fatigue of Materials"**, Cambridge University Press, -1998
2. **Julie. A. Benantine,** "Fundamentals of Metal Fatigue Analysis", Prentice Hall,1990
3. **Fatigue and Fracture**, ASM Hand Book, Vol 19,2002.

SYLLABUS COVERAGE FOR CIE-1, 2, 3
CIE-1: UNIT-1 (100%) + UNIT- 2 (50%)
CIE-2: UNIT-2 (50%) + UNIT -3 (First100%)
CIE-3: UNIT- 4 (100%) + UNIT- 5 (100%)

QUESTION PAPER PATTERN (SEE)

Q. No	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**
Unit	**1**		**2**		**3**		**4**		**5**	

SCHEME OF EXAMINATION (SEE)
1. Ten Full Questions to be set.
2. Five full Questions to be answered.
3. Students shall answer Q1 or Q2 from Unit-1, Q3 or Q4 from Unit-2, Q5 or Q6 from Unit-3, Q7 or Q8 from Unit-4, Q9 or Q10 from Unit-5 with two questions from each Unit.
4. Each question shall contain maximum of 2 subdivisions
5. Each main question carries equal Marks.

COURSE OUTCOMES:

Learners will able to

CO1	Predict failure of engineering components using appropriate failure theories.

CO2	Identify and explain the types of fractures of engineered materials and their characteristic features;
CO3	Estimate life of components using stress life, strain life and LEFM approach.
CO4	Categorize different types of surface failures.

MAPPING OF COs WITH POs

COs/POs	po1	po2	po3	po4	po5	po6	po7	po8	po9	po10	po11	po12
CO1	3	3	3	3	2	2	3	2	3	1	3	3
CO2	2	3	3	2	3	3	3	1	2	3	3	2
CO3	3	3	2	3	3	3	1	3	3	2	3	2
CO4	3	3	2	3	3	2	3	2	1	2	3	3

ADVANCED THEORY OF VIBRATIONS

Course Code	**:**	**18MMD22**		**CIE Marks**	**:**	**50**
Hrs./Week	**:**	**L: T: P: 4:0:0**		**SEE Marks**	**:**	**50**
Credits	**:**	**04**		**SEE Duration**	**:**	**3 hours**

Course Objective:

To teach students how to use the theoretical principles of vibration, and vibration analysis techniques, for the practical solution of vibration problems. The course thus builds on student's prior knowledge of vibration theory, and concentrates on the applications. Thus, the student will fully understand the importance of vibrations in mechanical design of machine parts that operate in vibratory conditions.

Course Content: Chapters/ Units

1. **Review of Mechanical Vibrations:** Basic concepts; free vibration of single degree of freedom systems with and without damping, forced vibration of single DOF-systems, Natural frequency.
   Transient Vibration of single Degree-of freedom systems: Impulse excitation, Arbitrary excitation, Laplace transform formulation, pulse excitation and rise time, Shock response spectrum, Shock isolation. **08 Hours**

2. **Vibration Control:** Introduction, Vibration isolation theory, Vibration isolation and motion isolation for harmonic excitation, practical aspects of vibration analysis, shock isolation, Dynamic vibration absorbers, Vibration dampers.
   Vibration Measurement and applications: Introduction, Transducers, Vibration pickups, Frequency measuring instruments, Vibration exciters, Signal analysis. **08 Hours**

3. **Random Vibrations:** Random phenomena, Time averaging and expected value, Frequency response function, Probability distribution, Correlation, Power spectrum and power spectral density, Fourier transforms, FTs and response. **08 Hours**

4. **Modal analysis & Condition Monitoring:** Dynamic Testing of machines and Structures, Experimental Modal analysis, Machine Condition monitoring and diagnosis. Non-Linear Vibrations: Introduction, Sources of nonlinearity, Qualitative analysis of nonlinear systems. Phase plane, Conservative systems, Stability of equilibrium, Method of isoclines, Perturbation method, Method of iteration, Self-excited oscillations. **14 Hours**

5. **Continuous Systems:** Vibrating string, longitudinal vibration of rods, Torsional vibration of rods, Euler equation for beams.
   Different methods of vibration dissipation in structural components for general and rotating machinery. **14 Hours**

NOTE: the students are advised to prepare the report in the form of assignment to understand the subject and its relevance in the industry

Text Books:

1. Theory of Vibration with Application, - William T. Thomson, Marie Dillon Dahleh, Chandramouli Padmanabhan, 5th edition Pearson Education
2. S. Graham Kelly, "Fundamentals of Mechanical Vibration" - McGraw-Hill, 2000
3. S. S. Rao, "Mechanical Vibrations", Pearson Education, 4^{th} edition.

Reference Books:

1. S. Graham Kelly, "Mechanical Vibrations", Schaum's Outlines, Tata McGraw Hill, 2007.
2. C Sujatha, "Vibrations and Acoustics – Measurement s and signal analysis Tata McGraw Hill, 2010

Course Outcome:

Upon completion of this course, the student will be able to

CO1	Model and analyze a free damped, undamped and forced response of a mechanical system.
CO2	Develop equation and analyze the transient response of a single degree freedom system.
CO3	Assess the response characteristics of a continuous mechanical system.
CO4	Analyze and discuss the behavior of single degree freedom system for linear and non-linear behavior.

SYLLABUS COVERAGE FOR CIE-1, 2, 3

CIE-1: UNIT-1 (100%) + UNIT- 2 (50%)

CIE-2: UNIT-2 (50%) + UNIT -3 (First100%)

CIE-3: UNIT- 4 (100%) + UNIT- 5 (100%)

QUESTION PAPER PATTERN (SEE)

Q. No	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**
Unit	**1**		**2**		**3**		**4**		**5**	

SCHEME OF EXAMINATION (SEE)

1. Ten Full Questions to be set.
2. Five full Questions to be answered.
3. Students shall answer Q1 or Q2 from Unit-1, Q3 or Q4 from Unit-2, Q5 or Q6 from Unit-3, Q7 or Q8 from Unit-4, Q9 or Q10 from Unit-5 with two questions from each Unit.
4. Each question shall contain maximum of 2 subdivisions
5. Each main question carries equal Marks.

MAPPING OF COs WITH POs

COs/POs	po1	po2	po3	po4	po5	po6	po7	po8	po9	po10	po11	po12
CO1	3	3	3	3	2	2	3	2	3	1	3	3
CO2	2	3	3	2	3	3	3	1	2	3	3	2
CO3	3	3	2	3	3	3	1	3	3	2	3	2
CO4	3	3	2	3	3	2	3	2	1	2	3	3

TRIBOLOGY AND BEARING DESIGN

Course Code	**:**	**18MMD231**		**CIE Marks**	**:**	**50**
Hrs/Week	**:**	**L: T: P: 4:0:0**		**SEE Marks**	**:**	**50**
Credits	**:**	**04**		**SEE Duration**	**:**	**3 hours**

Course Objective:

To educate students a clear understanding of factors to be considered in designing parts and components with focus on manufacturability.to study various regimes of lubrication. To acquaint with the concepts of pours and gas lubricated bearings. To study advanced bearing systems and their advantages over conventional bearing systems. Emphasis on various types of bearing systems.

1. **Introduction to Tribology:** Introduction, Friction, Wear, Wear Characterization, Regimes of lubrication, Classification of contacts, lubrication theories, Effect of pressure and temperature on viscosity. Newton's Law of viscous forces, Flow through stationary parallel plates. Hagen's Poiseuille's theory, viscometers. Numerical problems, Concept of lightly loaded bearings, Petroff's equation, Numerical problems. **8 Hours**

2. **Antifriction bearings:** Advantages, selection, nominal life, static and dynamic load bearing capacity, probability of survival, equivalent load, cubic mean load, bearing mountings.
   Porous Bearings: Introduction to porous and gas lubricated bearings. Governing differential equation for gas lubricated bearings, Equations for porous bearings and working principal, Fretting phenomenon and its stages. **08 Hours**

3. **Magnetic Bearings:** Introduction to magnetic bearings, Active magnetic bearings. Different equations used in magnetic bearings and working principal. Advantages and disadvantages of magnetic bearings, Electrical analogy, Magneto-hydrodynamic bearings.
   Advanced bearing systems and their advantages over conventional bearing systems, testing of different types of bearings **08 hours**

4. **Hydrodynamic Lubrications:** Pressure development mechanism. Converging and diverging films and pressure induced flow. Reynolds's 2D equation with assumptions. Introduction to idealized slide bearing with fixed shoe and Pivoted shoes. Expression for load carrying capacity. Location of center of pressure, effect of end leakage on performance, Numerical problems
   Journal Bearings: Introduction to idealized full journal bearings. Load carrying capacity of idealized full journal bearings, Sommer Feld number and its significance, short and partial bearings, Comparison between lightly loaded and heavily loaded bearings, effects of end leakage on performance, Numerical problems. **14 Hours**

5. **Hydrostatic Bearings:** Hydrostatic thrust bearings, hydrostatic circular pad, annular pad, rectangular pad bearings, types of flow restrictors, expression for discharge, load carrying capacity and condition for minimum power loss, numerical problems, and hydrostatic journal bearings.
   EHL Contacts: Introduction to Elasto- hydrodynamic lubricated bearings. Introduction to 'EHL' constant, Grubin type solution. **14 Hours**

NOTE: Students are advised to prepare the report in the form of assignment to understand the subject and its relevance in the industry

Text Books

1. Mujamdar.B.C "Introduction to Tribology of Bearing", Wheeler Publishing, New Delhi 2001
2. Radzimovsky, "Lubrication of Bearings - Theoretical principles and design" Oxford press Company, 2000

Reference Books

1. Dudley D. Fulier " Theory and practice of Lubrication for Engineers", New YorkCompany.1998
2. Moore "Principles and applications of Tribology" Pergamon press, 1975
3. Oscar Pinkus, Beno Sternlicht, "Theory of hydro dynamic lubrication", McGraw-Hill, 1961
4. G W Stachowiak, A W Batchelor, "Engineering Tribology", Elsevier publication 1993.
5. Hydrostatic and hybrid bearings, Butterworth 1983.
6. F. M. Stansfield, Hydrostatic bearings for machine tools and similar applications, Machinery Publishing, 1970

Course Outcome:

Upon completion of this course, the student will be able to

CO1	Students develop skills to design and selection of bearings on Various tribological factors to be considered in moving and rotating parts.
CO2	The students are exposed to orient towards the various types of bearings and their applications.
CO3	Students are exposed to synthesis and analysis of the bearings including fault diagnosis.

SYLLABUS COVERAGE FOR CIE-1, 2, 3

CIE-1: UNIT-1 (100%) + UNIT- 2 (50%)
CIE-2: UNIT-2 (50%) + UNIT -3 (First100%)
CIE-3: UNIT- 4 (100%) + UNIT- 5 (100%)

QUESTION PAPER PATTERN (SEE)

Q. No	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Unit	1		2		3		4		5	

SCHEME OF EXAMINATION (SEE)

1. Ten Full Questions to be set.
2. Five full Questions to be answered.

3. Students shall answer Q1 or Q2 from Unit-1, Q3 or Q4 from Unit-2, Q5 or Q6 from Unit-3, Q7 or Q8 from Unit-4, Q9 or Q10 from Unit-5 with two questions from each Unit.
4. Each question shall contain maximum of 2 subdivisions
5. Each main question carries equal Marks.

MAPPING OF COs WITH POs

COs/POs	po1	po2	po3	po4	po5	po6	po7	po8	po9	po10	po11	po12
CO1	3	3	3	3	2	2	3	2	3	1	3	3
CO2	2	3	3	2	3	3	3	1	2	3	3	2
CO3	3	3	2	3	3	3	1	3	3	2	3	2
CO4	3	3	2	3	3	2	3	2	1	2	3	3

ADMISSION YEAR:2018-19 **ACADEMIC YEAR: 2018-19**

COURSE TITLE: DESIGN OPTIMIZATION		
Sub Code:18MMD232	**No of Credits: L-T-P-SS 4:0:0:0 =4**	**No. of lecture hours/week: 04**
Exam Duration: 3 hours	**CIE Marks: 50**	**Exam Marks: 50**
Pre-requisites	**Research methodology, Composite material, Basic mathematics**	

COURSE OBJECTIVES:

It aids the students to acquire the basics of optimum design, Classical Optimization Techniques, Non - linear Programming, Unconstrained Optimization Techniques, Integer Programming and Dynamic Programming.To study the basics of Design optimization. To acquaint Optimum Design Problem Formulation. To study the Sensitivity Analysis, Linear and Non-Linear Approximations and Optimization Disciplines.To gain knowledge of different Manufacturability in Optimization Problems and Design Interpretation.

#	CONTENTS	Hrs
UNIT-1	**Engineering Design Practice:** Evolution of Design Technology, Introduction to Design and the Design Process, Design versus Analysis, Role of Computers in Design Cycle, Impact of CAE on Design, Numerical Modeling with FEA and Correlation with Physical Tests.	08
UNIT-2	**Optimum Design Problem Formulation**: Types of Optimization Problems, The Mathematics of Optimization, Design Variables and Design Constraints, Feasible and Infeasible Designs, Equality and Inequality Constraints, Discrete and Continuous Optimization, Linear and Non-Linear Optimization. **Optimization Theory** – Fundamental Concepts, Global and Local Minimum, Gradient Vector and Hessian Matrix, Concept of Necessary and Sufficient Conditions, Constrained and Unconstrained Problems, Lagrange Multipliers and Kuhn Tucker Conditions	08
UNIT-3	**Sensitivity Analysis, Linear and Non-Linear Approximations**. Gradient Based Optimization Methods – Dual and Direct. **Optimization Disciplines:** Conceptual Design Optimization and Design Fine Tuning, Combined Optimization, Optimization of Multiple Static and Dynamic Loads, Transient Simulations, Equivalent Static Load Methods	08
UNIT-4	**Manufacturability in Optimization Problems:** Design For Manufacturing, Manufacturing Methods and Rules, Applying Manufacturing Constraints to Optimization Problems. **Design Interpretation:** Unbound Problems, Over Constrained Problems, Problems with No of Multiple Solutions, Active and Inactive Constraints, Constraint Violations and Constraint Screening, Design Move Limits, Local and Global Optimum	14

UNIT-5	**Dynamic Programming:** Introduction, Multistage decision processes, Principle of optimality, Computational Procedure in dynamic programming, Initial value problem, Examples. **Applications of Optimization in Engineering Design:** Automotive, Aerospace and General Industry Applications, Optimization of Metallic and Composite Structures, Minimization and Maximization Problems, MDO and MOO	14

NOTE: the students are advised to prepare the report in the form of assignment to understand the subject and its relevance in the industry

Text Books:

1. S.S. Rao, Engineering Optimization: Theory and Practice, John Wiley, 2009
2. JasbirArora, Introduction to Optimum Design, McGraw Hill, 2011.

Reference Books:

1. Optimization and Probability in System Engg - Ram, Van Nostrand.
2. Optimization methods - K. V. Mital and C. Mohan, New age International Publishers, 1999.
3. Optimization methods for Engg. Design - R.L Fox, Addison – Wesley, 1971.

SYLLABUS COVERAGE FOR CIE-1, 2, 3

CIE-1: UNIT-1 (100%) + UNIT- 2 (50%)
CIE-2: UNIT-2 (50%) + UNIT -3 (First100%)
CIE-3: UNIT- 4 (100%) + UNIT- 5 (100%)

QUESTION PAPER PATTERN (SEE)

Q. No	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**
Unit	**1**		**2**		**3**		**4**		**5**	

SCHEME OF EXAMINATION (SEE)

1. Ten Full Questions to be set.
2. Five full Questions to be answered.
3. Students shall answer Q1 or Q2 from Unit-1, Q3 or Q4 from Unit-2, Q5 or Q6 from Unit-3, Q7 or Q8 from Unit-4, Q9 or Q10 from Unit-5 with two questions from each Unit.
4. Each question shall contain maximum of 2 subdivisions
5. Each main question carries equal Marks.

Course Outcome:

At the completion of this course, students will be able to:

CO1	It provides the student with knowledge required to optimize an existing design with single or multiple objective functions.
CO2	Skills acquired through commercial optimization programs
CO3	Acquire the knowledge of engineering system design

MAPPING OF COs WITH Pos

COs/POs	po1	po2	po3	po4	po5	po6	po7	po8	po9	po10	po11	po12
CO1	3	3	3	3	2	2	3	2	3	1	3	3
CO2	2	3	3	2	3	3	3	1	2	3	3	2
CO3	3	3	2	3	3	3	1	3	3	2	3	2
CO4	3	3	2	3	3	2	3	2	1	2	3	3

ADMISSION YEAR : 2018-19 ACADEMIC YEAR: 2018-19

COURSE TITLE: COMPOSITE MATERIALS TECHNOLOGY		
Sub Code:18MMD241	**No of Credits: L-T-P-SS 4:0:0:0 =4**	**No. of lecture hours/week: 04**
Exam Duration: 3 hours	**CIE Marks: 50**	**Exam Marks: 50**
Pre-requisites	MECHATRONICS, COMPOSITE MATERIALS, SMART MATERIALS	

COURSE OBJECTIVES:

To study the basics of Composite materials. To acquaint mechanics of lamina. To study the micro and macro analysis of the lamina. To gain knowledge of different techniques involved in production of composites.

#	CONTENTS	Hrs
UNIT-1	**Introduction to Composite Materials:** Definition, Classification, Types of matrices material and reinforcements, Characteristics &selection, Fiber composites, laminated composites, Particulate composites, Prepegs, and sandwich construction. **Metal Matrix Composites:** Reinforcement materials, Types, Characteristics and selection, Base metals, Selection, Applications	08
UNIT-2	**Macro Mechanics of a Lamina:** Hooke's law for different types of materials, Number of elastic constants, Derivation of nine independent constants for orthotropic material, Two - dimensional relationship of compliance and stiffness matrix. Hooke's law for two-dimensional angle lamina, engineering constants - Numerical problems. Invariant properties. Stress-Strain relations for lamina of arbitrary orientation, Numerical problems.	08
UNIT-3	**Micro Mechanical Analysis of a Lamina:** Introduction, Evaluation of the four elastic moduli, Rule of mixture, Numerical problems. Experimental Characterization of Lamina- Elastic Moduli and Strengths **Failure Criteria:** Failure criteria for an elementary composite layer or Ply, Maximum Stress and Strain Criteria, Approximate strength criteria, Inter-laminar Strength, Tsa-Hill theory, Tsai, Wu tensor theory, Numerical problem, practical recommendations	08
UNIT-4	**Macro Mechanical Analysis of Laminate**: Introduction, code, Kirchoff hypothesis, Classical Lamination Theory, A, B, and D matrices (Detailed derivation), Special cases of laminates, Numerical problems. Shear Deformation Theory, A, B, D and E matrices (Detailed derivation) **Analysis of Composite Structures:** Optimization of Laminates, composite laminates of uniform strength, application of optimal composite structures, composite pressure vessels, spinning composite disks, composite lattice structures	14
UNIT-5	**Manufacturing and Testing:** Layup and curing - open and closed Mould processing, Hand lay-up techniques, Bag moulding and filament winding. Pultrusion, Pulforming, Thermoforming, Injection moulding, Cutting, Machining, joining and repair. NDT tests – Purpose, Types of defects, NDT method - Ultrasonic inspection, Radiography, Acoustic emission and Acoustic ultrasonic method.	14

	Applications: Aircrafts, missiles, Space hardware, automobile, Electrical and Electronics, Marine, Recreational and sports equipment-future potential of composites. .	

NOTE: the students are advised to prepare the report in the form of assignment to understand the subject and its relevance in the industry

Text Books:

1. Autar K. Kaw, Mechanics of Composite materials, CRC Press, 2nd Ed, 2005.
2. Madhijit Mukhopadhay, Mechanics of Composite Materials & Structures, Universities Press, 2004.

Reference Books:

1. J. N. Reddy, Mechanics of Laminated Composite Plates & Shells, CRD Press, 2nd Ed, 2004.
2. Mein Schwartz, Composite Materials handbook, McGraw Hill, 1984.
3. Rober M. Jones, Mechanics of Composite Materials, Taylor & Francis, 1998.
4. Michael W, Hyer, Stress analysis of fiber Reinforced Composite Materials, Mc-Graw Hill International, 2009.
5. Composite Material Science and Engineering, Krishan K. Chawla, Springer, 3e, 2012.
6. Fiber Reinforced Composites, P.C. Mallik, Marcel Decker, 1993.

SYLLABUS COVERAGE FOR CIE-1, 2, 3

CIE-1: UNIT-1 (100%) + UNIT- 2 (50%)
CIE-2: UNIT-2 (50%) + UNIT -3 (First100%)
CIE-3: UNIT- 4 (100%) + UNIT- 5 (100%)

QUESTION PAPER PATTERN (SEE)

Q. No	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Unit	1		2		3		4		5	

SCHEME OF EXAMINATION (SEE)

1. Ten Full Questions to be set.
2. Five full Questions to be answered.
3. Students shall answer Q1 or Q2 from Unit-1, Q3 or Q4 from Unit-2, Q5 or Q6 from Unit-3, Q7 or Q8 from Unit-4, Q9 or Q10 from Unit-5 with two questions from each Unit.
4. Each question shall contain maximum of 2 subdivisions
5. Each main question carries equal Marks.

Course Outcome:

At the completion of this course, students will be able to:

CO1	Identify the role of matrices and reinforcements used in practical composite structures.
CO2	Analyze problems on micro and macro mechanical behavior of lamina.
CO3	Assess the strength of laminated composite and predict its failure for given static loading conditions.
CO4	Develop understanding of different methods of manufacturing and testing of composites.

MAPPING OF COs WITH POs

COs/POs	po1	po2	po3	po4	po5	po6	po7	po8	po9	po10	po11	po12
CO1	3	3	3	3	2	2	3	2	3	1	3	3
CO2	2	3	3	2	3	3	3	1	2	3	3	2
CO3	3	3	2	3	3	3	1	3	3	2	3	2
CO4	3	3	2	3	3	2	3	2	1	2	3	3

ADMISSION YEAR : 2018-19 ACADEMIC YEAR: 2018-19

COURSE TITLE: FINITE ELEMENT METHODS FOR HEAT TRANSFER AND FLUID FLOW ANALYSIS		
Sub Code: 18MMD242	**No of Credits: L-T-P-SS 4:0:0:0 =4**	**No. of lecture hours/week: 04**
Exam Duration: 3 hours	**CIE Marks: 50**	**Exam Marks: 50**
Pre-requisites	FINITE ELEMENT METHODS, BASIC THERMODYNAMICS, HEAT AND MASS TRANSFERR	

COURSE OBJECTIVES:

To study the basic sources of Heat transfer and fluid mechanics. To acquaint with the effects of steady state conduction heat transfer. To study the advance topic in conduction. To gain knowledge of Flows of Viscous Incompressible Fluids.

#	CONTENTS	Hrs
UNIT-1	**Introduction to Heat Transfer and Fluid Mechanics:** Mathematical Preliminaries, Governing equations of a continuum, Governing equation in terms of primitive variables, porous equations, low speed compressible flow equations, auxiliary transport equations, chemically reacting systems, boundary conditions, change of phase, enclosure radiation. 1. **Finite Element Methods:** Introduction, model differential equation, finite element approximations, interpolation functions, library of finite elements, modeling considerations, assembly of elements, numerical integration, discussion of results with some practical examples, time dependent problems.	08
UNIT-2	**Steady State Conduction Heat Transfer:** Introduction, one dimensional linear, quadratic element. Homogeneous, composite wall with uniform and varying cross-sectional area. Radial heat flow in a cylinder. Conduction –convection systems. Numerical examples. **Conduction Heat Transfer:** Interpolation functions for tetrahedral, hexahedral, pyramid and prism elements. Numerical integration, computation of surface flux, semi-discrete finite element model,	08
UNIT-3	**Advanced topic in Conduction:** specialty elements, computation of boundary conditions, bulk nodes, reactive materials, material motions Example problems on conduction, radiation, temperature dependent conductivity, anisotropic conduction, brazing and welding, investment casting.	08
UNIT-4	**Flows of Viscous Incompressible Fluids:** Governing equation mixed finite element model, penalty finite element models. Finite element models of porous flow, solution of nonlinear equations for transient problems. Radiation algorithms. Variable properties. **Computational consideration:** Interpolation functions for triangular, quadrilateral, tetrahedral and hexahedral elements. Evaluation of element matrices in penalty model, pressure calculation and traction boundary conditions. Numerical examples	14
UNIT-5	**Coupled Fluid Flow and Heat Transfer:** Introduction to non-isothermal incompressible flows, governing equations and boundary condition. Mixed, penalty finite element model. Finite element model for porous flow. Non-isothermal low speed compressible flows: governing equation, boundary conditions, mixed finite element model and solution methods. Convection with change of phase, convection with enclosure radiation, turbulent heat transfer, chemically reacting systems. Numerical examples.	14

NOTE: the students are advised to prepare the report in the form of assignment to understand the subject and its relevance in the industry

Text Books:

1. J N Reddy, David K. Gartling, "The finite element method in heat transfer and flu id dynamics" , CRC, 2004.
2. Roland Wynne Lewis, Perumal Nithiarasu, K. N. Seetharamu," Fundamentals of the finite element method for heat and fluid flow"
   John Wiley, 2004

Reference Books:

1. Ching Jen Chen, R. A. Bernatz, "Finite analytic method in flows and heat transfer", Taylor & Francis.
2. Gianni Comini, Stefano Del Giudice, Carlo Nonino, "Finite Element Analysis in Heat Transfer: Basic Formulation and Linear problems" Taylorand Francis, 1994.

SYLLABUS COVERAGE FOR CIE-1, 2, 3

CIE-1: UNIT-1 (100%) + UNIT- 2 (50%)
CIE-2: UNIT-2 (50%) + UNIT -3 (First100%)
CIE-3: UNIT- 4 (100%) + UNIT- 5 (100%)

QUESTION PAPER PATTERN (SEE)

Q. No	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Unit	1		2		3		4		5	

SCHEME OF EXAMINATION (SEE)

1. Ten Full Questions to be set.
2. Five full Questions to be answered.
3. Students shall answer Q1 or Q2 from Unit-1, Q3 or Q4 from Unit-2, Q5 or Q6 from Unit-3, Q7 or Q8 from Unit-4, Q9 or Q10 from Unit-5 with two questions from each Unit.
4. Each question shall contain maximum of 2 subdivisions
5. Each main question carries equal Marks.

Course Outcome:

Upon completion of this course, the student will be able to

CO1	This course enables the student to use numerical methods for solving problems of fluid flow and heat transfer.
CO2	Analyze of the continuum mechanics problems like fluid flow, heat transfer.
CO3	Analyze of incompressible and compressible fluids.
CO4	Analyze modes of conduction in various mechanical systems

MAPPING OF COs WITH POs

COs/POs	po1	po2	po3	po4	po5	po6	po7	po8	po9	po10	po11	po12
CO1	3	3	3	3	2	2	3	2	3	1	3	3
CO2	2	3	3	2	3	3	3	1	2	3	3	2
CO3	3	3	2	3	3	3	1	3	3	2	3	2
CO4	3	3	2	3	3	2	3	2	1	2	3	3

ADMISSION YEAR:2018-19 **ACADEMIC YEAR: 2018-19**

COURSE TITLE: THEORY OF PLASTICITY		
Sub Code: MMD251	**No of Credits: L-T-P-SS 4:0:0:0 =4**	**No. of lecture hours/week: 04**
Exam Duration: 3 hours	**CIE Marks: 50**	**Exam Marks: 50**
Pre-requisites	**DESIGN OF MACHINE ELEMENTS, ADVANCED MECHANICS OF SOLIDS.**	

COURSE OBJECTIVES:

To study the basic concept of stresses, stress distribution, elastic constants when the material is subjected to loading within the elastic limits. Study the stress distribution in plane, polar and cylindrical coordinate systems. Analyze the material or component subjected to torsion of circular and non-circular shafts (elliptical, triangular bars) Study the thermo-elastic properties of the material at elevated temperatures.

#	CONTENTS	Hrs
UNIT-1	**DEFINITION AND SCOPE OF THE SUBJECT:** Brief review of elasticity, Octahedral normal and shear stresses, Spherical and deviatoric stress, Invariance in terms of the deviatoric stresses, Engineering and natural strains, Mathematical relationships between true stress and true strains, Cubical dilation, finite strains co- efficient Octahedral strain, Strain rate and the strain rate tensor.	08
UNIT-2	**BENDING OF BEAMS:** Torsion of rods and tubes, Nonlinear bending and torsion equations, Simple forms of indentation problems using upper bounds, Application of Metal forming: Extrusion, Drawing, Rolling and Forging.	08
UNIT-3	**SLIP LINE THEORY**: Introduction, Basic equations for incompressible two-dimensional flow, continuity equations, Stresses in conditions of plain strain convention for slip-lines, Geometry of slip lines, Properties of slip lines.	08
UNIT-4	**MATERIAL MODELS:** Stress-strain relations, Yield criteria for ductile metal, Von Mises, Tresca, Yield surface for an Isotropic Plastic material, Stress space, Experimental verification of Yield criteria, Yield criteria for an anisotropic material, flow rule normality of Yield locus, Symmetry and convexity, Deformation of isotropic and kinematic hardening, bilinear stress-strain relationship.	14
UNIT-5	**PLASTIC STRESS-STRAIN RELATIONS:** Prandtl-Reuss Saint Venant, Levy-Mises, Experimental verification of the Prandtl-Reuss equation, Upper and lower bound theorems. Application to problems: Uniaxial tension and compression.	**1**4

TEXT BOOKS

1. **R. A. C. Slater**, "Engineering Plasticity - Theory and Application to Metal Forming Process", McMillan Press Ltd., 1977.

2. **SADHU SINGH, "Theory of Plasticity and Metal forming Process", Khanna Publishers, Delhi, 1999.**

REFERENCE BOOKS

1. **HOFFMAN AND SACHS**, "Introduction to the Theory of Plasticity for Engineers", LLC, 2012.
2. **J CHAKRABARTY**, "Theory of plasticity", Butterworth, 2006. 3. Johnson and Mellor, "Plasticity for Mechanical Engineers", Van Nostrand, 1966.
3. **PLASTICITY FOR MECHANICAL ENGINEERS** - Johnson and Mellor, Van Nostrand, 1966.

SYLLABUS COVERAGE FOR CIE-1, 2, 3

CIE-1: UNIT-1 (100%) + UNIT- 2 (50%)
CIE-2: UNIT-2 (50%) + UNIT -3 (First100%)
CIE-3: UNIT- 4 (100%) + UNIT- 5 (100%)

QUESTION PAPER PATTERN (SEE)

Q. No	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**
Unit	**1**		**2**		**3**		**4**		**5**	

SCHEME OF EXAMINATION (SEE)

1. Ten Full Questions to be set.
2. Five full Questions to be answered.
3. Students shall answer Q1 or Q2 from Unit-1, Q3 or Q4 from Unit-2, Q5 or Q6 from Unit-3, Q7 or Q8 from Unit-4, Q9 or Q10 from Unit-5 with two questions from each Unit.
4. Each question shall contain maximum of 2 subdivisions
5. Each main question carries equal Marks.

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO1	Apply basic concepts in continuum mechanics of solids viz. Stress and strain tensors, equilibrium, compatibility and constitutive equations and methods of solution to elasticity problems
CO 2	Evaluate stresses and displacements in simple solids such as pressurized cylinders, shrink fitted cylinders, rotating disc and shaft, plate with hole and non-circular shafts and thin tubes under torsion.
CO 3	Use MATLAB or equivalent software to evaluate and plot particular solutions.
CO 4	Apply the principles of plastic deformation to estimate yielding in simple engineering structures.
CO 5	Apply principles of continuum mechanics to design a structure or component to achieve desired performance under realistic constraints.

MAPPING OF COs WITH POs

COs/POs	po1	po2	po3	po4	po5	po6	po7	po8	po9	po10	po11	po12
CO1	3	3	3	2	2	3	3	2	3	3	1	2
CO2	2	3	3	2	2	1	3	2	3	3	3	2
CO3	3	3	3	2	3	2	3	1	3	2	3	2
CO4	3	3	2	2	3	2	3	1	2	2	3	3

ROTOR DYNAMICS

Course Code	**:**	**18MMD252**		**CIE Marks**	**:**	**50**
Hrs/Week	**:**	**L: T: P: 4:0:0**		**SEE Marks**	**:**	**50**
Credits	**:**	**04**		**SEE Duration**	**:**	**3 hours**

Course Objective:
To make student to understand the concept of turbo machinery. To enable them to design specifically modeling of bearings, shafts and rotor stages. To guide them to predict instability like whirling including gyroscopic and Coriolis effect. To find the methods of reducing blade vibrations

1. **Fluid Film Lubrication:** Basic theory of fluid film lubrication, Derivation of generalized Reynolds equations, Boundary conditions, Fluid film stiffness and Damping coefficients, Stability and dynamic response for hydrodynamic journal bearing, Two lobe journal bearings.
08 Hours

2. **Critical Speed:** Dunkerley's method, Rayleigh's method, Stodola's method. Rotor Bearing System: Instability of rotors due to the effect of hydrodynamic oil layer in the bearings, support flexibility, Simple model with one concentrated mass at the center.
Introduction to Jeffcott rotor. Concepts, mathematical equations, applications. **08 Hours**

3. **Turbo rotor System Stability by Transfer Matrix Formulation:** General Turborotor system, development of element transfer matrices, the matrix differential equation, effect of shear and rotary inertia, the elastic rotors supported in bearings, numerical solutions. **08 Hours**

4. **Turbo rotor System Stability by Finite Element Formulation:** General Turborotor system, generalized forces and co-ordinates system assembly element matrices, Consistent mass matrix formulation, Lumped mass model, linearized model for journal bearings, System dynamic equations Fix stability analysis non dimensional stability analysis, unbalance response and Transient analysis. **14 Hours**

5. **Blade Vibration:** Centrifugal effect, Transfer matrix and Finite element, approaches. **14 Hours**

NOTE: the students are advised to prepare the report in the form of assignment to understand the subject and its relevance in the industry.

Reference Books:

1. Cameron, “Principles of Lubrication”, Longman Publishing Group, 1986
2. Bolotin, “Nonconservative problems of the Theory of elastic stability”, Macmillan, 1963
3. Peztel, Lockie, “Matrix Methods in Elasto Mechanic s”, McGraw-Hill, 1963.
4. Timoshenko, “Vibration Problems in Engineering”, Ox ford City Press, 2011
5. Zienkiewicz, “The finite element method in engineering science”, McGraw-Hill, 1971

Course Outcomes:

Upon completion of this course, the student will be able to

CO1	Model a rotating machine element theoretically for rotor dynamic analysis.
CO2	Analyze Free and Forced lateral response of simple rotor models and of more complex systems including shafts, bearings, seals and stators.
CO3	Formulate Finite element and carry out analysis for Turborotor System Stability.
CO4	Apply Finite element approach to blade vibration.

SYLLABUS COVERAGE FOR CIE-1, 2, 3

CIE-1: UNIT-1 (100%) + UNIT- 2 (50%)
CIE-2: UNIT-2 (50%) + UNIT -3 (First100%)
CIE-3: UNIT- 4 (100%) + UNIT- 5 (100%)

QUESTION PAPER PATTERN (SEE)

Q. No	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Unit	1		2		3		4		5	

SCHEME OF EXAMINATION (SEE)

1. Ten Full Questions to be set.
2. Five full Questions to be answered.
3. Students shall answer Q1 or Q2 from Unit-1, Q3 or Q4 from Unit-2, Q5 or Q6 from Unit-3, Q7 or Q8 from Unit-4, Q9 or Q10 from Unit-5 with two questions from each Unit.
4. Each question shall contain maximum of 2 subdivisions
5. Each main question carries equal Marks.

MAPPING OF COs WITH POs

COs/POs	po1	po2	po3	po4	po5	po6	po7	po8	po9	po10	po11	po12
CO1	3	3	3	2	2	3	3	2	3	3	1	2
CO2	2	3	3	2	2	1	3	2	3	3	3	2
CO3	3	3	3	2	3	2	3	1	3	2	3	2
CO4	3	3	2	2	3	2	3	1	2	2	3	3

RESEARCH METHODOLOGY

Course Code	**:**	**18RM27**		**CIE Marks**	**:**	**50**
Hrs/Week	**:**	**L: T: P: 2:0:0**		**SEE Marks**	**:**	**50**
Credits	**:**	**02**		**SEE Duration**	**:**	**3 hours**

Course Learning Objectives: Students are expected to

- Have a basic understanding of the underlying principles of quantitative and qualitative research
- Identify the overall process of designing a research study from its inception to its report.
- Choose the most appropriate research method to address a particular research question
- Gain a overview of a range of quantitative and qualitative approaches to data analysis

1. **Overview of Research:** Research and its types, identifying and defining research problem and introduction to different research designs. Essential constituents of Literature Review. Basic principles of experimental design, Primary data and Secondary Data, methods of primary data collection, classification of secondary data, designing questionnaires and schedules. **8 Hours**

2. **Sampling Methods:** Probability sampling: simple random sampling, systematic sampling, stratified sampling, cluster sampling and multistage sampling. Non-probability sampling: convenience sampling, judgment sampling, quota sampling. Sampling distributions. **6 Hours**

3. **Processing and analysis of Data:** Statistical measures and their significance: Central tendencies, variation, skewness, Kurtosis, time series analysis, correlation and regression, Testing of Hypotheses: Parametric (t and Chi Square). **6 Hours**

4. **Essential of Report writing and Ethical issues**: Significance of Report Writing, Different Steps in Writing Report, Layout of the Research Report, Ethical issues related to Research, Plagiarism and self- Plagiarism, Publishing. **6 Hours**

Reference Books:

1. Krishnaswami, K.N., Sivakumar, A. I. and Mathirajan, M., Management Research Methodology, Pearson Education: New Delhi.
2. Kothari C.R., Research Methodology Methods and techniques by, New Age International Publishers, 2nd edition
3. Levin, R.I. and Rubin, D.S., Statistics for Management, 7th Edition, Pearson Education: New Delhi.

Course Outcome:

At the end of the course students will:

CO1	Describe a range of quantitative and qualitative research designs and identify the advantages and disadvantages associated with these designs
CO2	Choose appropriate quantitative or qualitative method to collect data
CO3	Analyse and test the given data using appropriate methods
CO4	Design an appropriate mixed-method research study to answer a research question

SEMESETER III

ADMISSION YEAR:2018-19 **ACADEMIC YEAR: 2018-19**

COURSE TITLE: FRACTURE MECHANICS		
Sub Code: 18MMD31	**No of Credits: L-T-P-SS** **4:0:0:0=4**	**No. of lecture hours/week :04**
Exam Duration :3 hours	**CIE Marks:50**	**Exam Marks :50**
Pre-requisites	**Metrology & Measurements, Design of Machine Elements'**	

COURSE OBJECTIVES:

Fracture mechanics provides a methodology for prediction, prevention and control of fracture in materials, components and structures. It provides a background for damage tolerant design. It quantifies toughness as materials resistance to crack propagation.

#	CONTENTS	Hrss
UNIT-1	**FRACTURE MECHANICS PRINCIPLES:** Introduction and historical review, Sources of micro and macro cracks. Stress concentration due to elliptical hole, Strength ideal materials, Griffith's energy balance approach. Fracture mechanics approach to design. NDT and Various NDT methods used in fracture mechanics. The Airy stress functions. Complex stress function. Effect of finite size. Special cases, Elliptical cracks.	08
UNIT-2	**PLASTICITY EFFECTS:** Irwin plastic zone correction. Dugdale approach. The shape of the plastic zone for plane stress and plane strain cases, Plastic constraint factor. The Thickness effect, numerical problems. **Determination of Stress intensity factors and plane strain fracture toughness**: Introduction, analysis and numerical methods, experimental methods, estimation of stress intensity factors. Plane strain fracture toughness test, The Standard test.	08
UNIT-3	**THE ENERGY RELEASE RATE:** Criteria for crack growth. The crack resistance (R curve). Compliance, J integral. Tearing modulus. Stability.	08

UNIT-4	**ELASTIC PLASTIC FRACTURE MECHANICS:** Fracture beyond general yield. The Crack-tip opening displacement. The Use of CTOD criteria. Experimental determination of CTOD. Parameters affecting the critical CTOD. Use of J integral. Limitation of J integral. **DYNAMICS AND CRACK ARREST:** Crack speed and kinetic energy. Dynamic stress intensity and elastic energy release rate. Crack branching. Principles of crack arrest. Crack arrest in practice. Dynamic fracture toughness**.**	14
UNIT-5	**FATIGUE CRACK PROPAGATION AND APPLICATIONS OF FRACTURE MECHANICS:** Crack growth and the stress intensity factor. Factors affecting crack propagation. variable amplitude service loading, means to provide fail-safety, required information for fracture mechanics approach, Mixed mode (combined) loading and design criteria.	14

Text Books:

1. **David Broek,** "Elementary Engineering Fracture Mechanics", Springer Netherlands,2011
2. **Anderson**, "Fracture Mechanics-Fundamental and Application", T.L CRC press1998.

Reference Books:

1. **Karen Hellan**, "Introduction to fracture mechanics", McGraw Hill, 2nd Edition
2. **S.A. Meguid**, "Engineering fracture mechanics" Elsevier Applied Science, 1989
3. **Jayatilaka,** "Fracture of Engineering Brittle Materials", Applied Science Publishers, 1979
4. **Rolfe and Barsom**, "Fracture and Fatigue Control in Structures", Prentice Hall, 1977
5. **Knott**, "Fundamentals of fracture mechanisms", Butterworths, 1973

SYLLABUS COVERAGE FOR CIE-1, 2, 3

CIE-1: UNIT-1 (100%) + UNIT- 2 (50%)

CIE-2: UNIT-2 (50%) + UNIT -3 (Firs100%)

CIE-3: UNIT- 4 (100%) + UNIT- 5 (100%)

QUESTION PAPER PATTERN (SEE)

Q. No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
UNIT	1		2		3		4		5	

(Irrespective of portions covered due to whatever might be the reason)

SCHEME OF EXAMINATION (SEE)

1. Ten Full Questions to be set.
2. Five full Questions to be answered.
3. Students shall answer Q1 or Q2 from Unit-1, Q3 or Q4 from Unit-2, Q5 or Q6 from Unit-3, Q7 or Q8 from Unit-4, Q9 or Q10 from Unit-5 with two questions from each Unit.
4. Each question shall contain maximum of 2 subdivisions
5. Each main question carries equal Marks.

COURSE OUTCOMES:

Learners will able to

CO1	Develop fundamental understanding of the effects of crack like defects on the performance of aerospace, civil, and mechanical engineering structures.
CO2	Select appropriate materials for engineering structures to ensure damage tolerance.
CO3	Employ modern numerical methods to determine critical crack sizes and fatigue crack propagation rates in engineering structures.
CO4	Gain appreciation of the status of academic research in field of fracture mechanics.

MAPPING OF COs WITH Pos

COs/POs	po1	po2	po3	po4	po5	po6	po7	po8	po9	po10	po11	po12
CO1	3	3	-	-	-	-	3	2	-	1	-	-
CO2	2	3	-	2	-	-	-	-	-	3	-	-
CO3	3	3	-	-	-	3	-	-	-	-	--	-
CO4	3	3	2	-	-	1	-	-	-	-	-	-

ADMISSION YEAR:2018-19 **ACADEMIC YEAR: 2019-2020**

COURSE TITLE: SMART MATERIALS AND STRUCTURES		
Sub Code: 18MMD321	**No of Credits: L-T-P-S** **4:0:0:0 =4**	**No. of lecture hours/week :04**
Exam Duration: 3 hours	**CIE Marks: 50**	**Exam Marks:50**
Pre-requisites	Mechatronics, Composite materials technology**.**	

COURSE OBJECTIVES:

To study the basic sources of smart materials and structures. To acquaint with the effects of Shape memory Alloy, ER and MR fluids. To study the usefulness of vibration absorbers and control of structures. To gain knowledge of MEMS and devices.

#	CONTENTS	Hrss
UNIT-1	**Smart Structures**: Types of Smart Structures, Potential Feasibility of Smart Structures, Key Elements of Smart Structures, Applications of Smart Structures. Piezoelectric materials, Properties, piezoelectric Constitutive Relations, Depoling and Coersive Field, field strain relation. Hysteresis, Creep and Strain Rate effects, Inchworm Linear Motor.	08
UNIT-2	**Beam Modeling:** Beam Modeling with induced strain Rate effects, Inchworm Linear Motor Beam Modeling with induced strain Actuation-single Actuators, dual Actuators, Pure Extension, Pure Bending harmonic excitation, Bernoulli-Euler beam Model, problems, Piezoelectric Applications.	08
UNIT-3	**Shape memory Alloy:** Experimental Phenomenology, Shape Memory Effect, Phase Transformation, Tanaka's Constitutive Model, testing of SMA Wires, Vibration Control through SMA, Multiplexing. Applications Of SMA and Problems. **ER and MR Fluids:** Mechanisms and properties, Fluid Composition and behavior, The Bingham Plastic and Related Models, Pre-Yield Response. Post-Yield flow applications in Clutches, Dampers and Others	08
UNIT-4	**Vibration Absorbers:** series and Parallel Damped Vibrations (Overview), Active Vibration Absorbers, Fiber Optics, Physical Phenomena, Characteristics, Sensors, Fiber Optics in Crack Detection, applications. **Control of Structures:** Modeling, Control Strategies and Limitations, Active Structures in Practice.	14
UNIT-5	**MEMS** – Mechanical Properties of MEMS Materials, Scaling of Mechanical Systems, Fundamentals of Theory, The Intrinsic Characteristics of MEMS, Miniaturization, Microelectronics Integration.	14

	Devices: Sensors and Actuators, Conductivity of Semiconductors, Crystal Planes and Orientation, (Stress and Strain Relations, Flexural Beam Bending Analysis Under Simple Loading Conditions), Polymers in MEMS, Optical MEMS Applications.	

Text Books:

1. Smart Materials and Structures -**M. V. Gandhi and B.S Thompson**, Chapman and Hall, London; New York, 1992 (ISBN: 0412370107).

2. Smart Structures and Materials **- Culshaw, Artech House, Boston**, 1996 (ISBN :0890066817).

3. Smart Structures: Analysis & Design **- A. Srinivasan**, Cambridge University Press, Cambridge; New York, 2001 (ISBN: 0521650267).

Reference Books:

1. Electro ceramics: Materials, Properties and Applications - **A. J. Moulson and J. M. Herbert**. John Wiley & Sons, ISBN: 0471497429

2. **Piezoelectric Sensories**: Force, Strain, Pressure, Acceleration and Acoustic Emission Sensors. Materials and Amplifiers, Springer, Berlin; New York, 2002 (ISBN: 3540422595).

3. Piezoelectric Actuators and Wtrasonic Motors -**K. Uchino, Kluwer** Academic Publishers, Boston, 1997 (ISBN: 0792398114).
4. Handbook of Giant Magneto strictive Materials - **G. Engdahl**, Academic Press, San Diego, Calif.; London, 2000 (ISBN: 012238640X).

5. Shape Memory Materials **- K. Otsuka and C.M. Wayman**, Cambridge University Press, Cambridge; New York, 199~ (ISBN: 052144487X).

SYLLABUS COVERAGE FOR CIE-1, 2, 3

CIE-1: UNIT-1 (100%) + UNIT- 2 (100%)

CIE-2: UNIT-3 (100%) + UNIT -4 (50%)

CIE-3: UNIT- 4 (50%) + UNIT- 5 (100%)

QUESTION PAPER PATTERN (SEE)

Q. No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
UNIT	1		2		3		4		5	

(Irrespective of portions covered due to whatever might be the reason)

SCHEME OF EXAMINATION (SEE)

1. Ten Full Questions to be set.
2. Five full Questions to be answered.
3. Students shall answer Q1 or Q2 from Unit-1, Q3 or Q4 from Unit-2, Q5 or Q6 from Unit-3, Q7 or Q8 from Unit-4, Q9 or Q10 from Unit-5 with two questions from each Unit.
4. Each question shall contain maximum of 2 subdivisions
5. Each main question carries equal Marks.

Course Outcome:

At the completion of this course, students will be able to:

CO1	Understand the behavior and applicability of various smart materials.
CO2	Design Simple models for smart structures and materials
CO3	Perform simulation of smart structures and material application.
CO4	Conduct experiments to verify the predictions.

MAPPING OF COs WITH POs

COs/POs	po1	po2	po3	po4	po5	po6	po7	po8	po9	po10	po11	po12
CO1	3	3	--	-	2	-	-	-	-	-	-	-
CO2	2	3	-	2	-	-	-	1	-	-	3	-
CO3	3	-	2	-	3	-	1	-	-	2	-	2
CO4	3	-	2	-	-	-	-	-	-	-	-	-

ADMISSION YEAR: 2018-19 **ACADEMIC YEAR: 2019-20**

COURSE TITLE: STATISTICAL MODELING AND EXPERIMENTAL DESIGN		
Sub Code: 18MMD322	**No of Credits: L-T-P-SS** **4:0:0:0=4**	**No. of Lecture hours/week :04**
Exam Duration:3 hours	**CIE Marks: 50**	**Exam Marks :50**
Pre-requisites	Mom, Experimental Mechanics, Finite Element Method.	

COURSE OBJECTIVES:

The objective of this course is to impart students with a holistic view of the fundamentals of experimental designs, analysis tools and techniques, interpretation and applications.

	CONTENTS	**Hrss**
UNIT-1	**Statistical Modeling and Data Analysis:** Introduction, Review of basic statistical concepts: Concepts of random variable, Sample and population, Measure of Central tendency; Mean, median and mode. Illustration through Numerical examples, Normal, Log Normal & Weibull distributions. Illustration through Numerical examples.	10
UNIT-2	**Introduction to Designed Experiments:** Strategy of experimentation, some typical applications of experimental design, Basic principles, Guidelines for designing experiments, A brief history of statistical design, Summary: Using statistical techniques in experimentation.	10
UNIT-3	**Factorial Experiments** Basic definitions, The advantages of factorials, The two-factorial design. Introduction, Factorial Experiments Terminology: factors, levels, interactions, Two-level experimental designs for two factors and three factors. Illustration through Numerical examples.	10
UNIT-4	**Regression Analysis:** linear and multiple Regression analysis, Mathematical models from experimental data. Illustration through Numerical examples.	10
UNIT-5	**Signal to Noise Ratio:** Evaluation of sensitivity to noise. Signal to Noise ratios for static problems: Smaller-the-batter type, Nominal the-better-type, Larger-the better type. Signal to Noise for Dynamic problems. Illustration through Numerical examples.	**10**

TEXT BOOKS:

1. **Design and Analysis of Experiments,** Douglas C. Montgomery, 5th Edition Wiley India Pvt. Ltd. 2007.
2. **Quality engineering using robust design**, Madhav s. Phadke, Prentice Hall PTR, Englewood Cliffs, NewJersy 07632, 1989.

REFERENCES BOOKS:

1. Thomas B. Barker, **"Quality if experimental design",** Marcel Dekker Inc ASQC Quality Press.1985.
2. C.F. Jeff Wu Michael Hamada, **"Experiments Planning Analysis and Parameter Design Optimization",** Wiley Editions. 2002.
3. L. W. Condra**, "Reliability Improvement with design of Experiments",** 2nd ed, CRC Press, 2001
4. Phillip j. Ross, **"Taguchi Techniques for Quality Engineering",** 2nd ed. McGraw Hill International Editions, 1996.

REMINDER

BREAK-UP OF COURSE CONTENTS FOR;

CIE-1: UNIT 1 (100%) + UNIT 2 (100%)

CIE-2: UNIT 3 (100%) + UNIT 4 (FIRST 50%)

CIE-3: UNIT 4 (NEXT 50%) + UNIT 5 (100%)

(Irrespective of portions covered due to whatever might be the reason)

QUESTION PAPER PATTERN (SEE)

Q. No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
UNIT	1		2		3		4		5	

SCHEME OF EXAMINATION (SEE)

1. Ten Full Questions to be set.
2. Five full Questions to be answered.
3. Students shall answer Q1 or Q2 from Unit-1, Q3 or Q4 from Unit-2, Q5 or Q6 from Unit-3, Q7 or Q8 from Unit-4, Q9 or Q10 from Unit-5 with two questions from each Unit.
4. Each question shall contain maximum of 2 subdivisions
5. Each main question carries equal Marks.

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO1	Basic statistics including ANOVA and regression.
CO2	Experimental designs such as RCBD, BIBD, Latin Square, factorial and fractional factorial designs.
CO3	Application of statistical models in analyzing experimental data.
CO4	RSM to optimize response of interest from an experiment.
CO5	Robust design of process and product.

MAPPING OF COs WITH POs

COs/POs	po1	po2	po3	po4	po5	po6	po7	po8	po9	po10	po11	po12
CO1	1	1	-	2	-	-	-	-	-	-	-	-
CO2	2	-	3	2	-	-	-	--	-	-	-	-
CO3	3	3	-	2	3	2	3	-	-	-	-	-
CO4	3	-	2	-	-	-	-	-	2	-	-	-

ADMISSION YEAR: 2018-19 **ACADEMIC YEAR: 2019-20**

COURSE TITLE: OPTIMIZATION TECHNIQUES		
Sub Code: 18MMD323	**No of Credits: L-T-P-SS** **4:0:0:0=4**	**No. of Lecture hours/week :04**
Exam Duration:3 hours	**CIE Marks: 50**	**Exam Marks :50**
Pre-requisites	Mom, Experimental Mechanics, Finite Element Method.	

COURSE OBJECTIVES:

To understand the theory of optimization methods and algorithms developed for solving various types of optimization problems. To develop and promote research interest in applying optimization techniques in problems of Engineering and Technology. To apply the mathematical results and numerical techniques of optimization theory to concrete Engineering problems.

	CONTENTS	**Hrss**
UNIT-1	**Introduction:** Terminology, Design Variables, Constraints, Objective Function, Variable Bounds, Problem Formulation, Engineering Optimization Problems. Calculus method. Linear Programming. Simplex method, Concept of Duality.	08
UNIT-2	**Single Variable Optimization Problems:** Optimality Criterion, Bracketing Methods, Region Elimination Methods, Interval Halving Method, Fibonacci Search Method, Golden Section Method, Successive Quadratic Estimation Method. Gradient Based Methods: Newton-Raphson Method, Bisection Method, Secant Method. Application to Root finding.	08
UNIT-3	**Multivariable Optimization Algorithms:** Optimality Criteria, Unidirectional Search, Direct Search Methods: Hooke-Jeeves pattern search method, Powell's Conjugate Direction Method. Gradient Based Methods: Cauchy's Steepest Descent Method, Newton's method, Marquardt's Method.	08
UNIT-4	**Constrained Optimization Algorithms:** Kuhn Tucker conditions, Transformation Methods: Penalty Function Method, Method of Multipliers, Sensitivity analysis.	14

UNIT-5	**Topics in Optimization Techniques:** Quadratics Programming, sequential quadratic programming; Integer Programming, Penalty Function Method, Branch and Bound Method, Geometric Programming, Applications Design of experiments and Taguchi method – Application and problem solving; Dynamic programming, principle of optimality, recursive equation approach and applications; Genetic algorithm.	**14**

TEXT BOOKS:

1. S. S. Rao, **"Engineering Optimization: Theory and Practice",** John Wiley & Sons, 1996.

2. Kalyanmoy Deb, **"Optimization for Engineering Design: Algorithms and Examples",** 2nd ed, Prentice Hall of India, 2004.

REFERENCES BOOKS:

1. E. J. Haug and J. S. Arora, **"Applied Optimal Design",** Wiley, New York.
2. G.V. Reklaites, A. Ravindran and K.M. Rogsdeth, **"Optimization",** Wiley, New York.

REMINDER

BREAK-UP OF COURSE CONTENTS FOR;

CIE-1: UNIT 1 (100%) + UNIT 2 (100%)

CIE-2: UNIT 3 (100%) + UNIT 4 (FIRST 50%)

CIE-3: UNIT 4 (NEXT 50%) + UNIT 5 (100%)

(Irrespective of portions covered due to whatever might be the reason)

QUESTION PAPER PATTERN (SEE)

Q. No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
UNIT	1		2		3		4		5	

SCHEME OF EXAMINATION (SEE)

1. Ten Full Questions to be set.
2. Five full Questions to be answered.
3. Students shall answer Q1 or Q2 from Unit-1, Q3 or Q4 from Unit-2, Q5 or Q6 from Unit-3, Q7 or Q8 from Unit-4, Q9 or Q10 from Unit-5 with two questions from each Unit.
4. Each question shall contain maximum of 2 subdivisions
5. Each main question carries equal Marks.

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO1	Formulate engineering optimization problem and solve LPP by simplex method.
CO2	Solve single and multivariable optimization problem by various relevant method.
CO3	Develop algorithm for constrained optimization.
CO4	Examine various optimization techniques and demonstrate their applicability.
CO5	Cast engineering minima/maxima problems into optimization framework.

MAPPING OF COs WITH Pos

COs/POs	po1	po2	po3	po4	po5	po6	po7	po8	po9	po10	po11	po12
CO1	1	1	-	-	-	-	-	-	3	-	-	-
CO2	2	3	-	-	2	1	-	-	-	-	-	2
CO3	3	-	3	-	3	-	-	-	-	-	-	-
CO4	3	1	2	-	-	-	-	-	-	-	-	3

ADMISSION YEAR: 2018-19 **ACADEMIC YEAR: 2019-20**

COURSE TITLE: THEORY OF PLATES AND SHELLS		
Sub Code: 18MMD324	**No of Credits: L-T-P-SS** **4:0:0:0=4**	**No. of Lecture hours/week :04**
Exam Duration:3 hours	**CIE Marks: 50**	**Exam Marks :50**
Pre-requisites	Mom, Theory of Elasticity, Theory of Plasticity	

COURSE OBJECTIVES:

Understand the classical structural mechanics approximations of Membrane, Plate and Shell theories. Apply energy formulations to demonstrate the consistent derivation of approximate boundary conditions and edge effects. Identify the necessary tools to describe static, dynamic and non-linear motions. Evaluate the buckling, vibration and stress parameters in thin shells using numerical approximation techniques.

	CONTENTS	**Hrss**
UNIT-1	**General Introduction:** 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.	08
UNIT-2	**Classical Theory of Plates:** 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	08
UNIT-3	**Buckling Analysis of Rectangular Plates:** 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	08
UNIT-4	**Vibration of Plates:** 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	14

UNIT-5	**Analysis of Thin Elastic Shells of Revolution:** 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.	**14**

TEXT BOOKS:

1. Reddy, J.N., "**Theory and Analysis of Elastic Plates & Shells**", C.R.C. Press, NY, USA, 2nd Edition, ISBN 9780849384158
2. Timoshenko, S. and Krieger S.W. **Theory of Plates and Shells**, McGraw Hill Book Company, New York 1990, ISBN 0-13-913426-3

REFERENCES BOOKS:

1. Szilard, R., **Theory and Analysis of Plates,** Prentice Hall Inc., 1999, ISBN 0-12-9353336-2
2. Wilhelm Flügge, **Stresses in shells,** Springer –Verlag, ISBN 978-3-662-01028-0

REMINDER

BREAK-UP OF COURSE CONTENTS FOR;

CIE-1: UNIT 1 (100%) + UNIT 2 (100%)

CIE-2: UNIT 3 (100%) + UNIT 4 (FIRST 50%)

CIE-3: UNIT 4 (NEXT 50%) + UNIT 5 (100%)

(Irrespective of portions covered due to whatever might be the reason)

QUESTION PAPER PATTERN (SEE)

Q. No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
UNIT	1		2		3		4		5	

SCHEME OF EXAMINATION (SEE)

1. Ten Full Questions to be set.
2. Five full Questions to be answered.
3. Students shall answer Q1 or Q2 from Unit-1, Q3 or Q4 from Unit-2, Q5 or Q6 from Unit-3, Q7 or Q8 from Unit-4, Q9 or Q10 from Unit-5 with two questions from each Unit.
4. Each question shall contain maximum of 2 subdivisions
5. Each main question carries equal Marks.

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO1	Apply the structural mechanics approximations of membrane, plates and shells.
CO2	Develop simple modifications to the membrane plate and shell theories
CO3	Describe the static, dynamic, and non-linear motion of membrane, plate and shell structures.
CO4	Analyze numerical problems in shells of revolution.

MAPPING OF COs WITH Pos

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	3	1	-	-	-	-	-	-	-
CO2	-	-	-	2	-	1	-	-	-	-	-
CO3	3	1	1	-	-	-	-	-	-	-	-
CO4	1	2	-	3	3	1	-	-	-	-	-

ADMISSION YEAR: 2018-19 **ACADEMIC YEAR: 2019-20**

COURSE TITLE: COMPUTER APPLICATIONS IN DESIGN		
Sub Code: 18MMD331	**No of Credits: L-T-P-SS** **4:0:0:0=4**	**No. of Lecture hours/week :04**
Exam Duration:3 hours	**CIE Marks: 50**	**Exam Marks :50**
Pre-requisites	Mom, Finite Element Method.	

COURSE OBJECTIVES:

Memorize the equations of transformations, curves, solid models and surfaces. Understand the concept of computer Graphics. Demonstrate the principles of wire frame, Geometric, and surface modeling. Distinguish the different concepts of algorithm.

	CONTENTS	Hrss
UNIT-1	**Computer Graphics:** Line drawing algorithms: DDA, Bresenham's algorithms, Mid-point circle algorithms, coordinate systems, windowing, View generation, Clipping, Transformations of geometry.	10
UNIT-2	**Software Configuration:** Software configuration of a graphics system, Functions of a graphics package, Mathematics of projections, Hidden line removal, Hidden surface removal, Shading, Rendering. **Basics of geometry modeling:** Requirements of geometric modeling, geometric models, geometric construction methods, modeling facilities desired.	10
UNIT-3	**Wireframe Modeling:** Classification of wire frame entities, curve representation methods, parametric representation of analytic curves, curvature continuity, Lagrange interpolation, Parametric representation of synthetic curves, curve manipulations.	10
UNIT-4	**Solid Modeling:** Application of solid models, modeling considerations of solids, geometry and topology, solid modeling scheme, Boundary Representation, Winged edge data structure for Boundary representation, Euler operations, Constructive solid geometry, Sweeping, Solid Manipulations.	10
UNIT-5	**Surface modeling:** Introduction, Planes, Vector Planes, surface entities, Surface representation methods, Quadratic Surface in normal forms, Quadratic Surface in general forms, Quadratic Surface in matrix form, parametric surfaces, Parametric representation of analytic surfaces, Parametric representation of synthetic surfaces, Surface Manipulations.	**10**

TEXT BOOKS:

1. Chennakesava R Alavala **"CAD/CAM Concepts and Applications",** 1st Ed PHI, New Delhi, 2009.
2. P.N. Rao**, "CAD/CAM Principles and Applications",** 3rd Ed., McGraw Hill, Education Pvt Ltd.

REFERENCES BOOKS:

1. Ibrahim Zeid, **"Mastering CAD/CAM",** 2nd Ed., TMH Publishing Company Limited., New Delhi.
2. M.P. Groover and 3 E W Zimmers**, CAD/CAM Computer aided Design and Manufacturing**, 9th Ed, 1993.

REMINDER

BREAK-UP OF COURSE CONTENTS FOR;

CIE-1: UNIT 1 (100%) + UNIT 2 (100%)

CIE-2: UNIT 3 (100%) + UNIT 4 (FIRST 50%)

CIE-3: UNIT 4 (NEXT 50%) + UNIT 5 (100%)

(Irrespective of portions covered due to whatever might be the reason)

QUESTION PAPER PATTERN (SEE)

Q. No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
UNIT	1		2		3		4		5	

SCHEME OF EXAMINATION (SEE)

1. Ten Full Questions to be set.
2. Five full Questions to be answered.
3. Students shall answer Q1 or Q2 from Unit-1, Q3 or Q4 from Unit-2, Q5 or Q6 from Unit-3, Q7 or Q8 from Unit-4, Q9 or Q10 from Unit-5 with two questions from each Unit.
4. Each question shall contain maximum of 2 subdivisions
5. Each main question carries equal Marks.

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO1	Discuss the concepts of Computer Graphics in CAD in product development
CO2	Apply the concepts of CAD in the manufacturing industry
CO3	Analyze the concepts of computer Aided Design
CO4	Evaluating the techniques involved in CAD.

MAPPING OF COs WITH POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	2	3	3	-	-	-	-	-	-	-	-
CO2	3	2	2	1	-	-	-	-	-	-	-
CO3	1	3	-	3	2	-	-	-	-	-	-
CO4	-	-	1	2	3	1	-	-	-	-	-

- High-3
- Medium-2
- Low-1

ADMISSION YEAR: 2018-19 **ACADEMIC YEAR: 2019-20**

COURSE TITLE: ADVANCED SYSTEM DESIGN		
Sub Code: 18MMD332	**No of Credits: L-T-P-SS** **4:0:0:0=4**	**No. of Lecture hours/week :04**
Exam Duration:3 hours	**CIE Marks: 50**	**Exam Marks :50**
Pre-requisites	Mom, Project Management, Engineering Economics.	

<u>COURSE OBJECTIVES</u>:

To study the basic concepts of different types of design. Need analysis in engineering systems
Analyze the concept of design with respect to economics and optimization.

	CONTENTS	**Hrss**
UNIT-1	**INTRODUCTION**: What is designing, Man as a designer: Design by evolution, inadequacies of traditional design method: System approach of engineering problems: Need models: design history of large-scale existing system. Morphology of Design: The three phases of design projects, the structure of design process, decision making and iteration.	10
UNIT-2	**Identification, Need analysis &Design Concept:** Preliminary need statement, analysis of need, specifications, and standards of performance and constraints. Process of idealization, mental fixity, analysis, AIDA, brain storming etc.	10
UNIT-3	**Preliminary Design:** Mathematical modeling for functional design: concept of sensitivity, compatibility and stability analysis. Evaluation Of Alternatives and Design Decisions.	10
UNIT-4	**Design Tree:** Quality of design, Concept of utility, multi criteria decisions, decisions under uncertainty and risk (Numerical), Bath tub curve, exponential reliability function, system reliability concept. (Numerical)	10
UNIT-5	**Economics And Optimization in Engineering Design**: Economics in Engineering Design, Fixed and variable costs, break-even analysis. (Numerical) Optimization: Introduction to LPP. Man, Machine Interaction, Designing for use and maintenance, Man-Machine Cycle, Design of displays and controls. Factors influencing displays and controls.	**10**

REFERENCES BOOKS:

1. **Mechanical System Design** by: W. E. Eder lecturer In Mechanical Engineering And's. Gosling
2. Harrison Kim, Dept. of Industrial and Enterprise Systems Engineering (ISE) - 2 - 1. Papa Lambros, P.Y. and Wilde, D., **Principles of Optimal Design** (2nd Ed.), Cambridge University Press, New York, 2000. 2.

REMINDER

BREAK-UP OF COURSE CONTENTS FOR;

CIE-1: UNIT 1 (100%) + UNIT 2 (100%)

CIE-2: UNIT 3 (100%) + UNIT 4 (FIRST 50%)

CIE-3: UNIT 4 (NEXT 50%) + UNIT 5 (100%)

(Irrespective of portions covered due to whatever might be the reason)

QUESTION PAPER PATTERN (SEE)

Q. No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
UNIT	1		2		3		4		5	

SCHEME OF EXAMINATION (SEE)

1. Ten Full Questions to be set.
2. Five full Questions to be answered.
3. Students shall answer Q1 or Q2 from Unit-1, Q3 or Q4 from Unit-2, Q5 or Q6 from Unit-3, Q7 or Q8 from Unit-4, Q9 or Q10 from Unit-5 with two questions from each Unit.
4. Each question shall contain maximum of 2 subdivisions
5. Each main question carries equal Marks.

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO1	Analyze the types of design and concepts
CO2	Applying the concept of need based design.
CO3	Implement preliminary design concept in real life.
CO4	Analyzing the process of design in the form of sequence of actions.

MAPPING OF COs WITH POs

COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO 1
1	3	--	-	-	-	-	-	-	-	1	-	2
2	2	-	3	-	1	-	3	-	-	-	-	-
3	3	3	2	-	-	-	-	-	-	-	-	-
4	3	3	2	1	-	-	-	-	-	-	-	-

- High-3
- Medium-2
- Low-1

ADMISSION YEAR: 2018-19 **ACADEMIC YEAR: 2019-20**

COURSE TITLE: DESIGN OF HYDRAULICS AND PNEUMATICS		
Sub Code: 18MMD333	**No of Credits: L-T-P-SS** **4:0:0:0=4**	**No. of Lecture hours/week :04**
Exam Duration:3 hours	**CIE Marks: 50**	**Exam Marks :50**
Pre-requisites	Mom, Design of Machine Elements, Finite Element Method.	

COURSE OBJECTIVES:

Identify the symbolic representation of hydraulic systems. Understand the working of industrial systems employing fluid power. Identify the working of hydraulic circuits. Select the appropriate components through design calculations and Demonstrate the electronic components in pneumatic systems.

	CONTENTS	Hrss
UNIT-1	**Hydraulic Actuators and Motors:** Pascal's law and problems on Pascal's Law, continuity equations, introduction to conversion of units. Structure of Hydraulic Control System Linear Hydraulic Actuators [cylinders], Mechanics of Hydraulic Cylinder loading, Hydraulic Rotary Actuators, Gear motors, vane motors, piston motors, Hydraulic motor theoretical torque, power and flow rate, and hydraulic motor performance.	08
UNIT-2	**Control Components in Hydraulic Systems:** Directional Control Valves – Symbolic representation, Constructional features, pressure control valves – direct and pilot operated types, flow control valves. **Hydraulic Circuit Design and Analysis:** Control of single and double – acting Hydraulic Cylinder, regenerative circuit, pump unloading circuit, Double pump Hydraulic system, Counter Balance Valve application, and Hydraulic cylinder sequencing circuits. Locked cylinder using pilot check valve, cylinder synchronizing circuits, speed control of hydraulic cylinder, speed control of hydraulic motors, accumulators and accumulator circuits.	08
UNIT-3	**Introduction to Pneumatic Control:** Choice of working medium, characteristics of compressed air. Structure of Pneumatic control system. Pneumatic Actuators: Linear cylinders – Types, conventional type of cylinder working, end position cushioning, seals, mounting arrangements applications. Rod–less cylinders, types, working advantages. Rotary cylinder types construction and application. Design parameters, selection.	08
UNIT-4	**Directional Control Valves:** Symbolic representation as per ISO 1219 and ISO 5599. Design and constructional aspects, poppet valves, slide valves spool valve, suspended seat type slide valve. Simple Pneumatic Control: Direct and indirect actuation pneumatic cylinders, use of memory valve.	14

	Flow control valves and speed control of cylinders supply air throttling and exhaust air throttling use of quick exhaust valve. Signal processing elements: Use of Logic gates – OR and AND gates pneumatic applications. Practical examples involving the use of logic gates. Pressure dependent controls types construction–practical applications. Time dependent controls – Principle, construction, practical applications.	
UNIT-5	**Multi-cylinder Applications:** Coordinated and sequential motion control. Motion and control diagrams – Signal elimination methods. Cascading method – principle. Practical application examples (up to two cylinders) using cascading method (using reversing valves). Electro-Pneumatic control: Principles-signal input and output pilot assisted solenoid control of directional control valves, use of relay and contactors. Control circuitry for simple single cylinder applications. Compressed air: Production of compressed air – compressors, preparation of compressed air- Driers, Filters, Regulators, Distribution of compressed air- Piping layout.	**14**

TEXT BOOKS:

1. S.R. Majumdar **Oil Hydraulic Systems - Principles and Maintenance**, Tata Mc Graw Hill publishing company Ltd. 2001. ISBN- 10: 0074637487
2. S.R. Majumdar Pneumatic Systems, Tata Mc Graw Hill publishing Co., 1995. ISBN- 0074602314.

REFERENCES BOOKS:

1. Anthony Esposito **Fluid Power with applications**, Fifth edition Pearson education, Inc. 2000. ISBN- 10: 129202387
2. Andrew Parr **Pneumatics and Hydraulics**. Jaico Publishing Co. 2000. ISBN- 10: 0750644192

REMINDER

BREAK-UP OF COURSE CONTENTS FOR;

CIE-1: UNIT 1 (100%) + UNIT 2 (100%)

CIE-2: UNIT 3 (100%) + UNIT 4 (FIRST 50%)

CIE-3: UNIT 4 (NEXT 50%) + UNIT 5 (100%)

(Irrespective of portions covered due to whatever might be the reason)

QUESTION PAPER PATTERN (SEE)

Q. No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
UNIT	1		2		3		4		5	

SCHEME OF EXAMINATION (SEE)

1. Ten Full Questions to be set.
2. Five full Questions to be answered.
3. Students shall answer Q1 or Q2 from Unit-1, Q3 or Q4 from Unit-2, Q5 or Q6 from Unit-3, Q7 or Q8 from Unit-4, Q9 or Q10 from Unit-5 with two questions from each Unit.
4. Each question shall contain maximum of 2 subdivisions
5. Each main question carries equal Marks.

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO1	Illustrate and explain the significance hydraulic and pneumatic components.
CO2	Describe the symbolic representations of fluid power components in an industrial circuit.
CO3	Integrate and differentiate a function for given set of tabulated data with greater accuracy for engineering problems.
CO4	Evaluate the selection of valves for specific applications
CO5	Design and develop hydraulic and pneumatic based system for industrial applications.

MAPPING OF COs WITH POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	-	-	-	-	-	-	-	-	-	-
CO2	-	3	2	2	2	-	-	-	-	-	-
CO3	-	-	2	2	-	-	-	-	-	-	-
CO4	3	2	1	-	3	-	1	-	-	-	-

ADMISSION YEAR: 2018-19 **ACADEMIC YEAR: 2019-20**

COURSE TITLE: COMPUTATIONAL METHODS IN ENGINEERING ANALYSIS		
Sub Code: 18MMD334	**No of Credits: L-T-P-SS** **4:0:0:0=4**	**No. of Lecture hours/week :04**
Exam Duration:3 hours	**CIE Marks: 50**	**Exam Marks :50**
Pre-requisites	Mom, Design of Machine Elements, Finite Element Method.	

COURSE OBJECTIVES:

The aim of the course is to equip an engineer with skills to develop mathematical models: It is an art of applying mathematics to complex real-world problems. The course combines mathematical theory, practical engineering and scientific computing to address today's technological challenges. It facilitates conversion of scientific statements into a form Engineers understand.

	CONTENTS	Hrss
UNIT-1	**Approximations and Round off Errors:** Significant figures, accuracy and precision, error definitions, round off errors and truncation errors. Mathematical modeling and Engineering problem solving, simple mathematical model, Conservation Laws of Engineering.	08
UNIT-2	**Roots of Equations:** Bracketing Methods-Graphical method, Bisection method, False position method, Newton- Raphson method, Secant Method. Multiple roots, Simple fixed-point iteration. **Roots of Polynomial:** Polynomials in Engineering and Science, Muller's method, Bairstow's Method Graeffe's Roots Squaring Method.	08
UNIT-3	**Numerical Differentiation and Numerical Integration:** Newton –Cotes and Gauss Quadrature Integration formulae, Integration of Equations, Romberg integration, Numerical Differentiation Applied to Engineering problems, High Accuracy differentiation formulae.	08
UNIT-4	**System of Linear Algebraic Equations and Eigen Value Problems:** Introduction, Direct methods, Cramer's Rule, Gauss Elimination Method, Gauss-Jordan Elimination Method, Triangularization method, Cholesky Method, Partition method, Error Analysis for direct methods, Iteration Methods. **Eigen values and Eigen Vectors:** Bounds on Eigen Values, Jacobi method for symmetric matrices, Givens method for symmetric matrices, Rutishauser method for arbitrary matrices, Power method, Inverse power method.	14

UNIT-5	**Linear Transformation:** Introduction to Linear Transformation, The matrix of Linear Transformation, Linear Models in Science and Engineering **Orthogonality and Least Squares**: Inner product, length and orthogonality, orthogonal sets, Orthogonal projections, The Gram-Schmidt process, Least Square problems, Inner product spaces.	**14**

TEXT BOOKS:

3. Steven C. Chapra, Raymond P. Canale **"Numerical Methods for Engineers**"- 5th Edition, Tata McGraw Hill, 2007.
4. S. S. Sastry "**Introductory Method of Numerical Analysis**", PHI, 2009.
5. M K. Jain, S.R.K Iyengar, R K. Jain "**Numerical Methods for Scientific and Engg. Computation**". New Age International, 2003.

REFERENCES BOOKS:

3. Perviz Moin **"Fundamentals of Engineering Numerical Analysis",** Cambridge, 2010.
4. David. C. Lay, **"Linear Algebra and its applications"** -3rd edition, Pearson Education, 2005.
5. Laurence V Fausett, **"Applied Numerical Analysis using Matlab"**, Pearson, 2008.

REMINDER

BREAK-UP OF COURSE CONTENTS FOR;
CIE-1: UNIT 1 (100%) + UNIT 2 (100%)
CIE-2: UNIT 3 (100%) + UNIT 4 (FIRST 50%)
CIE-3: UNIT 4 (NEXT 50%) + UNIT 5 (100%)
(Irrespective of portions covered due to whatever might be the reason)
QUESTION PAPER PATTERN (SEE)

Q. No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
UNIT	1		2		3		4		5	

SCHEME OF EXAMINATION (SEE)

1. Ten Full Questions to be set.
2. Five full Questions to be answered.
3. Students shall answer Q1 or Q2 from Unit-1, Q3 or Q4 from Unit-2, Q5 or Q6 from Unit-3, Q7 or Q8 from Unit-4, Q9 or Q10 from Unit-5 with two questions from each Unit.
4. Each question shall contain maximum of 2 subdivisions
5. Each main question carries equal Marks.

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO1	Construct and analyze mathematical models of physical applications.
CO2	Find the roots of polynomials, algebraic, transcendental or simultaneous system of equations in science and engineering problems.
CO3	Integrate and differentiate a function for given set of tabulated data with greater accuracy for engineering problems.
CO4	Solve system of linear algebraic equations and compute eigen values and eigen vectors of matrices.
CO5	Demonstrate use of computational tools like MAT Lab to obtain solution to complex mathematical models.

MAPPING OF COs WITH POs

COs/POs	po1	po2	po3	po4	po5	po6	po7	po8	po9	po10	po11	po12
CO1	2	-	-	-	2	-	3	-	-	-	-	-
CO2	2	3	3	-	-	-	-	-	-	-	-	-
CO3	3	3	-	-	-	-	-	-	-	-	-	-
CO4	3	3	2	-	-	-	-	1	-	-	-	-

INTERNSHIP-18MMDI34

Internship: The student shall undergo internship for 16 weeks.

Preliminary Report submission and Evaluation after 8^{th} week of Internship to be carried out by the Internal Guide of the college and a senior faculty for 100 marks

Final Report submission and Evaluation after 16^{th} week of Internship to be carried out by the Internal Guide of the college and a senior faculty of Dept. Report Evaluation to be completed within two weeks of submission for 100 marks.

Viva-Voce on Internship - To be conducted by the Internship Guide (from the college) and the External Guide / Examiner within 2 weeks of Submission with a senior faculty / HoD as chairman for 100 marks

COURSE TITLE: Modelling & Analysis Lab		
Sub Code: 18MMDL35	**No of Credits: L-T-P-SS 1:0:3:0=4**	**No. of Lecture hours/week :03**
Exam Duration:3 hours	**CIE Marks: 50**	**Exam Marks :50**
Pre-requisites	Design and vibration knowledge.	

Note:

1) These are independent laboratory exercises
2) A student may be given one or two problems stated herein
3) Student must submit a comprehensive report on the problem solved and give a Presentation on the same for Internal Evaluation
4) Any one of the exercises done from the following list has to be asked in the Examination for evaluation.

Course Content:

Experiment #1 Structural Analysis

Part A: FE Modeling of a stiffened Panel using a commercial preprocessor.

Part B: Buckling, Bending and Modal analysis of stiffened Panels.

Part C: Parametric Studies.

Experiment #2 Design Optimization

Part A: Shape Optimization of a rotating annular disk.

Part B: Weight Minimization of a Rail Car Suspension Spring.

Part C: Topology Optimization of a Bracket.

Experiment #3 Thermal analysis

Part A: Square Plate with Temperature Prescribed on one edge and Opposite edge insulated.

Part B: A Thick Square Plate with the Top Surface exposed to a Fluid at high temperature, Bottom Surface at room temperature, Lateral Surfaces Insulated.

Experiment #4 Thermal Stress Analysis

Part A: A Thick-Walled Cylinder with specified Temperature at inner and outer Surfaces.

Part B: A Thick-Walled Cylinder filled with a Fluid at high temperature and Outer Surface exposed to atmosphere.

Experiment#5 CFD Analysis

Part A: CFD Analysis of a Hydro Dynamic Bearing using commercial code.

Part B: Comparison of predicted Pressure and Velocity distributions with Target solutions.

Part C: Experimental Investigations using a Journal Bearing Test Rig.

Part D: Correlation Studies.

Experiment #6 Welded Joints.

Part A: Fabrication and Testing.

Part B: FE Modeling and Failure Analysis.

Experiment #7 Bolted Joints.

Part A: Fabrication and Testing.

Part B: FE Modeling and Failure Analysis.

Part C: Correlation Studies.

Experiment #8 Adhesive Bonded Joints.

Part A: Fabrication and Testing.

Part B: FE Modeling and Failure Analysis.

Part C: Correlation Studies.

Course Outcomes:

Upon completion of this course, the student will be able to

CO1	Acquire knowledge of stresses, strains and failure theories and analyze them in terms of mathematical models.
CO2	Design and conduct experiments involving photo elasticity and strain gauges.
CO3	Apply Experimental techniques for different engineering problems.
CO4	Use Finite element analysis software and make comparison with other techniques.

COURSE TITLE: TECHANICAL SEMINAR		
Sub Code: 18MMDS36	**No of Credits: L-T-P-SS 0:0:2:0=2**	**No. of Lecture hours/week :02**
CIE Marks: 50		

Course Outcomes:

Upon completion of this course, the student will be able to

CO1	Identify and understand current trends and real-world issues related to topics in Machine Design.
CO2	Classify appropriate content and sources, through literature survey, that can be summarized and integrated into presentation
CO3	Review, analyze, and interpret data & results using critical thinking skills
CO4	Revise and present scientific case studies in presentation
CO5	Collaborate effectively with other students in analyzing results and preparing oral presentations
CO6	Prepare a technical seminar report and communicate effectively through oral presentation using multimedia tools

III SEMESTER

PROJECT PHASE: I 18MMDP37

Problem formulation and submission of **synopsis** within 8 weeks from the commencement of 3rd semester, which shall be evaluated for 50 marks by the committee constituted for the purpose by the Head of the Department comprising the guide, senior faculty of the department with HoD as Chairman.

Literature survey and progress done after 16 weeks shall be evaluated by guide and external examiner with senior faculty / HoD as chairman for 50 marks.

IV SEMESTER

- **Project Phase-II** - Internal Evaluation of progress in Project work shall be evaluated after 8 weeks for 25 marks by the committee constituted for the purpose by the Head of the Department comprising the guide and senior faculty of the department with HoD as Chairman
- **Project Phase-III** - Internal Evaluation of Project Demonstration, which shall be evaluated after 15 weeks for 25 marks by the committee constituted for the purpose by the Head of the Department.
- **Final Evaluation of Project Work and Viva-voce**.
  - Final evaluation of project to be carried out after 16 weeks from the date of commencement of 4^{th} semester.
  - The Internal Examiner (the project guide with a teaching experience of at least three years) and External Examiner with HoD as chairman will complete the final evaluation of Project.
- Internal and External Examiners shall carry out the evaluation for 100 Marks each and the average of these marks shall be the final marks of the Project Evaluation.
- **Viva – Voce:** The Viva-Voce shall be conducted jointly by Internal Examiner and External Examiner with HoD as chairman for 100 Marks.

DR AMBEDKAR INSTITUTE OF TECHONOLOGY

DEPARTMENT OF MECHNICAL ENGINEERING

SCHEME AND SYLLABUS

FOR

M. Tech MACHINE DESIGN

YEAR 2019-20

PROGRAM EDUCATIONAL OBJECTIVES

PEO1--Graduates will have knowledge in the discipline of Machine Design with hands on skill in using modern engineering tools to address real world engineering problems and be socially responsible.

PEO2– Graduates shall be successful in their career as analysts and designers of structural components of conventional and advanced materials, participating in a team or individually in an industry, research or academia.

PEO3– Graduates shall be proficient in their communication, presentation and will be prepared to engage in the process of life-long learning through professional development and research.

PROGRAM OUTCOMES

PO No.	Program Outcomes (PO)
PO1	Acquire in-depth knowledge of specific discipline or professional area, including wider and global perspective, with an ability to discriminate, evaluate, analyze and synthesize existing and new knowledge, and integration of the same for enhancement of knowledge.
PO2	Analyze complex engineering problems critically, apply independent judgment for synthesizing information to make intellectual and/or creative advances for conducting research in a wider theoretical, practical and policy context
PO3	Think laterally and originally, conceptualize and solve engineering problems, evaluate a wide range of potential solutions for those problems and arrive at feasible, optimal solutions after considering public health and safety, cultural, societal and environmental factors in the core areas of expertise.
PO4	Extract information pertinent to unfamiliar problems through literature survey and experiments, apply appropriate research methodologies, techniques and tools, design, conduct experiments, analyze and interpret data, demonstrate higher order skill and view things in a broader perspective, contribute individually/in group(s) to the development of scientific/technological knowledge in one or more domains of engineering.
PO5	Create, select, learn and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modeling, to complex engineering activities with an understanding of the limitations.
PO6	Possess knowledge and understanding of group dynamics, recognize opportunities and contribute positively to collaborative-multidisciplinary scientific research, demonstrate a capacity for self-management and teamwork, decision-making based on open-mindedness, objectivity and rational analysis in order to achieve common goals and further the learning of themselves as well as others.
PO7	Demonstrate knowledge and understanding of engineering and management principles and apply the same to one's own work, as a member and leader in a team, manage projects efficiently in respective disciplines and multidisciplinary environments after consideration of economic and financial factors.
PO8	Communicate with the engineering community, and with society at large, regarding complex engineering activities confidently and effectively, such as, being able to comprehend and write effective reports and design documentation by adhering to appropriate standards, make effective presentations, and give and receive clear instructions.
PO9	Recognize the need for, and have the preparation and ability to engage in life-long learning independently, with a high level of enthusiasm and commitment to improve knowledge and competence continuously.
PO10	Acquire professional and intellectual integrity, professional code of conduct, ethics of research and scholarship, consideration of the impact of research outcomes on professional practices and an understanding of responsibility to contribute to the community for sustainable development of society.
PO11	Observe and examine critically the outcomes of one's actions and make corrective

BATCH **2019-20** **MACHINE DESIGN**

FIRST SEMSTER			L	T	P	C
1	18MMD11	ADVANCED MECHANICS OF SOLIDS	4	0	0	4.0
2	18MMD12	FINITE ELEMENT METHOD	3	0	2	4.0
3	18MMD131	EXPERIMENTAL MECHANICS	3	0	2	4.0
4	18MMD132	ROBUST DESIGN	4	0	0	
5	18MMD141	DYNAMICS AND MACHINE DESIGN	4	0	0	4.0
6	18MMD142	DESIGN FOR MANUFACTURE	4	0	0	
7	18MMD151	MECHATRONICS SYSTEM DESIGN	4	0	0	4.0
8	18MMD152	AUTOMOBILE SYSTEM DESIGN	4	0	0	
9	18MMD16	INDUSTRIAL VISIT		0	2	2.0
FIRST SEMESTER END CREDITS						22.0

SECOND SEMSTER			L	T	P	C
1	18MMD21	ADVANCED MACHINE DESIGN	4	0	0	4.0
2	18MMD22	ADVANCED THEORY OF VIBRATIONS	3	0	2	4.0
3	18MMD231	TRIBOLOGY AND BEARING DESIGN	4	0	0	4.0
4	18MMD232	DESIGN OPTIMIZATION	4	0	0	
5	18MMD241	COMPOSITE MATERIALS TECHONOLOGY	4	0	0	4.0
6	18MMD242	FINITE ELEMENT METHODS FOR HEAT TRANSFER	4	0	0	
7	18MMD251	THEORY OF PLASTICITY	4	0	0	4.0
8	18MMD252	ROTOR DYNAMICS	4	0	0	
9	RM27	RESEARCH METHODOLOGY	2	0	0	2.0
SECOND SEMESTER END CREDITS						22.0
FIRST YEAR CREDITS						44.0
CUMULATIVE CREDITS AT END OF 1st YEAR						44.0

BATCH **2019-20** **MACHINE DESIGN**

THIRD SEMSTER			L	T	P	C
1	18MMD31	FRACTURE MECHANICS	3	0	0	3.0
2	18MMD32X	ELECTIVE -1	3	0	0	3.0
3	18MMD33X	ELECTIVE -2	3	0	0	3.0
4	18MMDI34	INTERNSHIP	0	0	6	6.0
5	18MMDL35	MODELING AND ANALYSIS LAB	0	0	2	2.0
6	18MMDS36	TECHNICAL SEMINAR	0	0	1	1.0
7	18MMDP37	PROJECT PHASE -1	0	2	0	2.0
THIRD SEMESTER END CREDITS						20.0

ELECTIVE 1			ELECTIVE-2		
SL.NO	NAME OF THE SUBJECT	Subject code	SL.NO	NAME OF THE SUBJECT	Subject Code
1	SMART MATERIALS AND STRUCTURES	18MMD321	1	COMPUTER APPLICATIONS IN DESIGN	18MMD331
2	STATISTICAL MODELLING& EXPERIMENTAL DESIGN	18MMD322	2	ADVANCE SYSTEM DESIGN	18MMD332
3	OPTIMIZATION TECHNIQUES	18MMD323	3	DESIGN OF HYDRAULICS AND PNEUMATICS	18MMD333
4	THEORY OF PLATES AND SHELLS	18MMD324	4	COMPUTATIONAL METHODS IN ENGINEERING ANALYSIS	18MMD334

FOURTH SEMSTER			L	T	P	C
1	18MMDP41	PROJECT WORK PHASE II – MIDTERM INTERNAL EVALUATION	0	0	2	2.0
2	18MMDP42	PROJECT WORK EVALUATION AND VIVA VOCE	0	0	22	22
FOURTH SEMESTER END CREDITS						24.0
SECOND YEAR CREDITS						44.0
CUMULATIVE CREDITS AT END OF 2nd YEAR						88.0

1ST SEMESTER

ADMISSION YEAR:2019-20 **ACADEMIC YEAR: 2019-20**

COURSE TITLE: ADVANCED MECHANICS OF SOLIDS		
Sub Code:18MMD11	**No of Credits: L-T-P-SS 4:0:0:0 =4**	**No. of lecture hours/week: 04**
Exam Duration: 3 hours	**CIE Marks: 50**	**Exam Marks: 50**
Pre-requisites	**MOM, DESIGN OF MACHINE ELEMENTS.**	

COURSE OBJECTIVES:

To study the basic concept of stresses, stress distribution, elastic constants when the material is subjected to loading within the elastic limits. Study the stress distribution in plane, polar and cylindrical coordinate systems. Analyze the material or component subjected to torsion of circular and non-circular shafts (elliptical, triangular bars) Study the thermo-elastic properties of the material at elevated temperatures.

#	CONTENTS	Hrs
UNIT-1	**INTRODUCTION TO STRESS:** Definition and Notation for forces and stresses. Components of stresses, equations of Equilibrium, Specification of stress at a point. Principal stresses and shear stresses and Mohr's diagram in three dimensions. Boundary conditions. Stress transformation, Stress components on an arbitrary plane, Stress invariants, Octahedral stresses, Decomposition of state of stress.	10
UNIT-2	**INTRODUCTION TO STRAIN**: Deformation, Strain Displacement relations, Strain components, The state of strain at a point, Principal strain, Strain transformation, Compatibility equations, Cubical dilatation. **STRESS-STRAIN RELATIONS AND THE GENERAL EQUATIONS OF ELASTICITY**: Generalized Hooke's; law in terms of engineering constants. Formulation of elasticity Problems. Existence and uniqueness of solution, Saint -Venant's principle, Principle of super position and reciprocal theorem.	10
UNIT-3	**ENERGY METHODS**: Work done by forces and elastic strain energy stored, Begg's Deformeter, First theorem of Castigliano, Theorem of virtual work, Kirchhoff's theorem.	10
UNIT-4	**TWO DIMENSIONAL PROBLEMS IN CARTESIAN CO-ORDINATES:** Airy's stress function, investigation for simple beam problems. Bending of a narrow cantilever beam under end load, simply supported beam with uniform load, Use of Fourier series to solve two dimensional problems. **TORSION OF PRISMATIC BARS:** Torsion of Circular and elliptical cross section bars, Membrane analogy, Torsion of thin-walled closed tubes.	12

UNIT-5	**TWO DIMENSIONAL PROBLEMS IN POLAR CO-ORDINATES:** General equations, stress distribution symmetrical about an axis, thick cylinder, shrink fit, Strain components in polar co-ordinates, Rotating disk and cylinder, Thermal stresses in thin discs, Stress concentration around a circular hole in an infinite plate. Thermo-elastic stress –strain relations.	10

TEXT BOOKS:
1. **Advanced Mechanics of solids**, L. S. Srinath, Tata Mc. Graw Hill, 2003
2. **Theory of Elasticity,** S. P. Timoshenko and J. N Gordier, McGraw Hill International, 3rd edition, 1972

REFERENCES BOOKS:
1. **Theory of Elasticity,** Dr. Sadhu Singh, Khanna Publications, 1988
2. **Elasticity, Theory, Applications &Numericals,** Martin H Sadd, Elsevier. 2005
3. **Applied Elasticity,** Seetharaman & Govindaraju, Interline Publishing
4. **Applied Elasticity,** C.T. WANG Sc. D. Mc. Graw Hill Book Co.1953.

REMINDER
BREAK-UP OF COURSE CONTENTS FOR;
CIE-1: UNIT 1 (100%) + UNIT 2 (100%)
CIE-2: UNIT 3 (100%) + UNIT 4 (FIRST 50%)
CIE-3: UNIT 4 (NEXT 50%) + UNIT 5 (100%)
(Irrespective of portions covered due to whatever might be the reason)

QUESTION PAPER PATTERN (SEE)

Q. No	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**
Unit	**1**		**2**		**3**		**4**		**5**	

SCHEME OF EXAMINATION (SEE)
1. Ten Full Questions to be set.
2. Five full Questions to be answered.
3. Students shall answer Q1 or Q2 from Unit-1, Q3 or Q4 from Unit-2, Q5 or Q6 from Unit-3, Q7 or Q8 from Unit-4, Q9 or Q10 from Unit-5 with two questions from each Unit.
4. Each question shall contain maximum of 2 subdivisions
5. Each main question carries equal Marks.

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO1	Apply basic concepts in continuum mechanics of solids viz. Stress and strain tensors, equilibrium, compatibility and constitutive equations and methods of solution to elasticity problems
CO 2	Evaluate stresses and displacements in simple solids such as pressurized cylinders, shrink fitted cylinders, rotating disc and shaft, plate with hole and non-circular shafts and thin tubes under torsion.
CO 3	Use MATLAB or equivalent software to evaluate and plot particular solutions.
CO 4	Apply the principles of plastic deformation to estimate yielding in simple engineering structures.

CO 5	Apply principles of continuum mechanics to design a structure or component to achieve desired performance under realistic constraints.

MAPPING OF COs WITH POs

COs/POs	po1	po2	po3	po4	po5	po6	po7	po8	po9	po10	po11	po12
CO1	3	3	3	2	2	3	3	2	3	3	1	2
CO2	2	3	3	2	2	1	3	2	3	3	3	2
CO3	3	3	3	2	3	2	3	1	3	2	3	2
CO4	3	3	2	2	3	2	3	1	2	2	3	3

ADMISSION YEAR :2019-20 **ACADEMIC YEAR: 2019-20**

COURSE TITLE: FINITE ELEMENT METHOD		
Sub Code:18MMD12	**No of Credits: L-T-P-SS 3:0:0:1 =4**	**No. of lecture hours/week: 04**
Exam Duration: 3 hours	**CIE Marks: 50**	**Exam Marks: 50**
Pre-requisites	**Engineering Mechanics, Design of Machine Elements**	

COURSE OBJECTIVES:

This course enables the student to identify failure modes and evolve design by analysis methodology. Design against fatigue failure is given explicit attention. **To** impart structures analysis for stress, strain & dynamic loading knowledge. To enable formulation of the design problems into FEA. To comprehend the basic concepts and enhance capabilities for solving complex problems. To introduce the concepts of elastic and static analysis problems.

#	CONTENTS	Hrs
UNIT-1	**MATHEMATICS FOR FEM**: Significant figures, accuracy and precision, error definitions, round off errors and truncation errors. Mathematical modeling. **SYSTEM OF LINEAR ALGEBRAIC EQUATIONS AND EIGEN VALUE PROBLEMS:** Gauss Elimination Method, Gauss-Jordan Elimination Method, Triangularization method, Cholesky Method, Partition method, Iteration Methods. Eigen values and Eigen Vectors: Bounds on Eigen Values, Jacobi method for symmetric matrices.	10
UNIT-2	**Introduction to Finite Element Method:** Basic Steps in Finite Element Method to solve mechanical engineering (Solid, Fluid and Heat Transfer) Galerkin approach, Displacement Approach: Admissible Functions, Convergence Criteria: Conforming and Non-Conforming elements, C_o C_1 and C_n Continuity Elements. Basic Equations, Element Characteristic Equations, Assembly Procedure, Boundary and Constraint Conditions	10
UNIT-3	**Solid Mechanics: One-Dimensional Finite Element Formulations and Analysis** – Bars-uniform, varying and stepped cross section-Basic (Linear) and Higher Order Elements Formulations for Axial, Torsional and Temperature Loads with problems. Beams- Basic (Linear) Element Formulation-for uniform, varying and stepped cross section- for different loading and boundary conditions with problems.	10
UNIT-4	**FINITE ELEMENT FORMULATIONS FOR STRUCTURAL MECHANICS PROBLEMS:** Basics of plates and shell theories: Classical thin plate Theory, Shear deformation Theory and Thick Plate theory. Finite Element Formulations for triangular and quadrilateral Plate elements. Finite element formulation of flat, curved, cylindrical and conical Shell elements **TWO-DIMENSIONAL FINITE ELEMENT FORMULATIONS FOR SOLID MECHANICS PROBLEMS**: Triangular Membrane (TRIA 3, TRIA 6, TRIA 10) Element, Four-Noded Quadrilateral Membrane (QUAD 4, QUAD 8) Element Formulations for in-plane loading with sample problems. Triangular and Quadrilateral, Axis-symmetric basic and higher order Elements formulation for axis-symmetric loading only with sample	12

	problems.	
UNIT-5	**THREE-DIMENSIONAL FINITE ELEMENT FORMULATIONS FOR SOLID MECHANICS PROBLEMS:** Finite Element Formulation of Tetrahedral Element (TET 4, TET 10), Hexahedral Element (HEXA 8, HEXA 20), for different loading conditions. Serendipity and Lagrange family Elements. **DYNAMIC ANALYSIS:** Finite Element Formulation for point/lumped mass and distributed masses system, Finite Element Formulation of one-dimensional dynamic analysis: bar, truss, frame and beam element. Finite Element Formulation of Two-dimensional dynamic analysis: triangular membrane and axisymmetric element, quadrilateral membrane and axisymmetric element. Evaluation of eigen values and eigen vectors applicable to bars, shaft, beams, plane and space frame.	10

Text Books:

1. **S.S. SASTRY**, Introductory Methods of Numerical Analysis, PHI, 2005.
2. **STEVEN C. CHAPRA, RAYMOND P. CANALE**, Numerical Methods for Engineers, Tata McGraw Hill, 4th Ed, 2002.
3. **M K JAIN, S.R.K IYENGAR, R K. JAIN**, Numerical methods for Scientific and engg computation, New Age International, 2003.
4. **T. R. CHANDRUPATLA AND A. D. BELEGUNDU**, Introduction to Finite Elements in Engineering, Prentice Hall, 3rd Ed, 2002.
5. **LAKSHMINARAYANA H. V.**, Finite Elements Analysis– Procedures in Engineering, Universities Press, 2004.

Reference Books:

1. **RAO S. S.**, Finite Elements Method in Engineering- 4th Edition, Elsevier, 2006
2. **P. SESHU**, Textbook of Finite Element Analysis, PHI, 2004.
3. **BATHE K. J**., Finite Element Procedures, Prentice-Hall, 2006.
4. **COOK R. D.**, Finite Element Modeling for Stress Analysis, Wiley,1995.
5. **DAVID. C. LAY**, Linear Algebra and its applications, 3rd edition, Pearson Education, 2002

SYLLABUS COVERAGE FOR CIE-1, 2, 3
CIE-1: UNIT-1 (100%) + UNIT- 2 (50%)
CIE-2: UNIT-2 (50%) + UNIT -3 (Firs100%)
CIE-3: UNIT- 4 (100%) + UNIT- 5 (100%)

QUESTION PAPER PATTERN (SEE)

Q. No	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**
Unit	**1**		**2**		**3**		**4**		**5**	

SCHEME OF EXAMINATION (SEE)

1. Ten Full Questions to be set.

2. Five full Questions to be answered.
3. Students shall answer Q1 or Q2 from Unit-1, Q3 or Q4 from Unit-2, Q5 or Q6 from Unit-3, Q7 or Q8 from Unit-4, Q9 or Q10 from Unit-5 with two questions from each Unit.
4. Each question shall contain maximum of 2 subdivisions
5. Each main question carries equal Marks.

COURSE OUTCOMES: Learners will able to

CO1	Model some simple mathematical models of physical Applications. Develop governing equation for a mechanical system and apply principles of variation and integral formulation to formulate finite element equations.
CO2	Formulate and perform one dimensional, two-dimensional structural analysis using bar, beam, triangular and quadrilateral elements.
CO3	Formulate axisymmetric triangular element and analyze problems on solids of revolution.
CO4	Formulate mass matrices and compute eigen values and eigen vectors for a 1- D and 2D analysis of mechanical system.

MAPPING OF COs WITH POs

COs/POs	po1	po2	po3	po4	po5	po6	po7	po8	po9	po10	po11	po12
CO1	3	3	3	2	2	3	3	2	3	3	1	2
CO2	2	3	3	2	2	1	3	2	3	3	3	2
CO3	3	3	3	2	3	2	3	1	3	2	3	2
CO4	3	3	2	2	3	2	3	1	2	2	3	3

ADMISSION YEAR :2019-20 **ACADEMIC YEAR: 2019-20**

EXPERIMENTAL MECHANICS

Course Code	**:**	**18MMD131**		**CIE Marks**	**:**	**50**
Hrs./Week	**:**	**L: T: P: 3:1:0**		**SEE Marks**	**:**	**50**
Credits	**:**	**04**		**SEE Duration**	**:**	**3 hours**

Course Objective:
This course aims at a comprehensive study of mechanics of solids. The objective of this course is to familiarize the student with state-of-the-art experimental techniques namely strain gauges, photo elasticity, moiré interferometry, brittle coating, moiré fringes and holography.

Course Content: Chapters/ Units

1. **Introduction**: Definition of terms, calibration, standards, dimension and units, generalized measurement system, Basic concepts in dynamic measurements, system response, distortion, impedance matching, experiment planning.
   Analysis of Experimental Data: Cause and types of experimental errors, error analysis. Statistical analysis of experimental data- Probability distribution, gaussian, normal distribution. **10 Hours**

2. **Force, Torque and Strain Measurement:** Mass balance measurement, Elastic Element for force measurement, torque measurement. Strain Gages -Strain sensitivity of gage metals, Gage construction, Gage sensitivity and gage factor, Performance characteristics, Environmental effects Strain, gage circuits, Potentiometer, Wheat Stone's bridges, Constant current circuits. Strain Analysis Methods-Two element and three element, rectangular and delta rosettes, Correction for transverse strains effects, stress gage - plane shear gage, Stress intensity factor gage. **10 Hours**

3. **Stress Analysis:** Two-Dimensional Photo elasticity **-** Nature of light, - wave theory of light, - optical interference - Polariscopes stress optic law - effect of stressed model in plane and circular Polariscopes, Isoclinic, isochromatic fringe order determination. Calibration Photo elastic model materials. Model to prototype scaling**.** . **10 Hours**

4. **Three-Dimensional Photo elasticity:** Stress freezing method, General slice, Effective stresses, Stresses separation, Shear deference method, Oblique incidence method Secondary principal stresses, Scattered light photo elasticity, Principals, Polari scope and stress data analyses**.**
   Holography: Introduction, Equation for plane waves and spherical waves, Intensity, Coherence, Spherical radiator as an object (record process), Hurter, Driffield curves, Reconstruction process, Holographic interferometry, Realtime. and double exposure methods, Displacement measurement, Isopaches **10 Hours**

5. **Coating Methods:** a) Photo elastic Coating Method-Birefringence coating techniques Sensitivity Reinforcing and thickness effects - data reduction - Stress separation techniques Photo elastic strain gauges. b) Brittle Coatings Method: Brittle coating technique Principles data analysis - coating materials, Coating techniques. c) Moire Technique - Geometrical approach, Displacement approach-sensitivity of Moire data reduction, In plane and out plane Moire methods, Moire photography, Moire grid production. **12 Hours**

NOTE: the students are advised to prepare the lab report in the form of assignment to understand the subject and its relevance in the industry

Text Books:

1. **Holman,** “Experimental Methods for Engineers” 7thEdition, Tata McGraw-Hill Companies, Inc, New York, 2007.
2. **R. S. Sirohi, H. C. Radha Krishna,** “Mechanical measurements” New Age International Pvt. Ltd., New Delhi, 2004
3. **Experimental Stress Analysis** - Srinath, Lingaiah, Raghavan, Gargesa, Ramachandra and Pant, Tata McGraw Hill, 1984.
4. **Instrumentation, Measurement and Analysis -**Nakra & Chaudhry, B C Nakra K Chaudhry, Tata McGraw-Hill Companies, Inc, New York, Seventh Edition, 2006.

Reference Books:

1. **Measurement Systems Application and Design** - Doeblin E. A., 4th (S.I.) Edition, McGraw Hill, New York. 1989
2. **Design and Analysis of Experiments -** Montgomery D.C., John Wiley & Sons, 1997.
3. **Experimental Stress Analysis** - Dally and Riley, McGraw Hill, 1991.
4. **Experimental Stress Analysis -** Sadhu Singh, Khanna publisher, 1990.
5. **Photoelasticity Vol I and Vol II -** M.M.Frocht,. John Wiley and sons, 1969.
6. **Strain Gauge Primer -** Perry and Lissner, McGraw Hill, 1962.

Course Outcomes:

Upon completion of this course, the student will be able to

CO1	Understand functional requirements of a generalized measurement system and identify suitable components for an application.
CO2	Use concepts of Data Acquisition, Processing and apply the same for interpretation and analysis of experimental data.
CO3	Determine stresses and strains in a structure using different methods such as strain gages, photo-elasticity, brittle coating and holography.
CO4	Identify and apply suitable experimental stress analysis to practical problems

SYLLABUS COVERAGE FOR CIE-1, 2, 3

CIE-1: UNIT-1 (100%) + UNIT- 2 (50%)
CIE-2: UNIT-2 (50%) + UNIT -3 (Firs100%)
CIE-3: UNIT- 4 (100%) + UNIT- 5 (100%)

QUESTION PAPER PATTERN (SEE)

Q. No	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**
Unit	**1**		**2**		**3**		**4**		**5**	

SCHEME OF EXAMINATION (SEE)

1. Ten Full Questions to be set.
2. Five full Questions to be answered.
3. Students shall answer Q1 or Q2 from Unit-1, Q3 or Q4 from Unit-2, Q5 or Q6 from Unit-3, Q7 or Q8 from Unit-4, Q9 or Q10 from Unit-5 with two questions from each Unit.
4. Each question shall contain maximum of 2 subdivisions
5. Each main question carries equal Marks.

MAPPING OF COs WITH POs

COs/POs	po1	po2	po3	po4	po5	po6	po7	po8	po9	po10	po11	po12
CO1	3	3	3	2	2	3	3	2	3	3	1	2
CO2	2	3	3	2	2	1	3	2	3	3	3	2
CO3	3	3	3	2	3	2	3	1	3	2	3	2
CO4	3	3	2	2	3	2	3	1	2	2	3	3

ADMISSION YEAR :2019-20 **ACADEMIC YEAR: 2019-20**

ROBUST DESIGN

Sub Code: 18MMD132	No of Credits: L-T-P-SS 4:0:0:0=4	No. of lecture hours/week :04
Exam Duration: 3 hours	**CIE Marks: 50**	**Exam Marks :50**
Pre-requisites	Mom, Design of Machine Elements**.**	

COURSE OBJECTIVES:
To study the basic concept of stresses, stress distribution, elastic constants when the material is subjected to loading within the elastic limits.

#	CONTENTS	Hrs
UNIT-1	**QUALITY BY EXPERIMENTAL DESIGN**: Quality, western and Taguchi quality philosophy, Elements of cost, Noise factors causes of variation, Quadratic loss function and variation of quadratic loss functions. **ROBUST DESIGN:** Steps in robust design: parameter design and tolerance design, reliability improvement through experiments, illustration through numerical examples.	10
UNIT-2	**EXPERIMENTAL DESIGN:** Classical experiments: factorial experiments, terminology, factors. Levels, Interactions, Treatment combination, randomization, 2-level experimental design for two factors and three factors. 3-level experiment deigns for two factors and three factors, factor effects, factor interactions, Fractional factorial design, Saturated design, Central composite designs, Illustration through numerical examples.	10
UNIT-3	**Measures of Variability:** Measures of variability, Concept of confidence level, Statistical distributions: normal, log normal and Weibull distributions. Hypothesis testing, Probability plots, choice of sample size illustration through numerical examples. Analysis and interpretation of experimental data: Measures of variability, Ranking method, column effect method and plotting method, Analysis of variance (ANOVA), in factorial experiments: YATE's algorithm for ANOVA, Regression analysis, Mathematical models from experimental data, illustration through numerical examples.	10
UNIT-4	**TAGUCHI'S ORTHOGONAL ARRAYS:** Types orthogonal arrays, Selection of standard orthogonal arrays, Linear graphs and interaction assignment, dummy level technique, Compound factor method, modification of linear graphs, Column merging method, branching design, Strategies for constructing orthogonal arrays. Signal to Noise ratio (S-N Ratios): Evaluation of sensitivity to noise, Signal to noise ratios for static problems, Smaller – the – better types, Nominal – the –better – type, larger – the better – type. Signal to noise ratios for dynamic problems, Illustrations through numerical examples.	12
UNIT-5	**PARAMETER DESIGN AND TOLERANCE DESIGN:** Parameter and tolerance design concepts, Taguchi's inner and outer arrays, Parameter design strategy, Tolerance deign strategy, Illustrations through numerical examples. **RELIABILITY IMPROVEMENT THROUGH ROBUST DESIGN**: Role of S-N ratios in reliability improvement; Case study; illustrating the reliability improvement of routing process of a printed wiring board using robust design concepts.	**10**

Text Books:

1.**Madhav S. Phadake,** "Quality Engineering using Robust Design", Prentice Hall,1989.

2.**Douglas Montgomery,** "Design and analysis of experiment", Willey India Pvt. Ltd.,2007.

3.**Phillip J. Ross, Taguchi**, "Techniques for Quality Engineering" McGraw Hill Int.Ed.,1996.

Reference Books:

1. **Thomas B. Barker,** "Quality by Experimental Design" , Marcel Dekker IncASQC Quality Press,1985.
2. **C.F. Jeff Wu**, ichael Hamada, "Experiments planning, analysis and parameter design optimization", John Wiley Ed., 2002.
3. **W.L. Condra, Marcel Dekker**, "Reliability improvement by Experiments", Marcel Dekker Inc ASQC Quality Press, 1985.

SYLLABUS COVERAGE FOR CIE-1, 2, 3

CIE-1: UNIT-1 (100%) + UNIT- 2 (50%)
CIE-2: UNIT-2 (50%) + UNIT -3 (Firs100%)
CIE-3: UNIT- 4 (100%) + UNIT- 5 (100%)

QUESTION PAPER PATTERN (SEE)

Q. No	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**
Unit	**1**		**2**		**3**		**4**		**5**	

SCHEME OF EXAMINATION (SEE)

1. Ten Full Questions to be set.
2. Five full Questions to be answered.
3. Students shall answer Q1 or Q2 from Unit-1, Q3 or Q4 from Unit-2, Q5 or Q6 from Unit-3, Q7 or Q8 from Unit-4, Q9 or Q10 from Unit-5 with two questions from each Unit.
4. Each question shall contain maximum of 2 subdivisions
5. Each main question carries equal Marks.

COURSE OUTCOMES:

Learners will able to

CO1	Apply Design of Experiments (DOE) techniques to various methods of design.
CO 2	Analyze and evaluate design parameters using different design strategies.
CO 3	Illustrate through numerical examples improvements in design parameters.
CO 4	Perform case studies involving identification of parameters, analysis of experimental data in a robust design.

MAPPING OF COs WITH Pos

COs/POs	po1	po2	po3	po4	po5	po6	po7	po8	po9	po10	po11	po12
CO1	3	3	3	2	2	3	3	2	3	3	1	2
CO2	2	3	3	2	2	1	3	2	3	3	3	2
CO3	3	3	3	2	3	2	3	1	3	2	3	2
CO4	3	3	2	2	3	2	3	1	2	2	3	3

ADMISSION YEAR :2019-20 **ACADEMIC YEAR: 2019-20**

COURSE TITLE: ADVANCED DESIGN OF MECHANISM		
Sub Code: 18MMD141	**No of Credits: L-T-P-SS 4:0:0:0 =4**	**No. of lecture hours/week: 04**
Exam Duration: 3 hours	**CIE Marks: 50**	**Exam Marks: 100**
Pre-requisites	**Engineering mechanics, MOM, Material science and metallurgy**	

COURSE OBJECTIVES:

To include dynamics considerations in the design of mechanisms for engineering applications is the objective of this course. To study basic principles of machine design. To acquaint with the concepts of strength design related to various components. To familiarize with use of design data books & various codes of practice. To make conversant with preparation of working drawings based on designs and enable the students to have high ethical standards in terms of team work to be a good design engineer

#	CONTENTS	Hrs
UNIT-1	**GEOMETRY OF MOTION:** Introduction, analysis and synthesis, Mechanism terminology, planar, Spherical and spatial mechanisms, mobility, Grashoffs law, Equivalent mechanisms, Unique mechanisms, Kinematic analysis of plane mechanisms: Auxiliary point method using rotated velocity vector, Hall - Ault auxiliary point method, Goodman's indirect method.	10
UNIT-2	**GENERALIZED PRINCIPLES OF DYNAMICS:** Virtual work, principle of virtual work, Equilibrium and stability, Kinetic energy of a system, Angular momentum, Generalized momentum. Lagrange's Equation: Lagrange's equation from D'Alembert's principles, Examples, Hamilton's equations, Hamilton's principle, Lagrange's, equation from Hamilton's principle, Derivation of Hamilton's equations, Examples.	10
UNIT-3	**SPATIAL MECHANISMS**: Introduction, Position analysis problem, Velocity and acceleration analysis, Eulerian angles.	10
UNIT-4	**SYSTEM DYNAMICS:** Gyroscopic action in machines, Euler's equation of motion, Phase Plane representation, Phase plane Analysis, Response of Linear Systems to transient disturbances. Synthesis of Linkages: Type, number, and dimensional synthesis, Function generation, Path generation and Body guidance, Precision positions, Structural error, Chebyshev spacing, two position synthesis of slider crank mechanisms, Crank-rocker mechanisms with optimum transmission angle Motion Generation: Poles and relative poles, Location of poles and relative poles, pooled, Curvature, Inflection circle.	12
UNIT-5	**GRAPHICAL METHODS OF DIMENSIONAL SYNTHESIS:** Two position synthesis of crank and rocker mechanisms, three position synthesis, four position synthesis (point precision reduction) Overlay method, Coupler curve synthesis, Cognate linkages. Ana1ytical Methods of Dimensional Synthesis: Freudenstein's equation for four bar mechanism and slider crank mechanism, Examples, Bloch's method of synthesis, Analytical synthesis using complex algebra.	10

Text Books:

1. **GREENWOOD,** "Classical Dynamics", Prentice Hall of India, 1988.
2. **K.J. Waldron & G.L. Kinzel, "Kinematics, Dynamics and Design of Machinery",** Wiley India, 2007.

References Books:

1. **J E SHIGLEY**, "Theory of Machines and Mechanism" -McGraw-Hill, 1995
2. **A.G. AMBEKAR,** "Mechanism and Machine Theory", PHI, 2007.
3. **GHOSH AND MALLICK**, "Theory of Mechanism and Mechan ism", East West press 2007.
4. **DAVID H. MYSZKA,** "Machines and Mechanisms", Pearson Education, 2005.

SYLLABUS COVERAGE FOR CIE-1, 2, 3

CIE-1: UNIT-1 (100%) + UNIT- 2 (50%)
CIE-2: UNIT-2 (50%) + UNIT -3 (Firs100%)
CIE-3: UNIT- 4 (100%) + UNIT- 5 (100%)

QUESTION PAPER PATTERN (SEE)

Q. No	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**
Unit	**1**		**2**		**3**		**4**		**5**	

SCHEME OF EXAMINATION (SEE)

1. Ten Full Questions to be set.
2. Five full Questions to be answered.
3. Students shall answer Q1 or Q2 from Unit-1, Q3 or Q4 from Unit-2, Q5 or Q6 from Unit-3, Q7 or Q8 from Unit-4, Q9 or Q10 from Unit-5 with two questions from each Unit.
4. Each question shall contain maximum of 2 subdivisions
5. Each main question carries equal Marks.

<u>COURSE OUTCOMES:</u> Learners will able to

CO1	The knowledge of dynamics considerations in mechanism design is essential to use commercial multi body dynamics software in mechanical engineering design.
CO2	Carry out mobility analysis of mechanism and perform velocity and acceleration of complex planer mechanism.
CO3	Synthesize mechanisms for function generation and path generation.
CO4	Analyze the Dynamics of Mechanical systems using D'Alembert's, Lagrange's, and Hamilton's Principles.
CO5	Demonstrate the skills to use software to analyze mechanisms, synthesis of linkages.

MAPPING OF COs WITH POs

COs/POs	po1	po2	po3	po4	po5	po6	po7	po8	po9	po10	po11	po12
CO1	3	3	3	3	2	2	3	2	3	1	3	3
CO2	2	3	3	2	3	3	3	1	2	3	3	2
CO3	3	3	2	3	3	3	1	3	3	2	3	2
CO4	3	3	2	3	3	2	3	2	1	2	3	3

ADMISSION YEAR :2019-20 **ACADEMIC YEAR: 2019-20**

COURSE TITLE: DESIGN FOR MANUFACTURE		
Sub Code: 18MMD142	**No of Credits: L-T-P-SS 4:0:0:0 =4**	**No. of lecture hours/week: 04**
Exam Duration: 3 hours	**CIE Marks: 50**	**Exam Marks: 50**
Pre-requisites	**metrology & Measurements, Design Of Machine Elements.**	

COURSE OBJECTIVES:

To educate students a clear understanding of factors to be considered in designing parts and components with focus on manufacturability**.** To study Effect of material properties on mechanical design. To acquaint with the concepts of Tolerance. To Design the components with casting consideration. Emphasis on various types of limit gauges for both hole and shaft.

#	CONTENTS	Hrs
UNIT-1	**EFFECT OF MATERIALS AND MANUFACTURING PROCESS ON DESIGN:** Major phases of design. Effect of material properties on design, Effect of manufacturing processes on design. Material selection process cost per unit property, Weighted properties and limits on properties methods.	10
UNIT-2	**TRUE POSITIONAL THEORY:** Comparison between co-ordinate and convention method of feature location. Tolerance and true positioning tolerance virtual size concept, Floating and fixed fasteners. Projected tolerance zone. Assembly with gasket, zero position tolerance. Functional gauges, Paper layout gauging.	10
UNIT-3	**SELECTIVE ASSEMBLY:** interchangeable part manufacture and selective assembly, deciding the number of groups -model-1: group tolerance of mating parts equal, model total and group tolerances of shaft equal. control of axial play-introducing secondary machining operations, laminated shims, examples. Datum features: functional datum, datum for manufacturing, changing the datum. examples	10
UNIT-4	**DESIGN CONSIDERATIONS:** Design of components with casting consideration. Pattern, Mould, and Parting line. Cored holes and Machined holes. Identifying the possible and probable parting line. Casting requiring special sand cores. Designing to obviate sand cores. Component Design: Component design with machining considerations link design for turning components-milling, Drilling and other related processes including finish-machining operations.	12
UNIT-5	**Design of Gauges:** Design of gauges for checking components in assemble with emphasis on various types of limit gauges for both hole and shaft. **TOLERANCE ANALYSIS:** Process capability, mean, variance, skewness, kurtosis, Process capability metrics, Cp, Cpk, Cost aspects, Feature tolerances, Geometries tolerances, Geometric tolerances, Surface finish, Review of relationship between attainable tolerance grades and different machining process. Cumulative effect of tolerance- Sure fit law and truncated normal law.	10

Text Books:

1**. HARRY PECK**, “Designing for Manufacturing”, Pitman Publications, 1983.

2. **DIETER,** “Machine Design” - McGraw-Hill Higher Education, -2008.

3. **R.K. JAIN**, "Engineering Metrology", Khanna Publishers, 1986.

4. **GEOFFREY BOOTHROYD, PETER DEWHURST, WINSTON KNIGHT**, “Product design for manufacture and assembly”, Merce Dekker. Inc. CRC Press, Third Edition

5. **MATERIAL SELECTION AND DESIGN**, Vol. 20 - ASM Hand book.

SYLLABUS COVERAGE FOR CIE-1, 2, 3

CIE-1: UNIT-1 (100%) + UNIT- 2 (50%)
CIE-2: UNIT-2 (50%) + UNIT -3 (First100%)
CIE-3: UNIT- 4 (100%) + UNIT- 5 (100%)

QUESTION PAPER PATTERN (SEE)

Q. No	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**
Unit	**1**		**2**		**3**		**4**		**5**	

SCHEME OF EXAMINATION (SEE)

1. Ten Full Questions to be set.
2. Five full Questions to be answered.
3. Students shall answer Q1 or Q2 from Unit-1, Q3 or Q4 from Unit-2, Q5 or Q6 from Unit-3, Q7 or Q8 from Unit-4, Q9 or Q10 from Unit-5 with two questions from each Unit.
4. Each question shall contain maximum of 2 subdivisions
5. Each main question carries equal Marks.

<u>COURSE OUTCOMES:</u>

Upon completion of this course, the student will be able to

CO1	Understand the role of manufacture and assembly in development of mechanical parts and their assemblies.
CO2	Apply manufacturing considerations in the design and development of components made of casting and machining.
CO3	Apply geometrical dimensioning and tolerances issues in mechanical design.

MAPPING OF COs WITH POs

COs/POs	**po1**	**po2**	**po3**	**po4**	**po5**	**po6**	**po7**	**po8**	**po9**	**po10**	**po11**	**po12**
CO1	3	3	3	3	2	2	3	2	3	1	3	3
CO2	2	3	3	2	3	3	3	1	2	3	3	2
CO3	3	3	2	3	3	3	1	3	3	2	3	2
CO4	3	3	2	3	3	2	3	2	1	2	3	3

ADMISSION YEAR :2019-20 **ACADEMIC YEAR: 2019-20**

COURSE TITLE: MECHATRONICS SYSTEMS DESIGN		
Sub Code: 18MMD151	**No of Credits: L-T-P-SS 4:0:0:0 =4**	**No. of lecture hours/week: 04**
Exam Duration: 3 hours	**CIE Marks: 50**	**Exam Marks: 50**
Pre-requisites	BASIC ELECTRONICS, BASIC ELECTRICALS, MATERIAL SCIENCE AND METROLOGY	

COURSE OBJECTIVES:

To educate the student regarding integration of mechanical, electronic, electrical and computer systems in the design of CNC machine tools, Robots etc. To provide students with an understanding of the Mechatronic Design Process, actuators, Sensors, transducers, Signal Conditioning, MEMS and Microsystems and also the Advanced Applications in Mechatronics

#	CONTENTS	Hrs
UNIT-1	**Introduction:** Definition and Introduction to Mechatronic Systems. Modeling &Simulation of Physical systems Overview of Mechatronic Products and their functioning, measurement systems. Control Systems, simple Controllers.	10
UNIT-2	**Study of Sensors and Transducers:** Pneumatic and Hydraulic Systems, Mechanical Actuation System, Electrical Actual Systems, Real time interfacing and Hardware components for Mechatronics.	10
UNIT-3	**Electrical Actuation Systems:** Electrical systems, Mechanical switches, Solid state switches, solenoids, DC & AC motors, Stepper motors. **System Models:** Mathematical models: - mechanical system building blocks, electrical system building blocks, thermal system building blocks, electromechanical systems, hydro-mechanical systems, pneumatic systems.	10
UNIT-4	**Signal Conditioning:** Signal conditioning, the operational amplifier, Protection, Filtering, Wheatstone Bridge, Digital signals, Multiplexers, Data Acquisition, Introduction to digital system processing, pulse-modulation. **MEMS and Microsystems:** Introduction, Working Principle, Materials for MEMS and Microsystems, Micro System fabrication process, Overview of Micro Manufacturing, Micro system Design, and Micro system Packaging.	12
UNIT-5	**Data Presentation Systems:** Basic System Models, System Models, Dynamic Response of system. **Advanced Applications in Mechatronics:** Fault Finding, Design, Arrangements and Practical Case Studies, Design for manufacturing, User-friendly design	10

NOTE: the students are advised to prepare the report in the form of assignment to understand the subject and its relevance in the industry

Text Books:

1. W. Bolton, "Mechatronics" - Addison Wesley Longman Publication, 1999
2. HSU "MEMS and Microsystems design and manufacture"- Tata McGraw-Hill Education, 2002

Reference Books:

1. Kamm, "Understanding Electro-Mechanical Engineering an Introduction to Mechatronics"- IEEE Press, 1 edition ,1996
2. Shetty and Kolk "Mechatronics System Design"- Cengage Learning, 2010
3. Mahalik "Mechatronics"- Tata McGraw-Hill Education, 2003
4. HMT "Mechatronics"- Tata McGraw-Hill Education, 199 8
5. Michel.B. Histand& David. Alciatore, "Introduction to Mechatronics & Measurement Systems"–. Mc Graw Hill, 2002
6. "Fine Mechanics and Precision Instruments"- Pergamon Press, 1971.

SYLLABUS COVERAGE FOR CIE-1, 2, 3

CIE-1: UNIT-1 (100%) + UNIT- 2 (50%)
CIE-2: UNIT-2 (50%) + UNIT -3 (First100%)
CIE-3: UNIT- 4 (100%) + UNIT- 5 (100%)

QUESTION PAPER PATTERN (SEE)

Q. No	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Unit	1		2		3		4		5	

SCHEME OF EXAMINATION (SEE)

1. Ten Full Questions to be set.
2. Five full Questions to be answered.
3. Students shall answer Q1 or Q2 from Unit-1, Q3 or Q4 from Unit-2, Q5 or Q6 from Unit-3, Q7 or Q8 from Unit-4, Q9 or Q10 from Unit-5 with two questions from each Unit.
4. Each question shall contain maximum of 2 subdivisions
5. Each main question carries equal Marks.

Course Outcome:

At the completion of this course, students will be able to:

CO1	Appreciate multi-disciplinary nature of modern engineering systems.
CO2	Model and analyze mechanical and electrical systems and their connection.
CO3	Be able to integrate mechanical, electronics, control and computer engineering in the design of mechatronics systems.
CO4	Address issues of design, fabrication, and packaging issues of Microsystems.

MAPPING OF COs WITH POs

COs/POs	po1	po2	po3	po4	po5	po6	po7	po8	po9	po10	po11	po12
CO1	3	3	3	3	2	2	3	2	3	1	3	3
CO2	2	3	3	2	3	3	3	1	2	3	3	2
CO3	3	3	2	3	3	3	1	3	3	2	3	2
CO4	3	3	2	3	3	2	3	2	1	2	3	3

AUTOMOBILE SYSTEM DESIGN

Course Code	**:**	**18MMD152**		**CIE Marks**	**:**	**50**
Hrs./Week	**:**	**L: T: P: 4:0:0**		**SEE Marks**	**:**	**50**
Credits	**:**	**04**		**SEE Duration**	**:**	**3 hours**

Course Objective:
This course would facilitate understanding of the stages involved in automobile system design. The student will be exposed to industrial practices in design of various systems of an automobile.

Course Content: Chapters/ Units

1. **Body Shapes**: Aerodynamic Shapes, drag forces for small family cars.
   Fuel Injection: Spray formation, direct injection for single cylinder engines (both SI & CI), energy audit. **10 Hours**

2. **Design of I.C. Engine** I: Combustion fundamentals, combustion chamber design, cylinder head design for both SI & C. I. Engines. 10 **Hours**

3. **Design of I.C. Engine II**: Design of crankshaft, camshaft, connecting rod, piston & piston rings for small family cars (max up to 3cylinders). 10 **Hours**

4. **Transmission System**: Design of transmission systems – gearbox (max of 4-speeds), differential.
   Suspension System: Vibration fundamentals, vibration analysis (single & two degree of freedom, vibration due to engine unbalance, application to vehicle suspension. **10 Hours**

5. **Cooling System**: Heat exchangers, application to design of cooling system (water cooled).
   Emission Control: Common emission control systems, measurement of missions, exhaust gas emission testing. **12 Hours**

NOTE: the students are advised to prepare the report in the form of assignment to understand the subject and its relevance in the industry

Text Books:

1. **Design of Automotive Engines**, - A. Kolchin& V. Demidov, MIR Publishers, Moscow
2. **The motor vehicle, Newton steeds &Garratte -** Iliffee& sons Ltd., London
3. **I.C. Engines -** Edward F Obert, International text book company.

Reference Books:

1. **Introduction to combustion** - Turns
2. **Automobile Mechanic -**, N.K. Giri, Khanna Publications, 1994
3. **I.C. Engines** - Maleev, McGraw Hill book company, 1976
4. **Diesel engine design** – Heldt P.M., Chilton company New York.
5. **Problems on design of machine elements -** V.M. Faires & Wingreen, McMillan Company., 1965
6. **Design of I.C. Engines -** John Heywood, TMH

Course Outcome:

Upon completion of this course, the student will be able to

CO1	The student will be able to apply the knowledge in creating a preliminary design of automobile sub systems.
CO2	Students are exposed to aerodynamic analysis of the auto mobiles.
CO3	Students are exposed to engine performances, combustion analysis and exhaust gas analysis to meet the BIS standards (10000 series).

SYLLABUS COVERAGE FOR CIE-1, 2, 3

CIE-1: UNIT-1 (100%) + UNIT- 2 (50%)
CIE-2: UNIT-2 (50%) + UNIT -3 (First100%)
CIE-3: UNIT- 4 (100%) + UNIT- 5 (100%)

QUESTION PAPER PATTERN (SEE)

Q. No	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**
Unit	**1**		**2**		**3**		**4**		**5**	

SCHEME OF EXAMINATION (SEE)

1. Ten Full Questions to be set.
2. Five full Questions to be answered.
3. Students shall answer Q1 or Q2 from Unit-1, Q3 or Q4 from Unit-2, Q5 or Q6 from Unit-3, Q7 or Q8 from Unit-4, Q9 or Q10 from Unit-5 with two questions from each Unit.
4. Each question shall contain maximum of 2 subdivisions
5. Each main question carries equal Marks.

INDUSTRIAL VISIT

Course Code	**:**	**18MMDM16**		**CIE Marks**	**:**	**50**
Hrs./Week	**:**	**L: T: P: S 0:0:0:3**		**SEE Marks**	**:**	**50**
Credits	**:**	**02**		**SEE Duration**	**:**	**3 hours**

- **Industrial Visit**: At the end of second CIE the industrial visit will be arranged in the domain field, each student is required to submit the report of the visit.
- Report submissions and final Evaluation is to be carried out by the Internal Guide of the college and a senior faculty along with HOD.

II Semester

ADMISSION YEAR :2019-20 **ACADEMIC YEAR: 2019-20**

COURSE TITLE:	**ADVANCED MACHINE DESIGN**	
Sub Code: 18MMD21	**No of Credits: L-T-P-SS 4:0:0:0 =4**	**No. of lecture hours/week: 04**
Exam Duration: 3 hours	**CIE Marks: 50**	**Exam Marks: 50**
Pre-requisites	**Engineering Mechanics, MoM, Design of Machine Elements**	

COURSE OBJECTIVES:
To study Role of failure prevention analysis in mechanical design. To acquaint with the concepts of damage fraction and accumulation in various damage theories. To study Role of surface failure in mechanical design. Enable the students to have high ethical standards in terms of team work to be a good design engineer.

#	CONTENTS	Hrs
UNIT-1	**INTRODUCTION:** Role of failure prevention analysis in mechanical design, Modes of mechanical failure, Review of failure theories for ductile and brittle materials including Mohr's theory and modified Mohr's theory, Numerical examples. **FATIGUE OF MATERIALS:** Introductory concepts, High cycle and low cycle fatigue, Fatigue design models, Fatigue design methods, Fatigue design criteria, Fatigue testing, Test methods and standard test specimens.	10
UNIT-2	**FATIGUE FROM VARIABLE AMPLITUDE LOADING:** Spectrum loads and cumulative damage, Damage quantification and the concepts of damage fraction and accumulation, Cumulative damage theories, Load interaction and sequence effects, Cycle counting methods, Life estimation using stress life approach.	10
UNIT-3	**SURFACE FAILURE:** Introduction, Surface geometry, Mating surface, Friction, Adhesive wear, Abrasive wear, Corrosion wear, Surface fatigue spherical contact, cylindrical contact, General contact, Dynamic contact stresses, Surface fatigue strength	10
UNIT-4	**STESS-LIFE (S-N) APPROACH:** S-N curves, Statistical nature of fatigue test data, General S-N behavior, Mean stress effects, Different factors influencing S-N behavior, S-N curve representation and approximations, Constant life diagrams, Fatigue life estimation using S-N approach. **STRAIN-LIFE(E-N) APPROACH:** Monotonic stress-strain behavior, Strain controlled test methods, Cyclic stress-strain behavior, Strain based approach to life estimation, Determination of strain life fatigue properties, Mean stress effects, Effect of surface finish, Life estimation by ε-N approach.	12

UNIT-5	**LEFM APPROACH:** LEFM concepts, Crack tip plastic zone, Fracture toughness, Fatigue crack growth, Mean stress effects, Crack growth life estimation. Notches and their effects: Concentrations and gradients in stress and strain, S-N approach for notched membranes, mean stress effects and Haigh diagrams, Notch strain analysis and the strain – life approach, Neuber's rule, Glinka's rule, applications of fracture mechanics to crack growth at notches.	10

Text Books:

1. **Ralph I. Stephens, Ali Fatemi, Robert, Henry o. Fuchs,** "Metal Fatigue in engineering", John Wiley New York, Second edition. 2001.
2. **Failure of Materials in Mechanical Design**, Jack. A. Collins, John Wiley, New York 1992.
3. **Robert L. Norton, "Machine Design",** Pearson Education India, 2000

Reference Books:

1. **S. Suresh, "Fatigue of Materials"**, Cambridge University Press, -1998
2. **Julie. A. Benantine,** "Fundamentals of Metal Fatigue Analysis", Prentice Hall,1990
3. **Fatigue and Fracture**, ASM Hand Book, Vol 19,2002.

SYLLABUS COVERAGE FOR CIE-1, 2, 3
CIE-1: UNIT-1 (100%) + UNIT- 2 (50%)
CIE-2: UNIT-2 (50%) + UNIT -3 (First100%)
CIE-3: UNIT- 4 (100%) + UNIT- 5 (100%)

QUESTION PAPER PATTERN (SEE)

Q. No	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**
Unit	**1**		**2**		**3**		**4**		**5**	

SCHEME OF EXAMINATION (SEE)
1. Ten Full Questions to be set.
2. Five full Questions to be answered.
3. Students shall answer Q1 or Q2 from Unit-1, Q3 or Q4 from Unit-2, Q5 or Q6 from Unit-3, Q7 or Q8 from Unit-4, Q9 or Q10 from Unit-5 with two questions from each Unit.
4. Each question shall contain maximum of 2 subdivisions
5. Each main question carries equal Marks.

<u>COURSE OUTCOMES:</u>

Learners will able to

CO1	Predict failure of engineering components using appropriate failure theories.

CO2	Identify and explain the types of fractures of engineered materials and their characteristic features;
CO3	Estimate life of components using stress life, strain life and LEFM approach.
CO4	Categorize different types of surface failures.

MAPPING OF COs WITH POs

COs/POs	po1	po2	po3	po4	po5	po6	po7	po8	po9	po10	po11	po12
CO1	3	3	3	3	2	2	3	2	3	1	3	3
CO2	2	3	3	2	3	3	3	1	2	3	3	2
CO3	3	3	2	3	3	3	1	3	3	2	3	2
CO4	3	3	2	3	3	2	3	2	1	2	3	3

ADVANCED THEORY OF VIBRATIONS

Course Code	**:**	**18MMD22**		**CIE Marks**	**:**	**50**
Hrs./Week	**:**	**L: T: P: 4:0:0**		**SEE Marks**	**:**	**50**
Credits	**:**	**04**		**SEE Duration**	**:**	**3 hours**

Course Objective:

To teach students how to use the theoretical principles of vibration, and vibration analysis techniques, for the practical solution of vibration problems. The course thus builds on student's prior knowledge of vibration theory, and concentrates on the applications. Thus, the student will fully understand the importance of vibrations in mechanical design of machine parts that operate in vibratory conditions.

Course Content: Chapters/ Units

1. **Review of Mechanical Vibrations:** Basic concepts; free vibration of single degree of freedom systems with and without damping, forced vibration of single DOF-systems, Natural frequency.
   Transient Vibration of single Degree-of freedom systems: Impulse excitation, Arbitrary excitation, Laplace transform formulation, pulse excitation and rise time, Shock response spectrum, Shock isolation. **10 Hours**

2. **Vibration Control:** Introduction, Vibration isolation theory, Vibration isolation and motion isolation for harmonic excitation, practical aspects of vibration analysis, shock isolation, Dynamic vibration absorbers, Vibration dampers.
   Vibration Measurement and applications: Introduction, Transducers, Vibration pickups, Frequency measuring instruments, Vibration exciters, Signal analysis. **10 Hours**

3. **Random Vibrations:** Random phenomena, Time averaging and expected value, Frequency response function, Probability distribution, Correlation, Power spectrum and power spectral density, Fourier transforms, FTs and response. **10 Hours**

4. **Modal analysis & Condition Monitoring:** Dynamic Testing of machines and Structures, Experimental Modal analysis, Machine Condition monitoring and diagnosis. Non-Linear Vibrations: Introduction, Sources of nonlinearity, Qualitative analysis of nonlinear systems. Phase plane, Conservative systems, Stability of equilibrium, Method of isoclines, Perturbation method, Method of iteration, Self-excited oscillations. **12 Hours**

5. **Continuous Systems:** Vibrating string, longitudinal vibration of rods, Torsional vibration of rods, Euler equation for beams.
   Different methods of vibration dissipation in structural components for general and rotating machinery. **110 Hours**

NOTE: the students are advised to prepare the report in the form of assignment to understand the subject and its relevance in the industry

Text Books:

1. Theory of Vibration with Application, - William T. Thomson, Marie Dillon Dahleh, Chandramouli Padmanabhan, 5th edition Pearson Education
2. S. Graham Kelly, "Fundamentals of Mechanical Vibration" - McGraw-Hill, 2000
3. S. S. Rao, "Mechanical Vibrations", Pearson Education, 4^{th} edition.

Reference Books:

1. S. Graham Kelly, "Mechanical Vibrations", Schaum's Outlines, Tata McGraw Hill, 2007.
2. C Sujatha, "Vibrations and Acoustics – Measurement s and signal analysis Tata McGraw Hill, 2010

Course Outcome:

Upon completion of this course, the student will be able to

CO1	Model and analyze a free damped, undamped and forced response of a mechanical system.
CO2	Develop equation and analyze the transient response of a single degree freedom system.
CO3	Assess the response characteristics of a continuous mechanical system.
CO4	Analyze and discuss the behavior of single degree freedom system for linear and non-linear behavior.

SYLLABUS COVERAGE FOR CIE-1, 2, 3

CIE-1: UNIT-1 (100%) + UNIT- 2 (50%)

CIE-2: UNIT-2 (50%) + UNIT -3 (First100%)

CIE-3: UNIT- 4 (100%) + UNIT- 5 (100%)

QUESTION PAPER PATTERN (SEE)

Q. No	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**
Unit	**1**		**2**		**3**		**4**		**5**	

SCHEME OF EXAMINATION (SEE)

1. Ten Full Questions to be set.
2. Five full Questions to be answered.
3. Students shall answer Q1 or Q2 from Unit-1, Q3 or Q4 from Unit-2, Q5 or Q6 from Unit-3, Q7 or Q8 from Unit-4, Q9 or Q10 from Unit-5 with two questions from each Unit.
4. Each question shall contain maximum of 2 subdivisions
5. Each main question carries equal Marks.

MAPPING OF COs WITH POs

COs/POs	po1	po2	po3	po4	po5	po6	po7	po8	po9	po10	po11	po12
CO1	3	3	3	3	2	2	3	2	3	1	3	3
CO2	2	3	3	2	3	3	3	1	2	3	3	2
CO3	3	3	2	3	3	3	1	3	3	2	3	2
CO4	3	3	2	3	3	2	3	2	1	2	3	3

TRIBOLOGY AND BEARING DESIGN

Course Code	**:**	**18MMD231**		**CIE Marks**	**:**	**50**
Hrs/Week	**:**	**L: T: P: 4:0:0**		**SEE Marks**	**:**	**50**
Credits	**:**	**04**		**SEE Duration**	**:**	**3 hours**

Course Objective:

To educate students a clear understanding of factors to be considered in designing parts and components with focus on manufacturability.to study various regimes of lubrication. To acquaint with the concepts of pours and gas lubricated bearings. To study advanced bearing systems and their advantages over conventional bearing systems. Emphasis on various types of bearing systems.

1. **Introduction to Tribology:** Introduction, Friction, Wear, Wear Characterization, Regimes of lubrication, Classification of contacts, lubrication theories, Effect of pressure and temperature on viscosity. Newton's Law of viscous forces, Flow through stationary parallel plates. Hagen's Poiseuille's theory, viscometers. Numerical problems, Concept of lightly loaded bearings, Petroff's equation, Numerical problems. **10 Hours**

2. **Antifriction bearings:** Advantages, selection, nominal life, static and dynamic load bearing capacity, probability of survival, equivalent load, cubic mean load, bearing mountings.
   Porous Bearings: Introduction to porous and gas lubricated bearings. Governing differential equation for gas lubricated bearings, Equations for porous bearings and working principal, Fretting phenomenon and its stages. **10 Hours**

3. **Magnetic Bearings:** Introduction to magnetic bearings, Active magnetic bearings. Different equations used in magnetic bearings and working principal. Advantages and disadvantages of magnetic bearings, Electrical analogy, Magneto-hydrodynamic bearings.
   Advanced bearing systems and their advantages over conventional bearing systems, testing of different types of bearings **10 hours**

4. **Hydrodynamic Lubrications:** Pressure development mechanism. Converging and diverging films and pressure induced flow. Reynolds's 2D equation with assumptions. Introduction to idealized slide bearing with fixed shoe and Pivoted shoes. Expression for load carrying capacity. Location of center of pressure, effect of end leakage on performance, Numerical problems
   Journal Bearings: Introduction to idealized full journal bearings. Load carrying capacity of idealized full journal bearings, Sommer Feld number and its significance, short and partial bearings, Comparison between lightly loaded and heavily loaded bearings, effects of end leakage on performance, Numerical problems. **12 Hours**

5. **Hydrostatic Bearings:** Hydrostatic thrust bearings, hydrostatic circular pad, annular pad, rectangular pad bearings, types of flow restrictors, expression for discharge, load carrying capacity and condition for minimum power loss, numerical problems, and hydrostatic journal bearings.
   EHL Contacts: Introduction to Elasto- hydrodynamic lubricated bearings. Introduction to 'EHL' constant, Grubin type solution. **10 Hours**

NOTE: Students are advised to prepare the report in the form of assignment to understand the subject and its relevance in the industry

Text Books

1. Mujamdar.B.C "Introduction to Tribology of Bearing", Wheeler Publishing, New Delhi 2001
2. Radzimovsky, "Lubrication of Bearings - Theoretical principles and design" Oxford press Company, 2000

Reference Books

1. Dudley D. Fulier " Theory and practice of Lubrication for Engineers", New YorkCompany.1998
2. Moore "Principles and applications of Tribology" Pergamon press, 1975
3. Oscar Pinkus, Beno Sternlicht, "Theory of hydro dynamic lubrication", McGraw-Hill, 1961
4. G W Stachowiak, A W Batchelor, "Engineering Tribology", Elsevier publication 1993.
5. Hydrostatic and hybrid bearings, Butterworth 1983.
6. F. M. Stansfield, Hydrostatic bearings for machine tools and similar applications, Machinery Publishing, 1970

Course Outcome:

Upon completion of this course, the student will be able to

CO1	Students develop skills to design and selection of bearings on Various tribological factors to be considered in moving and rotating parts.
CO2	The students are exposed to orient towards the various types of bearings and their applications.
CO3	Students are exposed to synthesis and analysis of the bearings including fault diagnosis.

SYLLABUS COVERAGE FOR CIE-1, 2, 3

CIE-1: UNIT-1 (100%) + UNIT- 2 (50%)
CIE-2: UNIT-2 (50%) + UNIT -3 (First100%)
CIE-3: UNIT- 4 (100%) + UNIT- 5 (100%)

QUESTION PAPER PATTERN (SEE)

Q. No	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Unit	1		2		3		4		5	

SCHEME OF EXAMINATION (SEE)

1. Ten Full Questions to be set.
2. Five full Questions to be answered.

3. Students shall answer Q1 or Q2 from Unit-1, Q3 or Q4 from Unit-2, Q5 or Q6 from Unit-3, Q7 or Q8 from Unit-4, Q9 or Q10 from Unit-5 with two questions from each Unit.
4. Each question shall contain maximum of 2 subdivisions
5. Each main question carries equal Marks.

MAPPING OF COs WITH POs

COs/POs	po1	po2	po3	po4	po5	po6	po7	po8	po9	po10	po11	po12
CO1	3	3	3	3	2	2	3	2	3	1	3	3
CO2	2	3	3	2	3	3	3	1	2	3	3	2
CO3	3	3	2	3	3	3	1	3	3	2	3	2
CO4	3	3	2	3	3	2	3	2	1	2	3	3

ADMISSION YEAR:2019-20 **ACADEMIC YEAR: 2019-20**

COURSE TITLE: DESIGN OPTIMIZATION		
Sub Code:18MMD232	**No of Credits: L-T-P-SS 4:0:0:0 =4**	**No. of lecture hours/week: 04**
Exam Duration: 3 hours	**CIE Marks: 50**	**Exam Marks: 50**
Pre-requisites	**Research methodology, Composite material, Basic mathematics**	

COURSE OBJECTIVES:

It aids the students to acquire the basics of optimum design, Classical Optimization Techniques, Non - linear Programming, Unconstrained Optimization Techniques, Integer Programming and Dynamic Programming.To study the basics of Design optimization. To acquaint Optimum Design Problem Formulation. To study the Sensitivity Analysis, Linear and Non-Linear Approximations and Optimization Disciplines.To gain knowledge of different Manufacturability in Optimization Problems and Design Interpretation.

#	CONTENTS	Hrs
UNIT-1	**Engineering Design Practice:** Evolution of Design Technology, Introduction to Design and the Design Process, Design versus Analysis, Role of Computers in Design Cycle, Impact of CAE on Design, Numerical Modeling with FEA and Correlation with Physical Tests.	10
UNIT-2	**Optimum Design Problem Formulation**: Types of Optimization Problems, The Mathematics of Optimization, Design Variables and Design Constraints, Feasible and Infeasible Designs, Equality and Inequality Constraints, Discrete and Continuous Optimization, Linear and Non-Linear Optimization. **Optimization Theory** – Fundamental Concepts, Global and Local Minimum, Gradient Vector and Hessian Matrix, Concept of Necessary and Sufficient Conditions, Constrained and Unconstrained Problems, Lagrange Multipliers and Kuhn Tucker Conditions	10
UNIT-3	**Sensitivity Analysis, Linear and Non-Linear Approximations**. Gradient Based Optimization Methods – Dual and Direct. **Optimization Disciplines:** Conceptual Design Optimization and Design Fine Tuning, Combined Optimization, Optimization of Multiple Static and Dynamic Loads, Transient Simulations, Equivalent Static Load Methods	10
UNIT-4	**Manufacturability in Optimization Problems:** Design for Manufacturing, Manufacturing Methods and Rules, Applying Manufacturing Constraints to Optimization Problems. **Design Interpretation:** Unbound Problems, Over Constrained Problems, Problems with No of Multiple Solutions, Active and Inactive Constraints, Constraint Violations and Constraint Screening, Design Move Limits, Local and Global Optimum	12

UNIT-5	**Dynamic Programming:** Introduction, Multistage decision processes, Principle of optimality, Computational Procedure in dynamic programming, Initial value problem, Examples. **Applications of Optimization in Engineering Design:** Automotive, Aerospace and General Industry Applications, Optimization of Metallic and Composite Structures, Minimization and Maximization Problems, MDO and MOO	10

NOTE: the students are advised to prepare the report in the form of assignment to understand the subject and its relevance in the industry

Text Books:

1. S.S. Rao, Engineering Optimization: Theory and Practice, John Wiley, 2009
2. JasbirArora, Introduction to Optimum Design, McGraw Hill, 2011.

Reference Books:

1. Optimization and Probability in System Engg - Ram, Van Nostrand.
2. Optimization methods - K. V. Mital and C. Mohan, New age International Publishers, 1999.
3. Optimization methods for Engg. Design - R.L Fox, Addison – Wesley, 1971.

SYLLABUS COVERAGE FOR CIE-1, 2, 3

CIE-1: UNIT-1 (100%) + UNIT- 2 (50%)
CIE-2: UNIT-2 (50%) + UNIT -3 (First100%)
CIE-3: UNIT- 4 (100%) + UNIT- 5 (100%)

QUESTION PAPER PATTERN (SEE)

Q. No	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Unit	1		2		3		4		5	

SCHEME OF EXAMINATION (SEE)

1. Ten Full Questions to be set.
2. Five full Questions to be answered.
3. Students shall answer Q1 or Q2 from Unit-1, Q3 or Q4 from Unit-2, Q5 or Q6 from Unit-3, Q7 or Q8 from Unit-4, Q9 or Q10 from Unit-5 with two questions from each Unit.
4. Each question shall contain maximum of 2 subdivisions
5. Each main question carries equal Marks.

Course Outcome:

At the completion of this course, students will be able to:

CO1	It provides the student with knowledge required to optimize an existing design with single or multiple objective functions.
CO2	Skills acquired through commercial optimization programs
CO3	Acquire the knowledge of engineering system design

MAPPING OF COs WITH Pos

COs/POs	po1	po2	po3	po4	po5	po6	po7	po8	po9	po10	po11	po12
CO1	3	3	3	3	2	2	3	2	3	1	3	3
CO2	2	3	3	2	3	3	3	1	2	3	3	2
CO3	3	3	2	3	3	3	1	3	3	2	3	2
CO4	3	3	2	3	3	2	3	2	1	2	3	3

ADMISSION YEAR : 2019-20 ACADEMIC YEAR: 2019-20

COURSE TITLE: COMPOSITE MATERIALS TECHNOLOGY		
Sub Code:18MMD241	**No of Credits: L-T-P-SS 4:0:0:0 =4**	**No. of lecture hours/week: 04**
Exam Duration: 3 hours	**CIE Marks: 50**	**Exam Marks: 50**
Pre-requisites	MECHATRONICS, COMPOSITE MATERIALS, SMART MATERIALS	

COURSE OBJECTIVES:

To study the basics of Composite materials. To acquaint mechanics of lamina. To study the micro and macro analysis of the lamina. To gain knowledge of different techniques involved in production of composites.

#	CONTENTS	Hrs
UNIT-1	**Introduction to Composite Materials:** Definition, Classification, Types of matrices material and reinforcements, Characteristics &selection, Fiber composites, laminated composites, Particulate composites, Prepegs, and sandwich construction. **Metal Matrix Composites:** Reinforcement materials, Types, Characteristics and selection, Base metals, Selection, Applications	10
UNIT-2	**Macro Mechanics of a Lamina:** Hooke's law for different types of materials, Number of elastic constants, Derivation of nine independent constants for orthotropic material, Two - dimensional relationship of compliance and stiffness matrix. Hooke's law for two-dimensional angle lamina, engineering constants - Numerical problems. Invariant properties. Stress-Strain relations for lamina of arbitrary orientation, Numerical problems.	10
UNIT-3	**Micro Mechanical Analysis of a Lamina:** Introduction, Evaluation of the four elastic moduli, Rule of mixture, Numerical problems. Experimental Characterization of Lamina- Elastic Moduli and Strengths **Failure Criteria:** Failure criteria for an elementary composite layer or Ply, Maximum Stress and Strain Criteria, Approximate strength criteria, Inter-laminar Strength, Tsa-Hill theory, Tsai, Wu tensor theory, Numerical problem, practical recommendations	10
UNIT-4	**Macro Mechanical Analysis of Laminate**: Introduction, code, Kirchoff hypothesis, Classical Lamination Theory, A, B, and D matrices (Detailed derivation), Special cases of laminates, Numerical problems. Shear Deformation Theory, A, B, D and E matrices (Detailed derivation) **Analysis of Composite Structures:** Optimization of Laminates, composite laminates of uniform strength, application of optimal composite structures, composite pressure vessels, spinning composite disks, composite lattice structures	12
UNIT-5	**Manufacturing and Testing:** Layup and curing - open and closed Mould processing, Hand lay-up techniques, Bag moulding and filament winding. Pultrusion, Pulforming, Thermoforming, Injection moulding, Cutting, Machining, joining and repair. NDT tests – Purpose, Types of defects, NDT method - Ultrasonic inspection, Radiography, Acoustic emission and Acoustic ultrasonic method.	10

	Applications: Aircrafts, missiles, Space hardware, automobile, Electrical and Electronics, Marine, Recreational and sports equipment-future potential of composites. .	

NOTE: the students are advised to prepare the report in the form of assignment to understand the subject and its relevance in the industry

Text Books:

1. Autar K. Kaw, Mechanics of Composite materials, CRC Press, 2nd Ed, 2005.
2. Madhijit Mukhopadhay, Mechanics of Composite Materials & Structures, Universities Press, 2004.

Reference Books:

1. J. N. Reddy, Mechanics of Laminated Composite Plates & Shells, CRD Press, 2nd Ed, 2004.
2. Mein Schwartz, Composite Materials handbook, McGraw Hill, 1984.
3. Rober M. Jones, Mechanics of Composite Materials, Taylor & Francis, 1998.
4. Michael W, Hyer, Stress analysis of fiber Reinforced Composite Materials, Mc-Graw Hill International, 2009.
5. Composite Material Science and Engineering, Krishan K. Chawla, Springer, 3e, 2012.
6. Fiber Reinforced Composites, P.C. Mallik, Marcel Decker, 1993.

SYLLABUS COVERAGE FOR CIE-1, 2, 3

CIE-1: UNIT-1 (100%) + UNIT- 2 (50%)
CIE-2: UNIT-2 (50%) + UNIT -3 (First100%)
CIE-3: UNIT- 4 (100%) + UNIT- 5 (100%)

QUESTION PAPER PATTERN (SEE)

Q. No	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Unit	1		2		3		4		5	

SCHEME OF EXAMINATION (SEE)

1. Ten Full Questions to be set.
2. Five full Questions to be answered.
3. Students shall answer Q1 or Q2 from Unit-1, Q3 or Q4 from Unit-2, Q5 or Q6 from Unit-3, Q7 or Q8 from Unit-4, Q9 or Q10 from Unit-5 with two questions from each Unit.
4. Each question shall contain maximum of 2 subdivisions
5. Each main question carries equal Marks.

Course Outcome:

At the completion of this course, students will be able to:

CO1	Identify the role of matrices and reinforcements used in practical composite structures.
CO2	Analyze problems on micro and macro mechanical behavior of lamina.
CO3	Assess the strength of laminated composite and predict its failure for given static loading conditions.
CO4	Develop understanding of different methods of manufacturing and testing of composites.

MAPPING OF COs WITH POs

COs/POs	po1	po2	po3	po4	po5	po6	po7	po8	po9	po10	po11	po12
CO1	3	3	3	3	2	2	3	2	3	1	3	3
CO2	2	3	3	2	3	3	3	1	2	3	3	2
CO3	3	3	2	3	3	3	1	3	3	2	3	2
CO4	3	3	2	3	3	2	3	2	1	2	3	3

ADMISSION YEAR : 2019-20 ACADEMIC YEAR: 2019-20

COURSE TITLE: FINITE ELEMENT METHODS FOR HEAT TRANSFER AND FLUID FLOW ANALYSIS		
Sub Code: 18MMD242	**No of Credits: L-T-P-SS 4:0:0:0 =4**	**No. of lecture hours/week: 04**
Exam Duration: 3 hours	**CIE Marks: 50**	**Exam Marks: 50**
Pre-requisites	FINITE ELEMENT METHODS, BASIC THERMODYNAMICS, HEAT AND MASS TRANSFERR	

COURSE OBJECTIVES:

To study the basic sources of Heat transfer and fluid mechanics. To acquaint with the effects of steady state conduction heat transfer. To study the advance topic in conduction. To gain knowledge of Flows of Viscous Incompressible Fluids.

#	CONTENTS	Hrs
UNIT-1	**Introduction to Heat Transfer and Fluid Mechanics:** Mathematical Preliminaries, Governing equations of a continuum, Governing equation in terms of primitive variables, porous equations, low speed compressible flow equations, auxiliary transport equations, chemically reacting systems, boundary conditions, change of phase, enclosure radiation. **Finite Element Methods:** Introduction, model differential equation, finite element approximations, interpolation functions, library of finite elements, modeling considerations, assembly of elements, numerical integration, discussion of results with some practical examples, time dependent problems.	10
UNIT-2	**Steady State Conduction Heat Transfer:** Introduction, one dimensional linear, quadratic element. Homogeneous, composite wall with uniform and varying cross-sectional area. Radial heat flow in a cylinder. Conduction –convection systems. Numerical examples. **Conduction Heat Transfer:** Interpolation functions for tetrahedral, hexahedral, pyramid and prism elements. Numerical integration, computation of surface flux, semi-discrete finite element model,	10
UNIT-3	**Advanced topic in Conduction:** specialty elements, computation of boundary conditions, bulk nodes, reactive materials, material motions Example problems on conduction, radiation, temperature dependent conductivity, anisotropic conduction, brazing and welding, investment casting.	10
UNIT-4	**Flows of Viscous Incompressible Fluids:** Governing equation mixed finite element model, penalty finite element models. Finite element models of porous flow, solution of nonlinear equations for transient problems. Radiation algorithms. Variable properties. **Computational consideration:** Interpolation functions for triangular, quadrilateral, tetrahedral and hexahedral elements. Evaluation of element matrices in penalty model, pressure calculation and traction boundary conditions. Numerical examples	12
UNIT-5	**Coupled Fluid Flow and Heat Transfer:** Introduction to non-isothermal incompressible flows, governing equations and boundary condition. Mixed, penalty finite element model. Finite element model for porous flow. Non-isothermal low speed compressible flows: governing equation, boundary conditions, mixed finite element model and solution methods. Convection with change of phase, convection with enclosure radiation, turbulent heat transfer, chemically reacting systems. Numerical examples.	10

NOTE: the students are advised to prepare the report in the form of assignment to understand the subject and its relevance in the industry

Text Books:

1. J N Reddy, David K. Gartling, “The finite element method in heat transfer and flu id dynamics” , CRC, 2004.
2. Roland Wynne Lewis, Perumal Nithiarasu, K. N. Seetharamu,” Fundamentals of the finite element method for heat and fluid flow”
   John Wiley, 2004

Reference Books:

1. Ching Jen Chen, R. A. Bernatz, “Finite analytic method in flows and heat transfer”, Taylor & Francis.
2. Gianni Comini, Stefano Del Giudice, Carlo Nonino, “Finite Element Analysis in Heat Transfer: Basic Formulation and Linear problems” Taylorand Francis, 1994.

SYLLABUS COVERAGE FOR CIE-1, 2, 3

CIE-1: UNIT-1 (100%) + UNIT- 2 (50%)
CIE-2: UNIT-2 (50%) + UNIT -3 (First100%)
CIE-3: UNIT- 4 (100%) + UNIT- 5 (100%)

QUESTION PAPER PATTERN (SEE)

Q. No	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Unit	1		2		3		4		5	

SCHEME OF EXAMINATION (SEE)

1. Ten Full Questions to be set.
2. Five full Questions to be answered.
3. Students shall answer Q1 or Q2 from Unit-1, Q3 or Q4 from Unit-2, Q5 or Q6 from Unit-3, Q7 or Q8 from Unit-4, Q9 or Q10 from Unit-5 with two questions from each Unit.
4. Each question shall contain maximum of 2 subdivisions
5. Each main question carries equal Marks.

Course Outcome:

Upon completion of this course, the student will be able to

CO1	This course enables the student to use numerical methods for solving problems of fluid flow and heat transfer.
CO2	Analyze of the continuum mechanics problems like fluid flow, heat transfer.
CO3	Analyze of incompressible and compressible fluids.
CO4	Analyze modes of conduction in various mechanical systems

MAPPING OF COs WITH POs

COs/POs	po1	po2	po3	po4	po5	po6	po7	po8	po9	po10	po11	po12
CO1	3	3	3	3	2	2	3	2	3	1	3	3
CO2	2	3	3	2	3	3	3	1	2	3	3	2
CO3	3	3	2	3	3	3	1	3	3	2	3	2
CO4	3	3	2	3	3	2	3	2	1	2	3	3

ADMISSION YEAR:2019-20 **ACADEMIC YEAR: 2019-20**

COURSE TITLE: THEORY OF PLASTICITY		
Sub Code: MMD251	**No of Credits: L-T-P-SS 4:0:0:0 =4**	**No. of lecture hours/week: 04**
Exam Duration: 3 hours	**CIE Marks: 50**	**Exam Marks: 50**
Pre-requisites	**DESIGN OF MACHINE ELEMENTS, ADVANCED MECHANICS OF SOLIDS.**	

COURSE OBJECTIVES:

To study the basic concept of stresses, stress distribution, elastic constants when the material is subjected to loading within the elastic limits. Study the stress distribution in plane, polar and cylindrical coordinate systems. Analyze the material or component subjected to torsion of circular and non-circular shafts (elliptical, triangular bars) Study the thermo-elastic properties of the material at elevated temperatures.

#	CONTENTS	Hrs
UNIT-1	**DEFINITION AND SCOPE OF THE SUBJECT:** Brief review of elasticity, Octahedral normal and shear stresses, Spherical and deviatoric stress, Invariance in terms of the deviatoric stresses, Engineering and natural strains, Mathematical relationships between true stress and true strains, Cubical dilation, finite strains co- efficient Octahedral strain, Strain rate and the strain rate tensor.	10
UNIT-2	**PLASTIC STRESS-STRAIN RELATIONS:** Prandtl-Reuss Saint Venant, Levy-Mises, Experimental verification of the Prandtl-Reuss equation, Upper and lower bound theorems. Application to problems: Uniaxial tension and compression.	10
UNIT-3	**SLIP LINE THEORY**: Introduction, Basic equations for incompressible two-dimensional flow, continuity equations, Stresses in conditions of plain strain convention for slip-lines, Geometry of slip lines, Properties of slip lines.	10
UNIT-4	**MATERIAL MODELS:** Stress-strain relations, Yield criteria for ductile metal, Von Mises, Tresca, Yield surface for an Isotropic Plastic material, Stress space, Experimental verification of Yield criteria, Yield criteria for an anisotropic material, flow rule normality of Yield locus, Symmetry and convexity, Deformation of isotropic and kinematic hardening, bilinear stress-strain relationship.	12
UNIT-5	**BENDING OF BEAMS:** Torsion of rods and tubes, Nonlinear bending and torsion equations, Simple forms of indentation problems using upper bounds, Application of Metal forming: Extrusion, Drawing, Rolling and Forging.	**10**

TEXT BOOKS

1. **R. A. C. Slater**, "Engineering Plasticity - Theory and Application to Metal Forming Process", McMillan Press Ltd., 1977.

2. **SADHU SINGH, "Theory of Plasticity and Metal forming Process", Khanna Publishers, Delhi, 1999.**

REFERENCE BOOKS

1. HOFFMAN AND SACHS, "Introduction to the Theory of Plasticity for Engineers", LLC, 2012.
2. **J CHAKRABARTY**, "Theory of plasticity", Butterworth, 2006. 3. Johnson and Mellor, "Plasticity for Mechanical Engineers", Van Nostrand, 1966.
3. **PLASTICITY FOR MECHANICAL ENGINEERS** - Johnson and Mellor, Van Nostrand, 1966.

SYLLABUS COVERAGE FOR CIE-1, 2, 3

CIE-1: UNIT-1 (100%) + UNIT- 2 (50%)
CIE-2: UNIT-2 (50%) + UNIT -3 (First100%)
CIE-3: UNIT- 4 (100%) + UNIT- 5 (100%)

QUESTION PAPER PATTERN (SEE)

Q. No	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**
Unit	**1**		**2**		**3**		**4**		**5**	

SCHEME OF EXAMINATION (SEE)

1. Ten Full Questions to be set.
2. Five full Questions to be answered.
3. Students shall answer Q1 or Q2 from Unit-1, Q3 or Q4 from Unit-2, Q5 or Q6 from Unit-3, Q7 or Q8 from Unit-4, Q9 or Q10 from Unit-5 with two questions from each Unit.
4. Each question shall contain maximum of 2 subdivisions
5. Each main question carries equal Marks.

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO1	Apply basic concepts in continuum mechanics of solids viz. Stress and strain tensors, equilibrium, compatibility and constitutive equations and methods of solution to elasticity problems
CO 2	Evaluate stresses and displacements in simple solids such as pressurized cylinders, shrink fitted cylinders, rotating disc and shaft, plate with hole and non-circular shafts and thin tubes under torsion.
CO 3	Use MATLAB or equivalent software to evaluate and plot particular solutions.
CO 4	Apply the principles of plastic deformation to estimate yielding in simple engineering structures.
CO 5	Apply principles of continuum mechanics to design a structure or component to achieve desired performance under realistic constraints.

MAPPING OF COs WITH POs

COs/POs	po1	po2	po3	po4	po5	po6	po7	po8	po9	po10	po11	po12
CO1	3	3	3	2	2	3	3	2	3	3	1	2
CO2	2	3	3	2	2	1	3	2	3	3	3	2
CO3	3	3	3	2	3	2	3	1	3	2	3	2
CO4	3	3	2	2	3	2	3	1	2	2	3	3

ROTOR DYNAMICS

Course Code	**:**	**18MMD252**		**CIE Marks**	**:**	**50**
Hrs/Week	**:**	**L: T: P: 4:0:0**		**SEE Marks**	**:**	**50**
Credits	**:**	**04**		**SEE Duration**	**:**	**3 hours**

Course Objective:
To make student to understand the concept of turbo machinery. To enable them to design specifically modeling of bearings, shafts and rotor stages. To guide them to predict instability like whirling including gyroscopic and Coriolis effect. To find the methods of reducing blade vibrations

1. **Fluid Film Lubrication:** Basic theory of fluid film lubrication, Derivation of generalized Reynolds equations, Boundary conditions, Fluid film stiffness and Damping coefficients, Stability and dynamic response for hydrodynamic journal bearing, Two lobe journal bearings.
10 Hours

2. **Critical Speed:** Dunkerley's method, Rayleigh's method, Stodola's method. Rotor Bearing System: Instability of rotors due to the effect of hydrodynamic oil layer in the bearings, support flexibility, Simple model with one concentrated mass at the center.
Introduction to Jeffcott rotor. Concepts, mathematical equations, applications. **10 Hours**

3. **Turbo rotor System Stability by Transfer Matrix Formulation:** General Turborotor system, development of element transfer matrices, the matrix differential equation, effect of shear and rotary inertia, the elastic rotors supported in bearings, numerical solutions. **10 Hours**

4. **Turbo rotor System Stability by Finite Element Formulation:** General Turborotor system, generalized forces and co-ordinates system assembly element matrices, Consistent mass matrix formulation, Lumped mass model, linearized model for journal bearings, System dynamic equations Fix stability analysis non dimensional stability analysis, unbalance response and Transient analysis. **12 Hours**

5. **Blade Vibration:** Centrifugal effect, Transfer matrix and Finite element, approaches. **10 Hours**

NOTE: the students are advised to prepare the report in the form of assignment to understand the subject and its relevance in the industry.

Reference Books:

1. Cameron, "Principles of Lubrication", Longman Publishing Group, 1986
2. Bolotin, "Nonconservative problems of the Theory of elastic stability", Macmillan, 1963
3. Peztel, Lockie, "Matrix Methods in Elasto Mechanic s", McGraw-Hill, 1963.
4. Timoshenko, "Vibration Problems in Engineering", Ox ford City Press, 2011
5. Zienkiewicz, "The finite element method in engineering science", McGraw-Hill, 1971

Course Outcomes:

Upon completion of this course, the student will be able to

CO1	Model a rotating machine element theoretically for rotor dynamic analysis.
CO2	Analyze Free and Forced lateral response of simple rotor models and of more complex systems including shafts, bearings, seals and stators.
CO3	Formulate Finite element and carry out analysis for Turborotor System Stability.
CO4	Apply Finite element approach to blade vibration.

SYLLABUS COVERAGE FOR CIE-1, 2, 3
CIE-1: UNIT-1 (100%) + UNIT- 2 (50%)
CIE-2: UNIT-2 (50%) + UNIT -3 (First100%)
CIE-3: UNIT- 4 (100%) + UNIT- 5 (100%)

QUESTION PAPER PATTERN (SEE)

Q. No	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**
Unit	**1**		**2**		**3**		**4**		**5**	

SCHEME OF EXAMINATION (SEE)

1. Ten Full Questions to be set.
2. Five full Questions to be answered.
3. Students shall answer Q1 or Q2 from Unit-1, Q3 or Q4 from Unit-2, Q5 or Q6 from Unit-3, Q7 or Q8 from Unit-4, Q9 or Q10 from Unit-5 with two questions from each Unit.
4. Each question shall contain maximum of 2 subdivisions
5. Each main question carries equal Marks.

MAPPING OF COs WITH POs

COs/POs	**po1**	**po2**	**po3**	**po4**	**po5**	**po6**	**po7**	**po8**	**po9**	**po10**	**po11**	**po12**
CO1	3	3	3	2	2	3	3	2	3	3	1	2
CO2	2	3	3	2	2	1	3	2	3	3	3	2
CO3	3	3	3	2	3	2	3	1	3	2	3	2
CO4	3	3	2	2	3	2	3	1	2	2	3	3

RESEARCH METHODOLOGY

Course Code	**:**	**18RM27**		**CIE Marks**	**:**	**50**
Hrs/Week	**:**	**L: T: P: 2:0:0**		**SEE Marks**	**:**	**50**
Credits	**:**	**02**		**SEE Duration**	**:**	**3 hours**

Course Learning Objectives: Students are expected to

- Have a basic understanding of the underlying principles of quantitative and qualitative research
- Identify the overall process of designing a research study from its inception to its report.
- Choose the most appropriate research method to address a particular research question
- Gain a overview of a range of quantitative and qualitative approaches to data analysis

1. **Overview of Research:** Research and its types, identifying and defining research problem and introduction to different research designs. Essential constituents of Literature Review. Basic principles of experimental design, Primary data and Secondary Data, methods of primary data collection, classification of secondary data, designing questionnaires and schedules. **8 Hours**

2. **Sampling Methods:** Probability sampling: simple random sampling, systematic sampling, stratified sampling, cluster sampling and multistage sampling. Non-probability sampling: convenience sampling, judgment sampling, quota sampling. Sampling distributions. **6 Hours**

3. **Processing and analysis of Data:** Statistical measures and their significance: Central tendencies, variation, skewness, Kurtosis, time series analysis, correlation and regression, Testing of Hypotheses: Parametric (t and Chi Square). **6 Hours**

4. **Essential of Report writing and Ethical issues**: Significance of Report Writing, Different Steps in Writing Report, Layout of the Research Report, Ethical issues related to Research, Plagiarism and self- Plagiarism, Publishing. **6 Hours**

Reference Books:

1. Krishnaswami, K.N., Sivakumar, A. I. and Mathirajan, M., Management Research Methodology, Pearson Education: New Delhi.
2. Kothari C.R., Research Methodology Methods and techniques by, New Age International Publishers, 2^{nd} edition
3. Levin, R.I. and Rubin, D.S., Statistics for Management, 7th Edition, Pearson Education: New Delhi.

Course Outcome:

At the end of the course students will:

CO1	Describe a range of quantitative and qualitative research designs and identify the advantages and disadvantages associated with these designs
CO2	Choose appropriate quantitative or qualitative method to collect data
CO3	Analyse and test the given data using appropriate methods
CO4	Design an appropriate mixed-method research study to answer a research question

SEMESETER III

ADMISSION YEAR:2019-20 **ACADEMIC YEAR: 2019-20**

COURSE TITLE: FRACTURE MECHANICS		
Sub Code: 18MMD31	**No of Credits: L-T-P-SS** **4:0:0:0=4**	**No. of lecture hours/week :04**
Exam Duration :3 hours	**CIE Marks:50**	**Exam Marks :50**
Pre-requisites	**Metrology & Measurements, Design of Machine Elements'**	

COURSE OBJECTIVES:

Fracture mechanics provides a methodology for prediction, prevention and control of fracture in materials, components and structures. It provides a background for damage tolerant design. It quantifies toughness as materials resistance to crack propagation.

#	CONTENTS	Hrss
UNIT-1	**FRACTURE MECHANICS PRINCIPLES:** Introduction and historical review, Sources of micro and macro cracks. Stress concentration due to elliptical hole, Strength ideal materials, Griffith's energy balance approach. Fracture mechanics approach to design. NDT and Various NDT methods used in fracture mechanics. The Airy stress functions. Complex stress function. Effect of finite size. Special cases, Elliptical cracks.	10
UNIT-2	**PLASTICITY EFFECTS:** Irwin plastic zone correction. Dugdale approach. The shape of the plastic zone for plane stress and plane strain cases, Plastic constraint factor. The Thickness effect, numerical problems. **Determination of Stress intensity factors and plane strain fracture toughness**: Introduction, analysis and numerical methods, experimental methods, estimation of stress intensity factors. Plane strain fracture toughness test, The Standard test.	10
UNIT-3	**THE ENERGY RELEASE RATE:** Criteria for crack growth. The crack resistance (R curve). Compliance, J integral. Tearing modulus. Stability.	10

UNIT-4	**ELASTIC PLASTIC FRACTURE MECHANICS:** Fracture beyond general yield. The Crack-tip opening displacement. The Use of CTOD criteria. Experimental determination of CTOD. Parameters affecting the critical CTOD. Use of J integral. Limitation of J integral. **DYNAMICS AND CRACK ARREST:** Crack speed and kinetic energy. Dynamic stress intensity and elastic energy release rate. Crack branching. Principles of crack arrest. Crack arrest in practice. Dynamic fracture toughness.	12
UNIT-5	**FATIGUE CRACK PROPAGATION AND APPLICATIONS OF FRACTURE MECHANICS:** Crack growth and the stress intensity factor. Factors affecting crack propagation. variable amplitude service loading, means to provide fail-safety, required information for fracture mechanics approach, Mixed mode (combined) loading and design criteria.	10

Text Books:

1. **David Broek,** "Elementary Engineering Fracture Mechanics", Springer Netherlands,2011
2. **Anderson**, "Fracture Mechanics-Fundamental and Application", T.L CRC press1998.

Reference Books:

1. **Karen Hellan**, "Introduction to fracture mechanics", McGraw Hill, 2nd Edition
2. **S.A. Meguid**, "Engineering fracture mechanics" Elsevier Applied Science, 1989
3. **Jayatilaka,** "Fracture of Engineering Brittle Materials", Applied Science Publishers, 1979
4. **Rolfe and Barsom**, "Fracture and Fatigue Control in Structures", Prentice Hall, 1977
5. **Knott**, "Fundamentals of fracture mechanisms", Butterworths, 1973

SYLLABUS COVERAGE FOR CIE-1, 2, 3

CIE-1: UNIT-1 (100%) + UNIT- 2 (50%)

CIE-2: UNIT-2 (50%) + UNIT -3 (Firs100%)

CIE-3: UNIT- 4 (100%) + UNIT- 5 (100%)

QUESTION PAPER PATTERN (SEE)

Q. No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
UNIT	1		2		3		4		5	

(Irrespective of portions covered due to whatever might be the reason)

SCHEME OF EXAMINATION (SEE)

1. Ten Full Questions to be set.
2. Five full Questions to be answered.
3. Students shall answer Q1 or Q2 from Unit-1, Q3 or Q4 from Unit-2, Q5 or Q6 from Unit-3, Q7 or Q8 from Unit-4, Q9 or Q10 from Unit-5 with two questions from each Unit.
4. Each question shall contain maximum of 2 subdivisions
5. Each main question carries equal Marks.

COURSE OUTCOMES:

Learners will able to

CO1	Develop fundamental understanding of the effects of crack like defects on the performance of aerospace, civil, and mechanical engineering structures.
CO2	Select appropriate materials for engineering structures to ensure damage tolerance.
CO3	Employ modern numerical methods to determine critical crack sizes and fatigue crack propagation rates in engineering structures.
CO4	Gain appreciation of the status of academic research in field of fracture mechanics.

MAPPING OF COs WITH Pos

COs/POs	po1	po2	po3	po4	po5	po6	po7	po8	po9	po10	po11	po12
CO1	3	3	-	-	-	-	3	2	-	1	-	-
CO2	2	3	-	2	-	-	-	-	-	3	-	-
CO3	3	3	-	-	-	3	-	-	-	-	--	-
CO4	3	3	2	-	-	1	-	-	-	-	-	-

ADMISSION YEAR:2019-20 **ACADEMIC YEAR: 2019-2020**

COURSE TITLE: SMART MATERIALS AND STRUCTURES		
Sub Code: 18MMD321	**No of Credits: L-T-P-S** **4:0:0:0 =4**	**No. of lecture hours/week :04**
Exam Duration: 3 hours	**CIE Marks: 50**	**Exam Marks:50**
Pre-requisites	Mechatronics, Composite materials technology**.**	

COURSE OBJECTIVES:

To study the basic sources of smart materials and structures. To acquaint with the effects of Shape memory Alloy, ER and MR fluids. To study the usefulness of vibration absorbers and control of structures. To gain knowledge of MEMS and devices.

#	CONTENTS	Hrss
UNIT-1	**Smart Structures**: Types of Smart Structures, Potential Feasibility of Smart Structures, Key Elements of Smart Structures, Applications of Smart Structures. Piezoelectric materials, Properties, piezoelectric Constitutive Relations, Depoling and Coersive Field, field strain relation. Hysteresis, Creep and Strain Rate effects, Inchworm Linear Motor.	10
UNIT-2	**Beam Modeling:** Beam Modeling with induced strain Rate effects, Inchworm Linear Motor Beam Modeling with induced strain Actuation-single Actuators, dual Actuators, Pure Extension, Pure Bending harmonic excitation, Bernoulli-Euler beam Model, problems, Piezoelectric Applications.	10
UNIT-3	**Shape memory Alloy:** Experimental Phenomenology, Shape Memory Effect, Phase Transformation, Tanaka's Constitutive Model, testing of SMA Wires, Vibration Control through SMA, Multiplexing. Applications Of SMA and Problems. **ER and MR Fluids:** Mechanisms and properties, Fluid Composition and behavior, The Bingham Plastic and Related Models, Pre-Yield Response. Post-Yield flow applications in Clutches, Dampers and Others	12
UNIT-4	**Vibration Absorbers:** series and Parallel Damped Vibrations (Overview), Active Vibration Absorbers, Fiber Optics, Physical Phenomena, Characteristics, Sensors, Fiber Optics in Crack Detection, applications. **Control of Structures:** Modeling, Control Strategies and Limitations, Active Structures in Practice.	10
UNIT-5	**MEMS** – Mechanical Properties of MEMS Materials, Scaling of Mechanical Systems, Fundamentals of Theory, The Intrinsic Characteristics of MEMS, Miniaturization, Microelectronics Integration.	10

	Devices: Sensors and Actuators, Conductivity of Semiconductors, Crystal Planes and Orientation, (Stress and Strain Relations, Flexural Beam Bending Analysis Under Simple Loading Conditions), Polymers in MEMS, Optical MEMS Applications.	

Text Books:

1. Smart Materials and Structures -**M. V. Gandhi and B.S Thompson**, Chapman and Hall, London; New York, 1992 (ISBN: 0412370107).
2. Smart Structures and Materials **- Culshaw, Artech House, Boston**, 1996 (ISBN :0890066817).
3. Smart Structures: Analysis & Design **- A. Srinivasan**, Cambridge University Press, Cambridge; New York, 2001 (ISBN: 0521650267).

Reference Books:

1. Electro ceramics: Materials, Properties and Applications - **A. J. Moulson and J. M. Herbert**. John Wiley & Sons, ISBN: 0471497429
2. **Piezoelectric Sensories**: Force, Strain, Pressure, Acceleration and Acoustic Emission Sensors. Materials and Amplifiers, Springer, Berlin; New York, 2002 (ISBN: 3540422595).
3. Piezoelectric Actuators and Wtrasonic Motors -**K. Uchino, Kluwer** Academic Publishers, Boston, 1997 (ISBN: 0792398114).
4. Handbook of Giant Magneto strictive Materials - **G. Engdahl**, Academic Press, San Diego, Calif.; London, 2000 (ISBN: 012238640X).
5. Shape Memory Materials **- K. Otsuka and C.M. Wayman**, Cambridge University Press, Cambridge; New York, 199~ (ISBN: 052144487X).

SYLLABUS COVERAGE FOR CIE-1, 2, 3

CIE-1: UNIT-1 (100%) + UNIT- 2 (100%)

CIE-2: UNIT-3 (100%) + UNIT -4 (50%)

CIE-3: UNIT- 4 (50%) + UNIT- 5 (100%)

QUESTION PAPER PATTERN (SEE)

Q. No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
UNIT	1		2		3		4		5	

(Irrespective of portions covered due to whatever might be the reason)

SCHEME OF EXAMINATION (SEE)

1. Ten Full Questions to be set.
2. Five full Questions to be answered.
3. Students shall answer Q1 or Q2 from Unit-1, Q3 or Q4 from Unit-2, Q5 or Q6 from Unit-3, Q7 or Q8 from Unit-4, Q9 or Q10 from Unit-5 with two questions from each Unit.
4. Each question shall contain maximum of 2 subdivisions
5. Each main question carries equal Marks.

Course Outcome:

At the completion of this course, students will be able to:

CO1	Understand the behavior and applicability of various smart materials.
CO2	Design Simple models for smart structures and materials
CO3	Perform simulation of smart structures and material application.
CO4	Conduct experiments to verify the predictions.

MAPPING OF COs WITH POs

COs/POs	po1	po2	po3	po4	po5	po6	po7	po8	po9	po10	po11	po12
CO1	3	3	--	-	2	-	-	-	-	-	-	-
CO2	2	3	-	2	-	-	-	1	-	-	3	-
CO3	3	-	2	-	3	-	1	-	-	2	-	2
CO4	3	-	2	-	-	-	-	-	-	-	-	-

ADMISSION YEAR: 2019-20 **ACADEMIC YEAR: 2019-20**

COURSE TITLE: STATISTICAL MODELING AND EXPERIMENTAL DESIGN		
Sub Code: 18MMD322	**No of Credits: L-T-P-SS** **4:0:0:0=4**	**No. of Lecture hours/week :04**
Exam Duration:3 hours	**CIE Marks: 50**	**Exam Marks :50**
Pre-requisites	Mom, Experimental Mechanics, Finite Element Method.	

COURSE OBJECTIVES:

The objective of this course is to impart students with a holistic view of the fundamentals of experimental designs, analysis tools and techniques, interpretation and applications.

	CONTENTS	**Hrss**
UNIT-1	**Statistical Modeling and Data Analysis:** Introduction, Review of basic statistical concepts: Concepts of random variable, Sample and population, Measure of Central tendency; Mean, median and mode. Illustration through Numerical examples, Normal, Log Normal & Weibull distributions. Illustration through Numerical examples.	10
UNIT-2	**Introduction to Designed Experiments:** Strategy of experimentation, some typical applications of experimental design, Basic principles, Guidelines for designing experiments, A brief history of statistical design, Summary: Using statistical techniques in experimentation.	10
UNIT-3	**Factorial Experiments** Basic definitions, The advantages of factorials, The two-factorial design. Introduction, Factorial Experiments Terminology: factors, levels, interactions, Two-level experimental designs for two factors and three factors. Illustration through Numerical examples.	12
UNIT-4	**Regression Analysis:** linear and multiple Regression analysis, Mathematical models from experimental data. Illustration through Numerical examples.	10
UNIT-5	**Signal to Noise Ratio:** Evaluation of sensitivity to noise. Signal to Noise ratios for static problems: Smaller-the-batter type, Nominal the-better-type, Larger-the better type. Signal to Noise for Dynamic problems. Illustration through Numerical examples.	**10**

TEXT BOOKS:

1. **Design and Analysis of Experiments,** Douglas C. Montgomery, 5th Edition Wiley India Pvt. Ltd. 2007.
2. **Quality engineering using robust design**, Madhav s. Phadke, Prentice Hall PTR, Englewood Cliffs, NewJersy 07632, 1989.

REFERENCES BOOKS:

1. Thomas B. Barker, **"Quality if experimental design",** Marcel Dekker Inc ASQC Quality Press.1985.
2. C.F. Jeff Wu Michael Hamada, **"Experiments Planning Analysis and Parameter Design Optimization",** Wiley Editions. 2002.
3. L. W. Condra**, "Reliability Improvement with design of Experiments",** 2nd ed, CRC Press, 2001
4. Phillip j. Ross, **"Taguchi Techniques for Quality Engineering",** 2nd ed. McGraw Hill International Editions, 1996.

REMINDER

BREAK-UP OF COURSE CONTENTS FOR;

CIE-1: UNIT 1 (100%) + UNIT 2 (100%)

CIE-2: UNIT 3 (100%) + UNIT 4 (FIRST 50%)

CIE-3: UNIT 4 (NEXT 50%) + UNIT 5 (100%)

(Irrespective of portions covered due to whatever might be the reason)

QUESTION PAPER PATTERN (SEE)

Q. No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
UNIT	1		2		3		4		5	

SCHEME OF EXAMINATION (SEE)

1. Ten Full Questions to be set.
2. Five full Questions to be answered.
3. Students shall answer Q1 or Q2 from Unit-1, Q3 or Q4 from Unit-2, Q5 or Q6 from Unit-3, Q7 or Q8 from Unit-4, Q9 or Q10 from Unit-5 with two questions from each Unit.
4. Each question shall contain maximum of 2 subdivisions
5. Each main question carries equal Marks.

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO1	Basic statistics including ANOVA and regression.
CO2	Experimental designs such as RCBD, BIBD, Latin Square, factorial and fractional factorial designs.
CO3	Application of statistical models in analyzing experimental data.
CO4	RSM to optimize response of interest from an experiment.
CO5	Robust design of process and product.

MAPPING OF COs WITH POs

COs/POs	po1	po2	po3	po4	po5	po6	po7	po8	po9	po10	po11	po12
CO1	1	1	-	2	-	-	-	-	-	-	-	-
CO2	2	-	3	2	-	-	-	--	-	-	-	-
CO3	3	3	-	2	3	2	3	-	-	-	-	-
CO4	3	-	2	-	-	-	-	-	2	-	-	-

ADMISSION YEAR: 2019-20 **ACADEMIC YEAR: 2019-20**

COURSE TITLE: OPTIMIZATION TECHNIQUES		
Sub Code: 18MMD323	**No of Credits: L-T-P-SS** **4:0:0:0=4**	**No. of Lecture hours/week :04**
Exam Duration:3 hours	**CIE Marks: 50**	**Exam Marks :50**
Pre-requisites	Mom, Experimental Mechanics, Finite Element Method.	

COURSE OBJECTIVES:

To understand the theory of optimization methods and algorithms developed for solving various types of optimization problems. To develop and promote research interest in applying optimization techniques in problems of Engineering and Technology. To apply the mathematical results and numerical techniques of optimization theory to concrete Engineering problems.

	CONTENTS	**Hrss**
UNIT-1	**Introduction:** Terminology, Design Variables, Constraints, Objective Function, Variable Bounds, Problem Formulation, Engineering Optimization Problems. Calculus method. Linear Programming. Simplex method, Concept of Duality.	10
UNIT-2	**Single Variable Optimization Problems:** Optimality Criterion, Bracketing Methods, Region Elimination Methods, Interval Halving Method, Fibonacci Search Method, Golden Section Method, Successive Quadratic Estimation Method. Gradient Based Methods: Newton-Raphson Method, Bisection Method, Secant Method. Application to Root finding.	10
UNIT-3	**Multivariable Optimization Algorithms:** Optimality Criteria, Unidirectional Search, Direct Search Methods: Hooke-Jeeves pattern search method, Powell's Conjugate Direction Method. Gradient Based Methods: Cauchy's Steepest Descent Method, Newton's method, Marquardt's Method.	10
UNIT-4	**Constrained Optimization Algorithms:** Kuhn Tucker conditions, Transformation Methods: Penalty Function Method, Method of Multipliers, Sensitivity analysis.	10

UNIT-5	**Topics in Optimization Techniques:** Quadratics Programming, sequential quadratic programming; Integer Programming, Penalty Function Method, Branch and Bound Method, Geometric Programming, Applications Design of experiments and Taguchi method – Application and problem solving; Dynamic programming, principle of optimality, recursive equation approach and applications; Genetic algorithm.	**12**

TEXT BOOKS:

1. S. S. Rao, **"Engineering Optimization: Theory and Practice",** John Wiley & Sons, 1996.

2. Kalyanmoy Deb, **"Optimization for Engineering Design: Algorithms and Examples",** 2nd ed, Prentice Hall of India, 2004.

REFERENCES BOOKS:

1. E. J. Haug and J. S. Arora, **"Applied Optimal Design",** Wiley, New York.
2. G.V. Reklaites, A. Ravindran and K.M. Rogsdeth, **"Optimization",** Wiley, New York.

REMINDER

BREAK-UP OF COURSE CONTENTS FOR;

CIE-1: UNIT 1 (100%) + UNIT 2 (100%)

CIE-2: UNIT 3 (100%) + UNIT 4 (FIRST 50%)

CIE-3: UNIT 4 (NEXT 50%) + UNIT 5 (100%)

(Irrespective of portions covered due to whatever might be the reason)

QUESTION PAPER PATTERN (SEE)

Q. No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
UNIT	1		2		3		4		5	

SCHEME OF EXAMINATION (SEE)

1. Ten Full Questions to be set.
2. Five full Questions to be answered.
3. Students shall answer Q1 or Q2 from Unit-1, Q3 or Q4 from Unit-2, Q5 or Q6 from Unit-3, Q7 or Q8 from Unit-4, Q9 or Q10 from Unit-5 with two questions from each Unit.
4. Each question shall contain maximum of 2 subdivisions
5. Each main question carries equal Marks.

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO1	Formulate engineering optimization problem and solve LPP by simplex method.
CO2	Solve single and multivariable optimization problem by various relevant method.
CO3	Develop algorithm for constrained optimization.
CO4	Examine various optimization techniques and demonstrate their applicability.
CO5	Cast engineering minima/maxima problems into optimization framework.

MAPPING OF COs WITH Pos

COs/POs	po1	po2	po3	po4	po5	po6	po7	po8	po9	po10	po11	po12
CO1	1	1	-	-	-	-	-	-	3	-	-	-
CO2	2	3	-	-	2	1	-	-	-	-	-	2
CO3	3	-	3	-	3	-	-	-	-	-	-	-
CO4	3	1	2	-	-	-	-	-	-	-	-	3

ADMISSION YEAR: 2019-20 **ACADEMIC YEAR: 2019-20**

COURSE TITLE: THEORY OF PLATES AND SHELLS		
Sub Code: 18MMD324	**No of Credits: L-T-P-SS** **4:0:0:0=4**	**No. of Lecture hours/week :04**
Exam Duration:3 hours	**CIE Marks: 50**	**Exam Marks :50**
Pre-requisites	Mom, Theory of Elasticity, Theory of Plasticity	

COURSE OBJECTIVES:

Understand the classical structural mechanics approximations of Membrane, Plate and Shell theories. Apply energy formulations to demonstrate the consistent derivation of approximate boundary conditions and edge effects. Identify the necessary tools to describe static, dynamic and non-linear motions. Evaluate the buckling, vibration and stress parameters in thin shells using numerical approximation techniques.

	CONTENTS	Hrss
UNIT-1	**General Introduction:** 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.	10
UNIT-2	**Classical Theory of Plates:** 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	12
UNIT-3	**Buckling Analysis of Rectangular Plates:** 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	10
UNIT-4	**Vibration of Plates:** 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	10

UNIT-5	**Analysis of Thin Elastic Shells of Revolution:** 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.	**10**

TEXT BOOKS:

1. Reddy, J.N., "**Theory and Analysis of Elastic Plates & Shells**", C.R.C. Press, NY, USA, 2nd Edition, ISBN 9780849384158
2. Timoshenko, S. and Krieger S.W. **Theory of Plates and Shells**, McGraw Hill Book Company, New York 1990, ISBN 0-13-913426-3

REFERENCES BOOKS:

1. Szilard, R., **Theory and Analysis of Plates,** Prentice Hall Inc., 1999, ISBN 0-12-9353336-2
2. Wilhelm Flügge, **Stresses in shells,** Springer –Verlag, ISBN 978-3-662-01028-0

REMINDER

BREAK-UP OF COURSE CONTENTS FOR;

CIE-1: UNIT 1 (100%) + UNIT 2 (100%)

CIE-2: UNIT 3 (100%) + UNIT 4 (FIRST 50%)

CIE-3: UNIT 4 (NEXT 50%) + UNIT 5 (100%)

(Irrespective of portions covered due to whatever might be the reason)

QUESTION PAPER PATTERN (SEE)

Q. No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
UNIT	1		2		3		4		5	

SCHEME OF EXAMINATION (SEE)

1. Ten Full Questions to be set.
2. Five full Questions to be answered.
3. Students shall answer Q1 or Q2 from Unit-1, Q3 or Q4 from Unit-2, Q5 or Q6 from Unit-3, Q7 or Q8 from Unit-4, Q9 or Q10 from Unit-5 with two questions from each Unit.
4. Each question shall contain maximum of 2 subdivisions
5. Each main question carries equal Marks.

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO1	Apply the structural mechanics approximations of membrane, plates and shells.
CO2	Develop simple modifications to the membrane plate and shell theories
CO3	Describe the static, dynamic, and non-linear motion of membrane, plate and shell structures.
CO4	Analyze numerical problems in shells of revolution.

MAPPING OF COs WITH Pos

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	3	1	-	-	-	-	-	-	-
CO2	-	-	-	2	-	1	-	-	-	-	-
CO3	3	1	1	-	-	-	-	-	-	-	-
CO4	1	2	-	3	3	1	-	-	-	-	-

ADMISSION YEAR: 2019-20 **ACADEMIC YEAR: 2019-20**

COURSE TITLE: COMPUTER APPLICATIONS IN DESIGN		
Sub Code: 18MMD331	**No of Credits: L-T-P-SS** **4:0:0:0=4**	**No. of Lecture hours/week :04**
Exam Duration:3 hours	**CIE Marks: 50**	**Exam Marks :50**
Pre-requisites	Mom, Finite Element Method.	

COURSE OBJECTIVES:

Memorize the equations of transformations, curves, solid models and surfaces. Understand the concept of computer Graphics. Demonstrate the principles of wire frame, Geometric, and surface modeling. Distinguish the different concepts of algorithm.

	CONTENTS	**Hrss**
UNIT-1	**Computer Graphics:** Line drawing algorithms: DDA, Bresenham's algorithms, Mid-point circle algorithms, coordinate systems, windowing, View generation, Clipping, Transformations of geometry.	10
UNIT-2	**Software Configuration:** Software configuration of a graphics system, Functions of a graphics package, Mathematics of projections, Hidden line removal, Hidden surface removal, Shading, Rendering. **Basics of geometry modeling:** Requirements of geometric modeling, geometric models, geometric construction methods, modeling facilities desired.	10
UNIT-3	**Wireframe Modeling:** Classification of wire frame entities, curve representation methods, parametric representation of analytic curves, curvature continuity, Lagrange interpolation, Parametric representation of synthetic curves, curve manipulations.	10
UNIT-4	**Solid Modeling:** Application of solid models, modeling considerations of solids, geometry and topology, solid modeling scheme, Boundary Representation, Winged edge data structure for Boundary representation, Euler operations, Constructive solid geometry, Sweeping, Solid Manipulations.	10
UNIT-5	**Surface modeling:** Introduction, Planes, Vector Planes, surface entities, Surface representation methods, Quadratic Surface in normal forms, Quadratic Surface in general forms, Quadratic Surface in matrix form, parametric surfaces, Parametric representation of analytic surfaces, Parametric representation of synthetic surfaces, Surface Manipulations.	**12**

TEXT BOOKS:

1. Chennakesava R Alavala **"CAD/CAM Concepts and Applications",** 1st Ed PHI, New Delhi, 2009.
2. P.N. Rao**, "CAD/CAM Principles and Applications",** 3rd Ed., McGraw Hill, Education Pvt Ltd.

REFERENCES BOOKS:

1. Ibrahim Zeid, **"Mastering CAD/CAM",** 2nd Ed., TMH Publishing Company Limited., New Delhi.
2. M.P. Groover and 3 E W Zimmers**, CAD/CAM Computer aided Design and Manufacturing**, 9th Ed, 1993.

REMINDER

BREAK-UP OF COURSE CONTENTS FOR;

CIE-1: UNIT 1 (100%) + UNIT 2 (100%)

CIE-2: UNIT 3 (100%) + UNIT 4 (FIRST 50%)

CIE-3: UNIT 4 (NEXT 50%) + UNIT 5 (100%)

(Irrespective of portions covered due to whatever might be the reason)

QUESTION PAPER PATTERN (SEE)

Q. No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
UNIT	1		2		3		4		5	

SCHEME OF EXAMINATION (SEE)

1. Ten Full Questions to be set.
2. Five full Questions to be answered.
3. Students shall answer Q1 or Q2 from Unit-1, Q3 or Q4 from Unit-2, Q5 or Q6 from Unit-3, Q7 or Q8 from Unit-4, Q9 or Q10 from Unit-5 with two questions from each Unit.
4. Each question shall contain maximum of 2 subdivisions
5. Each main question carries equal Marks.

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO1	Discuss the concepts of Computer Graphics in CAD in product development
CO2	Apply the concepts of CAD in the manufacturing industry
CO3	Analyze the concepts of computer Aided Design
CO4	Evaluating the techniques involved in CAD.

MAPPING OF COs WITH POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	2	3	3	-	-	-	-	-	-	-	-
CO2	3	2	2	1	-	-	-	-	-	-	-
CO3	1	3	-	3	2	-	-	-	-	-	-
CO4	-	-	1	2	3	1	-	-	-	-	-

- High-3
- Medium-2
- Low-1

ADMISSION YEAR: 2019-20 **ACADEMIC YEAR: 2019-20**

COURSE TITLE: ADVANCED SYSTEM DESIGN		
Sub Code: 18MMD332	**No of Credits: L-T-P-SS** **4:0:0:0=4**	**No. of Lecture hours/week :04**
Exam Duration:3 hours	**CIE Marks: 50**	**Exam Marks :50**
Pre-requisites	Mom, Project Management, Engineering Economics.	

COURSE OBJECTIVES:

To study the basic concepts of different types of design. Need analysis in engineering systems
Analyze the concept of design with respect to economics and optimization.

	CONTENTS	Hrss
UNIT-1	**INTRODUCTION**: What is designing, Man as a designer: Design by evolution, inadequacies of traditional design method: System approach of engineering problems: Need models: design history of large-scale existing system. Morphology of Design: The three phases of design projects, the structure of design process, decision making and iteration.	10
UNIT-2	**Identification, Need analysis &Design Concept:** Preliminary need statement, analysis of need, specifications, and standards of performance and constraints. Process of idealization, mental fixity, analysis, AIDA, brain storming etc.	10
UNIT-3	**Preliminary Design:** Mathematical modeling for functional design: concept of sensitivity, compatibility and stability analysis. Evaluation Of Alternatives and Design Decisions.	10
UNIT-4	**Design Tree:** Quality of design, Concept of utility, multi criteria decisions, decisions under uncertainty and risk (Numerical), Bath tub curve, exponential reliability function, system reliability concept. (Numerical)	10
UNIT-5	**Economics And Optimization in Engineering Design**: Economics in Engineering Design, Fixed and variable costs, break-even analysis. (Numerical) Optimization: Introduction to LPP. Man, Machine Interaction, Designing for use and maintenance, Man-Machine Cycle, Design of displays and controls. Factors influencing displays and controls.	**12**

REFERENCES BOOKS:

1. **Mechanical System Design** by: W. E. Eder lecturer In Mechanical Engineering And's. Gosling
2. Harrison Kim, Dept. of Industrial and Enterprise Systems Engineering (ISE) - 2 - 1. Papa Lambros, P.Y. and Wilde, D., **Principles of Optimal Design** (2nd Ed.), Cambridge University Press, New York, 2000. 2.

REMINDER

BREAK-UP OF COURSE CONTENTS FOR;

CIE-1: UNIT 1 (100%) + UNIT 2 (100%)

CIE-2: UNIT 3 (100%) + UNIT 4 (FIRST 50%)

CIE-3: UNIT 4 (NEXT 50%) + UNIT 5 (100%)

(Irrespective of portions covered due to whatever might be the reason)

QUESTION PAPER PATTERN (SEE)

Q. No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
UNIT	1		2		3		4		5	

SCHEME OF EXAMINATION (SEE)

1. Ten Full Questions to be set.
2. Five full Questions to be answered.
3. Students shall answer Q1 or Q2 from Unit-1, Q3 or Q4 from Unit-2, Q5 or Q6 from Unit-3, Q7 or Q8 from Unit-4, Q9 or Q10 from Unit-5 with two questions from each Unit.
4. Each question shall contain maximum of 2 subdivisions
5. Each main question carries equal Marks.

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO1	Analyze the types of design and concepts
CO2	Applying the concept of need-based design.
CO3	Implement preliminary design concept in real life.
CO4	Analyzing the process of design in the form of sequence of actions.

MAPPING OF COs WITH POs

COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO 1
1	3	--	-	-	-	-	-	-	-	1	-	2
2	2	-	3	-	1	-	3	-	-	-	-	-
3	3	3	2	-	-	-	-	-	-	-	-	-
4	3	3	2	1	-	-	-	-	-	-	-	-

- High-3
- Medium-2
- Low-1

ADMISSION YEAR: 2019-20 **ACADEMIC YEAR: 2019-20**

COURSE TITLE: DESIGN OF HYDRAULICS AND PNEUMATICS		
Sub Code: 18MMD333	**No of Credits: L-T-P-SS** **4:0:0:0=4**	**No. of Lecture hours/week :04**
Exam Duration:3 hours	**CIE Marks: 50**	**Exam Marks :50**
Pre-requisites	Mom, Design of Machine Elements, Finite Element Method.	

<u>COURSE OBJECTIVES</u>:

Identify the symbolic representation of hydraulic systems. Understand the working of industrial systems employing fluid power. Identify the working of hydraulic circuits. Select the appropriate components through design calculations and demonstrate the electronic components in pneumatic systems.

	CONTENTS	Hrss
UNIT-1	**Hydraulic Actuators and Motors:** Pascal's law and problems on Pascal's Law, continuity equations, introduction to conversion of units. Structure of Hydraulic Control System Linear Hydraulic Actuators [cylinders], Mechanics of Hydraulic Cylinder loading, Hydraulic Rotary Actuators, Gear motors, vane motors, piston motors, Hydraulic motor theoretical torque, power and flow rate, and hydraulic motor performance.	10
UNIT-2	**Control Components in Hydraulic Systems:** Directional Control Valves – Symbolic representation, Constructional features, pressure control valves – direct and pilot operated types, flow control valves. **Hydraulic Circuit Design and Analysis:** Control of single and double – acting Hydraulic Cylinder, regenerative circuit, pump unloading circuit, Double pump Hydraulic system, Counter Balance Valve application, and Hydraulic cylinder sequencing circuits. Locked cylinder using pilot check valve, cylinder synchronizing circuits, speed control of hydraulic cylinder, speed control of hydraulic motors, accumulators and accumulator circuits.	12
UNIT-3	**Introduction to Pneumatic Control:** Choice of working medium, characteristics of compressed air. Structure of Pneumatic control system. Pneumatic Actuators: Linear cylinders – Types, conventional type of cylinder working, end position cushioning, seals, mounting arrangements applications. Rod–less cylinders, types, working advantages. Rotary cylinder types construction and application. Design parameters, selection.	10
UNIT-4	**Directional Control Valves:** Symbolic representation as per ISO 1219 and ISO 5599. Design and constructional aspects, poppet valves, slide valves spool valve, suspended seat type slide valve. Simple Pneumatic Control: Direct and indirect actuation pneumatic cylinders, use of memory valve.	10

	Flow control valves and speed control of cylinders supply air throttling and exhaust air throttling use of quick exhaust valve. Signal processing elements: Use of Logic gates – OR and AND gates pneumatic applications. Practical examples involving the use of logic gates. Pressure dependent controls types construction–practical applications. Time dependent controls – Principle, construction, practical applications.	
UNIT-5	**Multi-cylinder Applications:** Coordinated and sequential motion control. Motion and control diagrams – Signal elimination methods. Cascading method – principle. Practical application examples (up to two cylinders) using cascading method (using reversing valves). Electro-Pneumatic control: Principles-signal input and output pilot assisted solenoid control of directional control valves, use of relay and contactors. Control circuitry for simple single cylinder applications. Compressed air: Production of compressed air – compressors, preparation of compressed air- Driers, Filters, Regulators, Distribution of compressed air- Piping layout.	**10**

TEXT BOOKS:

1. S.R. Majumdar **Oil Hydraulic Systems - Principles and Maintenance**, Tata Mc Graw Hill publishing company Ltd. 2001. ISBN- 10: 0074637487
2. S.R. Majumdar Pneumatic Systems, Tata Mc Graw Hill publishing Co., 1995. ISBN- 0074602314.

REFERENCES BOOKS:

1. Anthony Esposito **Fluid Power with applications**, Fifth edition Pearson education, Inc. 2000. ISBN- 10: 129202387
2. Andrew Parr **Pneumatics and Hydraulics**. Jaico Publishing Co. 2000. ISBN- 10: 0750644192

REMINDER

BREAK-UP OF COURSE CONTENTS FOR;

CIE-1: UNIT 1 (100%) + UNIT 2 (100%)

CIE-2: UNIT 3 (100%) + UNIT 4 (FIRST 50%)

CIE-3: UNIT 4 (NEXT 50%) + UNIT 5 (100%)

(Irrespective of portions covered due to whatever might be the reason)

QUESTION PAPER PATTERN (SEE)

Q. No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
UNIT	1		2		3		4		5	

SCHEME OF EXAMINATION (SEE)

1. Ten Full Questions to be set.
2. Five full Questions to be answered.
3. Students shall answer Q1 or Q2 from Unit-1, Q3 or Q4 from Unit-2, Q5 or Q6 from Unit-3, Q7 or Q8 from Unit-4, Q9 or Q10 from Unit-5 with two questions from each Unit.
4. Each question shall contain maximum of 2 subdivisions
5. Each main question carries equal Marks.

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO1	Illustrate and explain the significance hydraulic and pneumatic components.
CO2	Describe the symbolic representations of fluid power components in an industrial circuit.
CO3	Integrate and differentiate a function for given set of tabulated data with greater accuracy for engineering problems.
CO4	Evaluate the selection of valves for specific applications
CO5	Design and develop hydraulic and pneumatic based system for industrial applications.

MAPPING OF COs WITH POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	-	-	-	-	-	-	-	-	-	-
CO2	-	3	2	2	2	-	-	-	-	-	-
CO3	-	-	2	2	-	-	-	-	-	-	-
CO4	3	2	1	-	3	-	1	-	-	-	-

ADMISSION YEAR: 2019-20 **ACADEMIC YEAR: 2019-20**

COURSE TITLE: COMPUTATIONAL METHODS IN ENGINEERING ANALYSIS		
Sub Code: 18MMD334	**No of Credits: L-T-P-SS** **4:0:0:0=4**	**No. of Lecture hours/week :04**
Exam Duration:3 hours	**CIE Marks: 50**	**Exam Marks :50**
Pre-requisites	Mom, Design of Machine Elements, Finite Element Method.	

<u>COURSE OBJECTIVES</u>:

The aim of the course is to equip an engineer with skills to develop mathematical models: It is an art of applying mathematics to complex real-world problems. The course combines mathematical theory, practical engineering and scientific computing to address today's technological challenges. It facilitates conversion of scientific statements into a form Engineers understand.

	CONTENTS	**Hrss**
UNIT-1	**Approximations and Round off Errors:** Significant figures, accuracy and precision, error definitions, round off errors and truncation errors. Mathematical modeling and Engineering problem solving, simple mathematical model, Conservation Laws of Engineering.	10
UNIT-2	**Roots of Equations:** Bracketing Methods-Graphical method, Bisection method, False position method, Newton- Raphson method, Secant Method. Multiple roots, Simple fixed-point iteration. **Roots of Polynomial:** Polynomials in Engineering and Science, Muller's method, Bairstow's Method Graeffe's Roots Squaring Method.	10
UNIT-3	**Numerical Differentiation and Numerical Integration:** Newton –Cotes and Gauss Quadrature Integration formulae, Integration of Equations, Romberg integration, Numerical Differentiation Applied to Engineering problems, High Accuracy differentiation formulae.	10
UNIT-4	**System of Linear Algebraic Equations and Eigen Value Problems:** Introduction, Direct methods, Cramer's Rule, Gauss Elimination Method, Gauss-Jordan Elimination Method, Triangularization method, Cholesky Method, Partition method, Error Analysis for direct methods, Iteration Methods. **Eigen values and Eigen Vectors:** Bounds on Eigen Values, Jacobi method for symmetric matrices, Givens method for symmetric matrices, Rutishauser method for arbitrary matrices, Power method, Inverse power method.	12

UNIT-5	**Linear Transformation:** Introduction to Linear Transformation, The matrix of Linear Transformation, Linear Models in Science and Engineering **Orthogonality and Least Squares**: Inner product, length and orthogonality, orthogonal sets, Orthogonal projections, The Gram-Schmidt process, Least Square problems, Inner product spaces.	**10**

TEXT BOOKS:

3. Steven C. Chapra, Raymond P. Canale **"Numerical Methods for Engineers**"- 5^{th} Edition, Tata McGraw Hill, 2007.
4. S. S. Sastry "**Introductory Method of Numerical Analysis**", PHI, 2009.
5. M K. Jain, S.R.K Iyengar, R K. Jain "**Numerical Methods for Scientific and Engg. Computation**". New Age International, 2003.

REFERENCES BOOKS:

3. Perviz Moin **"Fundamentals of Engineering Numerical Analysis",** Cambridge, 2010.
4. David. C. Lay, **"Linear Algebra and its applications"** -3rd edition, Pearson Education, 2005.
5. Laurence V Fausett, **"Applied Numerical Analysis using MATLAB"**, Pearson, 2008.

REMINDER

BREAK-UP OF COURSE CONTENTS FOR;
CIE-1: UNIT 1 (100%) + UNIT 2 (100%)
CIE-2: UNIT 3 (100%) + UNIT 4 (FIRST 50%)
CIE-3: UNIT 4 (NEXT 50%) + UNIT 5 (100%)
(Irrespective of portions covered due to whatever might be the reason)
QUESTION PAPER PATTERN (SEE)

Q. No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
UNIT	1		2		3		4		5	

SCHEME OF EXAMINATION (SEE)

1. Ten Full Questions to be set.
2. Five full Questions to be answered.
3. Students shall answer Q1 or Q2 from Unit-1, Q3 or Q4 from Unit-2, Q5 or Q6 from Unit-3, Q7 or Q8 from Unit-4, Q9 or Q10 from Unit-5 with two questions from each Unit.
4. Each question shall contain maximum of 2 subdivisions
5. Each main question carries equal Marks.

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO1	Construct and analyze mathematical models of physical applications.
CO2	Find the roots of polynomials, algebraic, transcendental or simultaneous system of equations in science and engineering problems.
CO3	Integrate and differentiate a function for given set of tabulated data with greater accuracy for engineering problems.
CO4	Solve system of linear algebraic equations and compute eigen values and eigen vectors of matrices.
CO5	Demonstrate use of computational tools like MAT Lab to obtain solution to complex mathematical models.

MAPPING OF COs WITH POs

COs/POs	po1	po2	po3	po4	po5	po6	po7	po8	po9	po10	po11	po12
CO1	2	-	-	-	2	-	3	-	-	-	-	-
CO2	2	3	3	-	-	-	-	-	-	-	-	-
CO3	3	3	-	-	-	-	-	-	-	-	-	-
CO4	3	3	2	-	-	-	-	1	-	-	-	-

INTERNSHIP-18MMDI34

Internship: The student shall undergo internship for 16 weeks.

Preliminary Report submission and Evaluation after 8th week of Internship to be carried out by the Internal Guide of the college and a senior faculty for 100 marks

Final Report submission and Evaluation after 16th week of Internship to be carried out by the Internal Guide of the college and a senior faculty of Dept. Report Evaluation to be completed within two weeks of submission for 100 marks.

Viva-Voce on Internship - To be conducted by the Internship Guide (from the college) and the External Guide / Examiner within 2 weeks of Submission with a senior faculty / HoD as chairman for 100 marks

COURSE TITLE: Modelling & Analysis Lab		
Sub Code: 18MMDL35	**No of Credits: L-T-P-SS 1:0:3:0=4**	**No. of Lecture hours/week :03**
Exam Duration:3 hours	**CIE Marks: 50**	**Exam Marks :50**
Pre-requisites	Design and vibration knowledge.	

Note:

1) These are independent laboratory exercises
2) A student may be given one or two problems stated herein
3) Student must submit a comprehensive report on the problem solved and give a Presentation on the same for Internal Evaluation
4) Any one of the exercises done from the following list has to be asked in the Examination for evaluation.

Course Content:

Experiment #1 Structural Analysis

Part A: FE Modeling of a stiffened Panel using a commercial preprocessor.

Part B: Buckling, Bending and Modal analysis of stiffened Panels.

Part C: Parametric Studies.

Experiment #2 Design Optimization

Part A: Shape Optimization of a rotating annular disk.

Part B: Weight Minimization of a Rail Car Suspension Spring.

Part C: Topology Optimization of a Bracket.

Experiment #3 Thermal analysis

Part A: Square Plate with Temperature Prescribed on one edge and Opposite edge insulated.

Part B: A Thick Square Plate with the Top Surface exposed to a Fluid at high temperature, Bottom Surface at room temperature, Lateral Surfaces Insulated.

Experiment #4 Thermal Stress Analysis

Part A: A Thick-Walled Cylinder with specified Temperature at inner and outer Surfaces.

Part B: A Thick-Walled Cylinder filled with a Fluid at high temperature and Outer Surface exposed to atmosphere.

Experiment#5 CFD Analysis

Part A: CFD Analysis of a Hydro Dynamic Bearing using commercial code.

Part B: Comparison of predicted Pressure and Velocity distributions with Target solutions.

Part C: Experimental Investigations using a Journal Bearing Test Rig.

Part D: Correlation Studies.

Experiment #6 Welded Joints.

Part A: Fabrication and Testing.

Part B: FE Modeling and Failure Analysis.

Experiment #7 Bolted Joints.

Part A: Fabrication and Testing.

Part B: FE Modeling and Failure Analysis.

Part C: Correlation Studies.

Experiment #8 Adhesive Bonded Joints.

Part A: Fabrication and Testing.

Part B: FE Modeling and Failure Analysis.

Part C: Correlation Studies.

Course Outcomes:

Upon completion of this course, the student will be able to

CO1	Acquire knowledge of stresses, strains and failure theories and analyze them in terms of mathematical models.
CO2	Design and conduct experiments involving photo elasticity and strain gauges.
CO3	Apply Experimental techniques for different engineering problems.
CO4	Use Finite element analysis software and make comparison with other techniques.

COURSE TITLE: TECHANICAL SEMINAR		
Sub Code: 18MMDS36	**No of Credits: L-T-P-SS 0:0:2:0=2**	**No. of Lecture hours/week :02**
CIE Marks: 50		

Course Outcomes:

Upon completion of this course, the student will be able to

CO1	Identify and understand current trends and real-world issues related to topics in Machine Design.
CO2	Classify appropriate content and sources, through literature survey, that can be summarized and integrated into presentation
CO3	Review, analyze, and interpret data & results using critical thinking skills
CO4	Revise and present scientific case studies in presentation
CO5	Collaborate effectively with other students in analyzing results and preparing oral presentations
CO6	Prepare a technical seminar report and communicate effectively through oral presentation using multimedia tools

III SEMESTER

PROJECT PHASE: I 18MMDP37

Problem formulation and submission of **synopsis** within 8 weeks from the commencement of 3rd semester, which shall be evaluated for 50 marks by the committee constituted for the purpose by the Head of the Department comprising the guide, senior faculty of the department with HoD as Chairman.

Literature survey and progress done after 16 weeks shall be evaluated by guide and external examiner with senior faculty / HoD as chairman for 50 marks.

IV SEMESTER

- **Project Phase-II** - Internal Evaluation of progress in Project work shall be evaluated after 8 weeks for 25 marks by the committee constituted for the purpose by the Head of the Department comprising the guide and senior faculty of the department with HoD as Chairman
- **Project Phase-III** - Internal Evaluation of Project Demonstration, which shall be evaluated after 15 weeks for 25 marks by the committee constituted for the purpose by the Head of the Department.
- **Final Evaluation of Project Work and Viva-voce**.
  - ➢ Final evaluation of project to be carried out after 16 weeks from the date of commencement of 4^{th} semester.
  - ➢ The Internal Examiner (the project guide with a teaching experience of at least three years) and External Examiner with HoD as chairman will complete the final evaluation of Project.
- Internal and External Examiners shall carry out the evaluation for 100 Marks each and the average of these marks shall be the final marks of the Project Evaluation.
- **Viva – Voce:** The Viva-Voce shall be conducted jointly by Internal Examiner and External Examiner with HoD as chairman for 100 Marks.

ADMISSION YEAR : 2021-22 **ACADEMIC YEAR: 2021-22**

SEMESTER : FIRST

COURSE TITLE:ADVANCED MECHANICS OF SOLIDS		
Sub Code: 20MMD12	**No of Credits : L-T-P-SS 3:0:0:0=3**	**No. of Lecture hours/week :04**
Exam Duration:3 Hours	**CIE Marks: 50**	**SEE Marks :50**

COURSE OBJECTIVES:

1. To study the basic concept of stress, stress distribution, elastic constants when the material is subjected to loading within the elastic limits.
2. Study the stress distribution in plane, polar and cylindrical coordinate system.
3. Analyze the material or component subjected to torsion of circular and non-circular shafts (elliptical, triangular bars)
4. Study the thermo-elastic properties of the material at elevated temperatures.

#	CONTENTS	Hrs
UNIT-1	**Introduction to general theory of elasticity:** assumptions and applications of linear elasticity. Analysis of stress, stress tensors. State of stress at a point, principal stresses in two dimensions, Cauchy's stress principle, direction cosines, stress components on an arbitrary plane with stress transformation. Principal stresses in three dimensions, stress invariants, Equilibrium equations, octahedral stresses, Mohr's stress circle, construction of Mohr's Circle for two and three dimensional stress systems, equilibrium equations in polar coordinates for three-dimensional state of stresses.	**11**
UNIT-2	**Introduction to analysis of strain**, types of strain, strain tensors, strain transformation. Principal strains, strain invariants, octahedral strains, Mohr's Circle for Strain, equations of Compatibility for Strain, strain rosettes. Stress-strain relations, the Generalised Hooke's law, compatibility conditions, the transformation from Strain components to stress components. Strain energy in an elastic body, St.Venant's principle, uniqueness theorem.	**11**
UNIT-3	**Theories of Failure and Energy Methods:** Introduction, Theories of Failure, Use of Factor of Safety in Design, Mohr's theory of Failure, Ideally Plastic Solid, Stress space and Strain space, General nature of Yield locus, Yield Surfaces of Tresca and Von Mises, Stress- Strain relation (Plastic Flow), Prandtl Reuss theory, Saint venant – Von mises equations. **Principle of Superposition,** Reciprocal Relation, Maxwell-Betti-Rayleigh Reciprocal theorem, First theorem of Castigliano, Expressions for Strain Energy, Statically indeterminate structures, Theorem of Virtual Work, Second theorem of Castigliano, Maxwell – Mohr integrals.	**10**
UNIT-4	**Bending of Beams:** Introduction, Straight beams and Asymmetrical Bending, Euler – Bernoulli hypothesis, Shear centre or Centre of Flexure, Shear stresses in thin walled open sections, Bending of curved beams, Deflection of thick curved bars.	**10**
UNIT-5	**Torsion:** Introduction, Torsion of general prismatic bars – Solid sections, Torsion of Circular and Elliptical bars, Torsion of equivalent triangular bar, Torsion of rectangular bars, Membrane analogy, Torsion of thin walled tubes, Torsion of thin walled multiple cell closed sections, Multiple connected sections, Centre of twist and flexure centre	**10**

TEXT BOOKS:

1. Advanced Mechanics of solids, L. S. Srinath, Tata Mc. Graw Hill, 2003.
2. Theory of Elasticity, S. P. Timoshenko and J. N Gordier, Mc.Graw Hill International, 3rd edition, 1972.

REFERENCES BOOKS:

1. Theory of Elasticity, Dr. Sadhu Singh, Khanna Publications, 1988
2. Elasticity, Theory, Applications & Numericals, Martin H Sadd, Elsevier. 2005.
3. Applied Elasticity, Seetharamu & Govindaraju, Interline Publishing.
4. Applied Elasticity, C.T. WANG Sc. D. Mc. Graw Hill Book Co.1953.

COURSE OUTCOMES: After the completion of this course, student will be able to:

CO1	Apply basic concepts in continuum mechanics of solids viz. Stress and strain tensors, equilibrium, compatibility and constitutive equations and methods of solution to elasticity problems.
CO2	Evaluate stresses and displacements in simple solids such as pressurized cylinders, shrink fitted cylinders, rotating disc and shaft, plate with hole and non-circular shafts and thin tubes under torsion.
CO3	Examine bodies subjected to three dimensional stresses for the onset of failure based on failure Criteria.
CO4	Analyze deflections in beams subjected to different types of loads for elastic, elastoplastic and plastic conditions.
CO5	Evaluate stresses in bars subjected to torsion for elastic, elasto plastic and plastic conditions.

MAPPING OF COs WITH POs												
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	1	1			1				1			
CO2		1		1	1				1		1	
CO3	1		1		1						1	
CO4	1		1		1				1			
CO5	1		1						1		1	

QUESTION PAPER PATTERN (SEE)										
Q. No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
UNIT	1		2		3		4		5	
1. Two full questions (each of 20 Marks) are to be set from each unit.										
2. Student shall answer five full questions selecting one full question from each unit.										

ADMISSION YEAR : 2021-22 **ACADEMIC YEAR: 2021-22**
SEMESTER : FIRST

COURSE TITLE: FINITE ELEMENT METHOD		
Sub Code: 20MMD13	**No of Credits : L-T-P-SS 3:0:0:0=3**	**No. of Lecture hours/week :04**
Exam Duration:3 hours	**CIE Marks: 50**	**SEE Marks :50**
Pre-requisites	MOM, Design of Machine Elements.	

COURSE OBJECTIVES:

1. To present the Finite element method (FEM) as a numerical method for engineering analysis of continuum and structures.
2. To present Finite element formulation using variation and weighted residual approaches.
3. To present Finite elements for the analysis of bars & trusses, beams & frames, plane stress & plane strain problems and 3-D solids, for thermal and dynamics problems.
4. Learn to model complex geometry problems and technique of solutions.

#	CONTENTS	Hrs
UNIT-1	**Introduction to Finite Element Method**: basic steps in finite element method to solve mechanical engineering problems (solid, fluid and heat transfer). Functional approach and Galerkin approach. Displacement approach: admissible functions. Convergence criteria: conforming and nonconforming elements, C0, C1 and Cn continuity elements. Basic equations, element characteristic equations, assembly procedure, boundary and constraint conditions.	**11**
UNIT-2	**Solid Mechanics:** One-dimensional finite element formulations and analysibars-uniform, varying and stepped cross section. Basic (Linear) and higher order elements formulations for axial, torsional and temperature loads with problems. **Beams**- basic (linear) element formulation-for uniform, varying and stepped cross section- for different loading and boundary conditions, numericals. **Trusses, Plane frames and Space frame** – basic (Linear) elements formulations for different boundary conditions -axial, bending, torsional, and temperature loads, numericals.	**11**
UNIT-3	**Two dimensional finite element formulations for solid mechanics problems**: triangular membrane (tria 3, tria 6, tria 10) element, fournoded quadrilateral membrane (quad 4, quad 8) element formulations for in-plane loading with simple problems. Triangular and quadrilateral axi-symmetric basic and higher order elements formulation for axi-symmetric loading with simple numericals. **Three dimensional finite element formulations for solid mechanics problems**: finite element formulation of tetrahedral element (tet 4, tet 10), hexahedral element (hexa 8, hexa 20), for different loading conditions. Serendipity and Lagrange family elements.	**10**
UNIT-4	**Finite element formulations for structural mechanics problems:** Basics of plates and shell theories: classical thin plate theory, shear deformation theory and thick plate theory. Finite element formulations for triangular and quadrilateral plate elements. Finite element formulation of flat, curved, cylindrical and conical shell elements.	**10**
UNIT-5	**Dynamic analysis:** finite element formulation for point/lumped mass and distributed masses system, finite element formulation of one dimensional dynamic analysis: bar, truss, frame and beam element. Finite element formulation of two dimensional dynamic analysis: triangular membrane and axi-symmetric element, quadrilateral membrane and axi-symmetric element. Evaluation of eigen values and eigen vectors applicable to bars, shaft, beams, plane and space frame.	**10**

TEXT BOOKS:

1. T. R. Chandrupatla and A. D. Belegundu, Introduction to Finite Elements in Engineering, Prentice Hall, 3rd Ed, 2002.
2. Lakshminarayana H. V., Finite Elements Analysis– Procedures in Engineering, Universities Press, 2004.

REFERENCE BOOKS:

1. Rao S. S, Finite Elements Method in Engineering- 4th Edition, Elsevier, 2006
2. P.Seshu, Textbook of Finite Element Analysis, PHI, 2004.
3. J.N.Reddy, Introduction to Finite Element Method, mcgraw -Hill, 2006.
4. Bathe K. J, Finite Element Procedures, Prentice-Hall, 2006.
5. Cook R. D., Finite Element Modeling for Stress Analysis, Wiley, 1995.

COURSE OUTCOMES: After the completion of this course, student will be able to:

CO1	Understand the concepts of Variation methods and Weighted residual methods.
CO2	Identify the application and characteristics of FEA elements such as bars, beams, plane and isoparimetric elements, and 3D element.
CO3	Develop element characteristic equations and generate global stiffness equations.
CO4	Apply suitable boundary conditions to a global structural equation, and reduce it to a solvable form.
CO5	Identify how the finite element method expands beyond the structural domain, for problems involving dynamics and heat transfer.

MAPPING OF COs WITH POs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1		1					1			
CO2	1		1		1				1		1	
CO3	1		1						1		1	
CO4		1		1					1		1	
CO5	1	1			1						1	
High-3 Medium-2 Low-1												

QUESTION PAPER PATTERN (SEE)

Q. No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
UNIT	1		2		3		4		5	
1. Two full questions (each of 20 Marks) are to be set from each unit.										
2. Student shall answer five full questions selecting one full question from each unit.										

ADMISSION YEAR : 2021-22 **ACADEMIC YEAR: 2021-22**
SEMESTER : FIRST

COURSE TITLE: ADVANCED DESIGN OF MECHANISM		
Sub Code: 20MMD14	**No of Credits : L-T-P-SS 3:0:0:0=3**	**No. of Lecture hours/week :04**
Exam Duration:3 hours	**CIE Marks: 50**	**SEE Marks :50**
Pre-requisites	MOM, Design of Machine Elements.	

COURSE OBJECTIVES:

1. To provide a theoretical and practical foundation for analysis and design of articulated mechanical systems for desired applications.
2. Develop skills to analyze the displacement, velocity, and acceleration of mechanisms.
3. Improve understanding of the synthesis of mechanisms for given tasks.
4. To include dynamics for considerations in the design of mechanisms engineering applications.

#	CONTENTS	Hrs.
UNIT-1	**Geometry of Motion:** Introduction, analysis and synthesis, Mechanism terminology, planar, spherical and spatial mechanisms, mobility, Grashoffs law, Equivalent mechanisms, Unique mechanisms, Kinematic analysis of plane mechanisms: Development of different mechanisms and its inversions like four bar chain mechanism, slider crank mechanism, double slider cranks, mechanism.	**11**
UNIT-2	**Generalized Principles of Dynamics:** Fundamental laws of motion, Generalized coordinates, Configuration space, Constraints, Virtual work, Principle of Virtual Work, Energy and Momentum, Work and kinetic energy, Equilibrium and stability, Kinetic energy of a system, Angular momentum, Generalized momentum. Lagrange's Equation: Lagrange's equation from D'Alembert's principles, Examples, Hamilton's equations, Hamilton's principle, Lagrange's, equation from Hamilton's principle, Derivation of Hamilton's equations, Examples.	**11**
UNIT-3	**Analytical Methods of Dimensional Synthesis:** Synthesis of Linkages: Type, number, and dimensional synthesis, Function generation, Path generation and Body guidance, Precision positions, Structural error, Chebychev spacing, Two position synthesis of slider crank mechanisms, Crank-rocker mechanisms with optimum transmission angle Motion Generation: Poles and relative poles, Location of poles and relative poles, polode, Curvature, Inflection circle.	**10**
UNIT-4	**Graphical Methods of Dimensional Synthesis**: Two position synthesis of crank and rocker mechanisms, Three position synthesis, Four position synthesis (point precision reduction) Overlay method, Coupler curve synthesis, Cognate linkages. Ana1ytical Methods of 32 Dimensional Synthesis: Freudenstein's equation for four bar mechanism and slider crank mechanism, Examples, Bloch's method of synthesis, Analytical synthesis using complex algebra.	**10**
UNIT-5	**Spatial Mechanisms:** Introduction, Position analysis problem, Velocity and acceleration analysis, Eulerian angles.	**10**

TEXT BOOKS:

1. K.J.Waldron&G.L.Kinzel , "Kinematics, Dynamics and Design of Machinery", Wiley India, 2007.
2. Greenwood, "Classical Dynamics", Prentice Hall of India, 1988.

REFERENCES BOOKS:

1. J E Shigley, "Theory of Machines and Mechanism" -McGraw-Hill, 1995
2. A.G.Ambekar , "Mechanism and Machine Theory", PHI, 2007.
3. Ghosh and Mallick , "Theory of Mechanism and Mechanism", East West press 2007.
4. David H. Myszka , "Machines and Mechanisms", Pearson Education, 2005.

COURSE OUTCOMES: After the completion of this course, student will be able to:

CO1	The knowledge of dynamics considerations in mechanism design is essential to use commercial multi body dynamics software in mechanical engineering design.
CO2	Carry out mobility analysis of mechanism and perform velocity and acceleration of complex planer mechanism.
CO3	Synthesize mechanisms for function generation and path generation.
CO4	Analyze the Dynamics of Mechanical systems using D'Alemberts. ,Lagrange's, and Hamiltons Principles.
CO5	Demonstrate the skills to use software to analyze mechanisms, synthesis of linkages.

MAPPING OF COs WITH POs												
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	1		1		1				1		1	
CO2	1	1		1							1	
CO3	1				1		1		1			
CO4	1		1	1							1	
CO5	1			1			1		1			
High-3 Medium-2 Low-1												

QUESTION PAPER PATTERN (SEE)										
Q. No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
UNIT	1		2		3		4		5	
1. Two full questions (each of 20 Marks) are to be set from each unit.										
2. Student shall answer five full questions selecting one full question from each unit.										

ADMISSION YEAR : 2021-22 **ACADEMIC YEAR: 2021-22**
SEMESTER : FIRST

COURSE TITLE:EXPERIMENTAL METHODS		
Sub Code: 20MMD151	**No of Credits : L-T-P-SS 3:0:0:0=3**	**No. of Lecture hours/week :04**
Exam Duration:3 hours	**CIE Marks: 50**	**SEE Marks :50**
Pre-requisites	MOM, Design of Machine Elements.	

COURSE OBJECTIVES:

1. To introduce the concepts of dynamic measurements and analysis of experimental data.
2. To expose them to the techniques of Data Acquisition, Signal conditioning and processing.
3. To introduce students to different aspects of measuring deformation, strains, and stresses for developing a mechanistic understanding of both the material and the structure behavior.

#	CONTENTS	Hrs
UNIT-1	**Introduction:** Definition of terms, calibration, standards, dimensions and units, generalized measurement system, Basic concepts in dynamic measurements, system response, distortion, impedance matching, experiment planning. Analysis of Experimental Data: Cause and types of experimental errors, error analysis. Statistical analysis of experimental data- Probability distribution, gaussian, normal distribution. Chi-square test, Method of least square, correlation coefficient, multivariable regression, standard deviation of mean, graphical analysis and curve fitting, general consideration in data analysis.	**11**
UNIT-2	**Data Acquisition and Processing:** General data acquisition system, signal conditioning revisited, data transmission, Analog-to-Digital and Digital-to-Analog conversion, Basic components (storage and display) of data acquisition system. Computer program as a substitute for wired logic. Force, Torque and Strain Measurement: Mass balance measurement, Elastic Element for force measurement, torque measurement. Strain Gages -Strain sensitivity of gage metals, Gage construction, Gage sensitivity and gage factor, Performance characteristics, Environmental effects Strain, gage circuits, Potentiometer, Wheat Stone's bridges, Constant current circuits. Strain Analysis Methods-Two element and three element, rectangular and delta rosettes, Correction for transverse strains effects, stress gage - plane shear gage, Stress intensity factor gage.	**11**
UNIT-3	**Stress Analysis**: Two Dimensional Photo elasticity - Nature of light, - wave theory of light,- optical interference - Polariscopes stress optic law - effect of stressed model in plane and circular Polariscopes, IsoclinicsIso chromatics fringe order determination - Fringe multiplication techniques - Calibration Photoelastic model materials. Separation methods shear difference method, Analytical separation methods, Model to prototype scaling.	**10**
UNIT-4	**Three Dimensional Photo elasticity:** Stress freezing method, General slice, Effective stresses, Stresses separation, Shear deference method, Oblique incidence method Secondary principals stresses, Scattered light photo elasticity, Principals, Polari scope and stress data analyses.	**10**
UNIT-5	**Coating Methods:** **Photo elastic Coating Method**-Birefringence coating techniques Sensitivity Reinforcing and thickness effects - data reduction - Stress separation techniques Photo elastic strain gauges. **Brittle Coatings Method:** Brittle coating technique Principles data analysis - coating materials, Coating techniques. **Moire Technique** - Geometrical approach, Displacement approach-	**10**

	sensitivity of Moire data data reduction, In plane and out plane Moire methods, Moire photography, Moire grid production. Holography: Introduction, Equation for plane waves and spherical waves, Intensity, Coherence, Spherical radiator as an object (record process), Hurter, Driffeld curves, Reconstruction process, Holograpic interferomerty, Real time. and double exposure methods, Displacement measurement, Isopachics.	

TEXT BOOKS:

1. Holman,“Experimental Methods for Engineers” 7th Edition, Tata McGraw-Hill Companies, Inc, New York, 2007.
2. R. S. Sirohi, H. C. Radha Krishna, “Mechanical measurements” New Age International Pvt. Ltd., New Delhi, 2004 .
3. Experimental Stress Analysis - Srinath, Lingaiah, Raghavan, Gargesa, Ramachandra and Pant, Tata McGraw Hill, 1984.
4. Instrumentation, Measurement And Analysis -Nakra&Chaudhry, B C Nakra K KChaudhry, Tata McGraw-Hill Companies, Inc, New York, Seventh Edition, 2006.

REFERENCES BOOKS:

1. Measurement Systems Application and Design - Doeblin E. A., 4th (S.I.) Edition, McGraw Hill, New York. 1989 .
2. Design and Analysis of Experiments - Montgomery D.C., John Wiley & Sons, 1997.
3. Experimental Stress Analysis-Dally and Riley, McGraw Hill, 1991.
4. Experimental Stress Analysis-Sadhu Singh, Khanna publisher, 1990. 5. PhotoelasticityVol I and Vol II - M.M.Frocht,. John Wiley and sons, 1969. 6. Strain Gauge Primer - Perry and Lissner, McGraw Hill, 1962.

COURSE OUTCOMES: After the completion of this course, student will be able to:

CO1	Undertake experimental investigations to verify predictions by other methods.
CO2	To acquire skills for experimental investigations an accompanying laboratory course is desirable.
CO3	To analyze fringe patterns, calibration studies.
CO4	Analysis and evaluations of polariscope.
CO5	Study and evaluation techniques of coating technology.

MAPPING OF COs WITH POs												
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	1		1		1				1		1	
CO2		1			1				1		1	
CO3	1				1				1		1	
CO4	1		1	1					1			
CO5		1		1				1			1	
High-3 Medium-2 Low-1												

QUESTION PAPER PATTERN (SEE)										
Q. No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
UNIT	1		2		3		4		5	
1. Two full questions (each of 20 Marks) are to be set from each unit.										
2. Student shall answer five full questions selecting one full question from each unit.										

ADMISSION YEAR : 2021-22 ACADEMIC YEAR: 2021-22

SEMESTER : FIRST

COURSE TITLE : MECHATRONICS SYSTEMS DESIGN

Sub Code: 20MMD152	No of Credits : L-T-P-SS 3:0:0:0 =3	No. of lecture hours/week : 04
Exam Duration : 3 hours	CIE Marks: 50	SEE Marks :50

COURSE OBJECTIVES:

1. To educate the student regarding integration of mechanical, electronic, electrical and computer systems in the design of CNC machine tools, Robots etc.
2. To provide students with an understanding of the Mechatronic Design Process, actuators, Sensors, transducers, Signal Conditioning, MEMS and Microsystems and also the Advanced Applications in Mechatronics

#	CONTENTS	Hrs
UNIT-1	**INTRODUCTION:** Definition and Introduction to Mechatronic Systems. Modeling &Simulation of Physical systems Overview of Mechatronic Products and their functioning, measurement systems. Control Systems, simple Controllers.	**11**
UNIT-2	**STUDY OF SENSORS AND TRANSDUCERS:** Pneumatic and Hydraulic Systems, Mechanical Actuation System, Electrical Actual Systems, Real time interfacing and Hardware components for Mechatronics.	**11**
UNIT-3	**ELECTRICAL ACTUATION SYSTEMS:** Electrical systems, Mechanical switches, Solid state switches, solenoids, DC & AC motors, Stepper motors. **System Models:** Mathematical models:- mechanical system building blocks, electrical system building blocks, thermal system building blocks, electromechanical systems, hydro-mechanical systems, pneumatic systems.	**10**
UNIT-4	**SIGNAL CONDITIONING:** Signal conditioning, the operational amplifier, Protection, Filtering, Wheatstone Bridge, Digital signals , Multiplexers, Data Acquisition, Introduction to digital system processing, pulse-modulation. **MEMS AND MICROSYSTEMS:** Introduction, Working Principle, Materials for MEMS and Microsystems, Micro System fabrication process, Overview of Micro Manufacturing, Micro system Design, and Micro system Packaging.	**10**
UNIT-5	**DATA PRESENTATION SYSTEMS:** Basic System Models, System Models, Dynamic Response of system. **ADVANCED APPLICATIONS IN MECHATRONICS:** Fault Finding, Design, Arrangements and Practical Case Studies, Design for manufacturing, User-friendly design.	**10**

TEXT BOOKS:

1. W. Bolton, “Mechatronics” - Addison Wesley Longman Publication, 1999
2. HSU “MEMS and Microsystems design and manufacture”- Tata McGraw-Hill Education, 2002

REFERENCE BOOKS:

1. Kamm,“Understanding Electro-Mechanical Engineering an Introduction to Mechatronics”- IEEE Press, 1 edition ,1996
2. Shetty and Kolk, “Mechatronics System Design”- Cenga ge Learning, 2010
3. Mahalik ,“Mechatronics”- Tata McGraw-Hill Education, 2003
4. HMT “Mechatronics”- Tata McGraw-Hill Education, 199 8
5. Michel .B. Histand& David. Alciatore, “Introduction to Mechatronics & Measurement Systems”–. Mc Graw Hill, 2002.

COURSE OUTCOME: After the completion of this course, student will be able to:

CO1	Appreciate multi-disciplinary nature of modern engineering systems.
CO2	Model and analyze mechanical and electrical systems and their connection.
CO3	Be able to integrate mechanical, electronics, control and computer engineering in the design of mechatronics systems.
CO4	Address issues of design, fabrication, and packaging issues of Microsystems.
CO5	Design of system models in application of advanced mechatronics system.

MAPPING OF COs WITH POs												
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	1		1		1				1		1	
CO2		1	1	1					1			
CO3	1			1					1		1	
CO4		1	1						1		1	
CO5	1		1	1							1	
High-3 Medium-2 Low-1												

QUESTION PAPER PATTERN (SEE)										
Q. No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
UNIT	1		2		3		4		5	
1. Two full questions (each of 20 Marks) are to be set from each unit.										
2. Student shall answer five full questions selecting one full question from each unit.										

ADMISSION YEAR : 2021-22 **ACADEMIC YEAR: 2021-22**

SEMESTER : FIRST

COURSE TITLE: DESIGN FOR ADDITIVE MANUFACTURING

Sub Code: 20MMD153	No of Credits : L-T-P-SS 3:0:0:0=3	No. of Lecture hours/week :04
Exam Duration:3 hours	CIE Marks: 50	SEE Marks :50

COURSE OBJECTIVES:

1. To acquaint the learner on fundamentals of additive manufacturing/rapid prototyping, reverse engineering techniques and its applications.
2. To familiarize students with different processes in rapid prototyping systems.
3. To teach students about mechanical properties and geometric issues relating to specific rapid prototyping applications.

#	CONTENTS	Hrs
UNIT-1	**Introduction:** Need for the compression in product development, history of RP systems, Survey of applications, Growth of RP industry, and classification of RP systems. **Stereo Lithography Systems:** Principle, Process parameter, Process details, Data preparation, data files and machine details, Application.	**11**
UNIT-2	**Selective Laser Sintering and Fusion Deposition Modeling:** Type of machine, Principle of operation, process parameters, Data preparation for SLS, Applications, Principle of Fusion deposition modeling, Process parameter, Path generation, Applications.	**11**
UNIT-3	**Solid Ground Curing:** Principle of operation, Machine details, Applications. **Laminated Object Manufacturing:** Principle of operation, LOM materials. Process details, application.	**10**
UNIT-4	**Rapid Tooling:** Indirect Rapid tooling -Silicone rubber tooling – Aluminum filled epoxy tooling Spray metal tooling, Cast kirksite, 3Q keltool, Direct Rapid Tooling Direct. AIM, Quick cast process, Copper polyamide, Rapid Tool, DMILS, Prometal, Sand casting tooling, Laminate tooling soft Tooling vs. hard tooling.	**10**
UNIT-5	**RP Process Optimization:** factors influencing accuracy. Data preparation errors, Part building errors, Error in finishing, influence of build orientation.	**10**

REFERENCES BOOKS:

1. Stereo lithography and other RP & M Technologies -Paul F. Jacobs- SME, NY1996

2. Rapid Manufacturing - Flham D.T &Dinjoy S.S - Verlog London2001.

3. Rapid automated - Lament wood - Indus press NewYork

4. Wohler's Report 2000 - Terry Wohlers - Wohler's Association -2000

COURSE OUTCOMES: After the completion of this course, student will be able to:

CO1	Describe product development, conceptual design and classify rapid prototyping systems; explain stereo lithography process and applications
CO2	Explain direct metal laser sintering, LOM and fusion deposition modeling processes.
CO3	Demonstrate solid ground curing principle and process.
CO4	Discuss LENS, BPM processes, point out the application of RP system in medical field define virtual prototyping and identify simulation components.

CO5	Understand the RP Process Optimizations.

MAPPING OF COs WITH POs												
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	1			1		1			1		1	
CO2		1	1		1						1	
CO3	1		1			1			1		1	
CO4		1			1				1		1	
CO5	1	1			1						1	

QUESTION PAPER PATTERN (SEE)										
Q. No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
UNIT	1		2		3		4		5	
1. Two full questions (each of 20 Marks) are to be set from each unit.										
2. Student shall answer five full questions selecting one full question from each unit.										

ADMISSION YEAR : 2021-22 **ACADEMIC YEAR: 2021-22**
SEMESTER : FIRST

COURSE TITLE: MATERIAL HANDLING EQUIPMENT DESIGN		
Sub Code: 20MMD154	**No of Credits : L-T-P-SS**	**No. of Lecture hours/week :04**

	3:0:0:0=3	
Exam Duration:3 hours	**CIE Marks: 50**	**SEE Marks :50**

COURSE OBJECTIVES:

1. To develop competency for system visualization and design.
2. To enable student select materials and to design internal engine components.
3. To acquaint student to optimum design and use optimization methods to design mechanical components.
4. To enable and evaluate design material handling systems

#	CONTENTS	Hrs
UNIT-1	**Elements of Material Handling System:** Importance, Terminology, Objectives and benefits of better Material Handling; Principles and features of Material Handling System; Classification of Material Handling Equipment's, Interrelationships between material handling and plant layout, physical facilities and other organizational functions.	**11**
UNIT-2	**Selection of Material Handling Equipment's:** Factors affecting for selection; Material Handling Equation; Choices of Material Handling Equipment; General analysis Procedures; Basic Analytical techniques; The unit load concept; Selection of suitable types of systems for applications ; Activity cost data and economic analysis for design of components of Material Handling Systems; functions and parameters affecting service; packing and storage of materials.	**11**
UNIT-3	**Design of Mechanical Handling Equipment's:** **Design of Hoists: Drives for hoisting**, components, and hoisting mechanisms; rail traveling components and mechanisms; hoisting gear operation during transient motion; selecting the motor rating and determining breaking torque for hoisting mechanisms. **Design of Cranes:** Hand-propelled and electrically driven E.O.T. overheat Traveling cranes; Traveling mechanisms of cantilever and monorail cranes; design considerations for structures of rotary cranes with fixed radius ; fixed post and overhead traveling cranes; Stability of stationary rotary and traveling rotary cranes.	**10**
UNIT-4	**Study of systems and Equipment's used for Material Storage:** Objectives of storage; Bulk material handling; Gravity flow of solids through slides and chutes; Storage in bins and hoppers; Belt conveyors; Bucket-elevators; Screw conveyors; Vibratory Conveyors; Cabin conveyors; Mobile racks etc.	**10**
UNIT-5	**Material Handling / Warehouse Automation and Safety considerations:** **Storage and warehouse planning and design:** computerized warehouse planning; Need, Factors and Indicators for consideration in warehouse automation; which function, When and How to automate; Levels and Means of Mechanizations. **Safety and design;** Safety regulations and discipline.	**10**

TEXT BOOKS:

1. Materials Handling Equipment – N. Rudenko , Envee Publishers, New Delhi
2. Materials Handling Equipment – M.P. Alexandrov. Mie publications, Moscow

REFERENCE BOOKS:

1. Aspects of Material handling – Arora
2. Introduction to Material Handling- Ray
3. Plant Layout and Material Handling- Chowdary R B

COURSE OUTCOMES: After the completion of this course, student will be able to:

CO1	Explain about the different types of material handling, advantages and disadvantages. It also suggests the selection procedure for the material handling along with its specifications.
CO2	Need for Material handling also explained with different techniques like Automated Material handling Design Program, Computerized material handling Planning will be dealt.
CO3	Demonstrate ability to successfully complete Fork Lift Certification to safely and effectively operate in the manufacturing environment.
CO4	The Material handling is explained with models, selection procedure of material handling is depending on different function oriented systems. This also related with plant layout by which the minimization of the handling charges will come down.
CO5	The ergonomics related to material handling equipment about design and miscellaneous equipment's.

MAPPING OF COs WITH POs												
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	1		1		1				1		1	1
CO2	1		1						1			
CO3		1	1	1		1					1	
CO4	1				1				1		1	
CO5		1			1				1		1	

QUESTION PAPER PATTERN (SEE)										
Q. No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
UNIT	1		2		3		4		5	
1. Two full questions (each of 20 Marks) are to be set from each unit.										
2. Student shall answer five full questions selecting one full question from each unit.										

ADMISSION YEAR : 2021-22 **ACADEMIC YEAR: 2021-22**

SEMESTER : FIRST

COURSE TITLE : COMPOSITE MATERIALS & TECHONOLOGY		
Sub Code: 20MMD161	**No of Credits : L-T-P-SS**	**No. of lecture hours/week :04**

	3:0:0:0=4	
Exam Duration:3 hours	**CIE Marks:50**	**SEE Marks :50**

COURSE OBJECTIVES:

1. To study the basics of Composite materials.
2. To acquaint mechanics of lamina.
3. To study the micro and macro analysis of the lamina.
4. To gain knowledge of different techniques involved in production of composites.

#	CONTENTS	Hrs
UNIT-1	**INTRODUCTION TO COMPOSITE MATERIALS:** Definition, Classification, Types of matrices material and reinforcements, Characteristics &selection, Fiber composites, laminated composites, Particulate composites, Pre-pegs, and sandwich construction. **Metal Matrix Composites:** Reinforcement materials, Types, Characteristics and selection, Base metals, Selection, Applications	**11**
UNIT-2	**MACRO MECHANICS OF A LAMINA:** Hooke's law for different types of materials, Number of elastic constants, Derivation of nine independent constants for orthotropic material, Two - dimensional relationship of compliance and stiffness matrix. Hooke's law for two-dimensional angle lamina, engineering constants - Numerical problems. Invariant properties. Stress-Strain relations for lamina of arbitrary orientation, Numerical problems.	**11**
UNIT-3	**MICRO MECHANICAL ANALYSIS OF A LAMINA:** Introduction, Evaluation of the four elastic moduli, Rule of mixture, Numerical problems. Experimental Characterization of Lamina- Elastic Moduli and Strengths **Failure Criteria:** Failure criteria for an elementary composite layer or Ply, Maximum Stress and Strain Criteria, Approximate strength criteria, Inter-laminar Strength, Tsa-Hill theory, Tsai, Wu tensor theory, Numerical problem, practical recommendations	**10**
UNIT-4	**MACRO MECHANICAL ANALYSIS OF LAMINATE**: Introduction, code, Kirchoff hypothesis, Classical Lamination Theory, A, B, and D matrices (Detailed derivation), Special cases of laminates, Numerical problems. Shear Deformation Theory, A, B, D and E matrices (Detailed derivation) **Analysis of Composite Structures:** Optimization of Laminates, composite laminates of uniform strength, application of optimal composite structures, composite pressure vessels, spinning composite disks, composite lattice structures	**10**
UNIT-5	**MANUFACTURING AND TESTING:** Layup and curing - open and closed mould processing, Hand lay-up techniques, Bag moulding and filament winding. Pultrusion, Pulforming, Thermoforming, Injection moulding, Cutting, Machining, joining and repair. NDT tests – Purpose, Types of defects, NDT method - Ultrasonic inspection, Radiography, Acoustic emission and Acoustic ultrasonic method. **Applications:** Aircrafts, missiles, Space hardware, automobile, Electrical and Electronics, Marine, Recreational and sports equipment-future potential of composites.	**10**

TEXT BOOKS:

1. Autar K. Kaw, Mechanics of Composite materials, CRC Press, 2nd Ed, 2005.
2. Madhijit Mukhopadhay, Mechanics of Composite Materials & Structures, Universities Press, 2004.

REFERENCE BOOKS:

1. J. N. Reddy,Mechanics of Laminated Composite Plates & Shells, CRD Press, 2nd Ed, 2004.
2. Mein Schwartz, Composite Materials handbook, McGraw Hill, 1984.

3. Rober M. Jones,Mechanics of Composite Materials, Taylor & Francis, 1998.
4. Michael W,Hyer,Stress analysis of fiber Reinforced Composite Materials, Mc-Graw Hill International, 2009.

COURSE OUTCOME: At the completion of this course, students will be able to:

CO1	Identify the role of matrices and reinforcements used in practical composite structures.
CO2	Analyze problems on macro mechanical behavior of lamina.
CO3	Analyze problems on micro and assess the strength of laminated composite and predict its failure for given static loading conditions.
CO4	Understand various method involved in synthesis of composites and to optimize laminates.
CO5	Develop understanding of different methods of manufacturing and testing of composites

MAPPING OF COs WITH POs												
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	1		1	1					1			
CO2		1		1	1						1	
CO3		1		1	1				1		1	
CO4	1		1		1						1	
CO5		1	1		1						1	

QUESTION PAPER PATTERN (SEE)										
Q. No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
UNIT	1		2		3		4		5	
1. Two full questions (each of 20 Marks) are to be set from each unit.										
2. Student shall answer five full questions selecting one full question from each unit.										

ADMISSION YEAR : 2021-22 **ACADEMIC YEAR: 2021-22**
SEMESTER : FIRST

COURSE TITLE: TECHANICAL ACOUSTICS		
Sub Code: 20MMD162	**No of Credits : L-T-P-SS 3:0:0:0=3**	**No. of Lecture hours/week :04**
Exam Duration:3 hours	**CIE Marks: 50**	**SEE Marks :50**

COURSE OBJECTIVES:

1. To acquaint students the fundamentals of acoustics related to generation, transmission and control techniques.
2. To provide basic knowledge and understanding of noise and vibration control necessary for professional practice as a noise control engineer.
3. To expose them to acoustic instrumentation and techniques of sound measurement.
4. To understand Noise reduction and control techniques in Machinery, auditorium, and HVAC systems

#	CONTENTS	Hrs
UNIT-1	**Introduction to Acoustics:** Basics of acoustics - speed of sound, wavelength, frequency, and wave number, acoustic pressure and particle velocity, acoustic intensity and acoustic energy density, spherical wave, directivity factor and directivity index, levels and the decibel, combination of sound sources, octave bands, weighted sound levels.	**11**
UNIT-2	**Acoustics Evaluation Techniques:** Room Acoustics, Reverberation time, Acoustic materials, Absorption and Absorption Coefficient, Evaluation techniques. Sound and vibration analyzer (SVAN) Sound sources and Propagation – Plane and spherical waves, near and far field, free and reverberant field - Anechoic and Reverberant chambers.	**11**
UNIT-3	**Noise and physiological effects:** Noise and physiological effects , Acoustic criteria, the human ear, hearing loss, industrial noise criteria, speech interference level, noise criteria for interior spaces , Loudness, hearing, hearing loss, hearing protectors, Mechanism -Weighted Networks -Noise standards for traffic - Community noise -Aircraft - Environmental noise, Articulation index, and Machinery acoustics.	**10**
UNIT-4	**Acoustic Instrumentation:** Sound level and intensity meters - Octave analyzers, octave band filters, acoustic analysers, dosimeter, measurement of sound power, sound power measurement in a reverberant room, sound power measurement in an anechoic chamber, sound power survey measurements, measurement of the directivity factor, calibration, noise measurement procedures. **Sound power estimation** - Instruments for building acoustics -Speech Interference - Sound systems and Auditorium acoustics.	**10**
UNIT-5	**Noise control techniques:** At source and transmission path-Barriers and Enclosures- HVAC system noise, Machinery acoustics and levels- Near field monitoring and diagnostics - Active noise control techniques. Noise control in rooms, sound absorption.	**10**

TEXT BOOKS:

1. J.D. Irwin and E.R.Graf, (2001), Industrial Noise and Vibration control, Prentice Hall Inc.

REFERENCE BOOKS:

1. Bies and Colin. H. Hanson, (2001): Engg. Noise Control, E &FN SPON.
2. Noise Control Hand Book of Principles and Practices, David M.Lipsdomls Van Nostrand Reinhold Company.
3. Acoustic and Noise Control, (2000), B.J. Smith, R.J.Peters, Stephanie Owen.
4. Harris, C.K.–Handbook of Noise Control.
5. Petrusowicz and Longmore –Noise and Vibration control for industrialists.
6. Thumann and Miller- Secrets of Noise control.

COURSE OUTCOMES: After the completion of this course, student will be able to:

CO1	Select appropriate noise control techniques for the solution of practical noise problems and evaluate their performance.
CO2	Understand how to use pressure wave expressions to describe sound transmission in different media.
CO3	Analyze complex noise environments and predict sound levels in desired locations.
CO4	Evaluate acoustic enclosures, barriers and walls for effective noise control.
CO5	Become familiar with sound measurement instrumentation.

MAPPING OF COs WITH POs												
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	1		1	1					1		1	
CO2		1		1			1		1			
CO3	1		1		1				1		1	
CO4		1		1	1						1	
CO5	1			1	1				1			

QUESTION PAPER PATTERN (SEE)										
Q. No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
UNIT	1		2		3		4		5	
1. Two full questions (each of 20 Marks) are to be set from each unit.										
2. Student shall answer five full questions selecting one full question from each unit.										

ADMISSION YEAR : 2021-22 **ACADEMIC YEAR: 2021-22**
SEMESTER : FIRST

COURSE TITLE : DESIGN OPTIMIZATION		
Sub Code: 20MMD163	**No of Credits : L-T-P-SS 3:0:0:0=3**	**No. of lecture hours/week :04**
Exam Duration : 3 hours	**CIE Marks: 50**	**SEE Marks :50**

Pre-requisites	Research Methodology, Composite Material, Basic Mathematics

COURSE OBJECTIVES:

1. To induce the students to the basics of Design optimization.
2. To acquaint Optimum Design Problem Formulation.
3. To analyze sensitivity analysis, Linear and Non Linear Approximations and Optimization Disciplines.
4. To explore and distinguish knowledge of different Manufacturability in Optimization Problems and Design Interpretation.

#	CONTENTS	Hrs
UNIT-1	**Engineering Design Practice:** Evolution of Design Technology, Introduction to Design and the Design Process, Design versus Analysis, Role of Computers in Design Cycle, Impact of CAE on Design, Numerical Modeling with FEA and Correlation with Physical Tests.	**11**
UNIT-2	**Optimum Design Problem Formulation**: Types of Optimization Problems, The Mathematics of Optimization, Design Variables and Design Constraints, Feasible and Infeasible Designs, Equality and Inequality Constraints, Discrete and Continuous Optimization, Linear and Non Linear Optimization. **Optimization Theory** – Fundamental Concepts, Global and Local Minimum, Gradient Vector and Hessian Matrix, Concept of Necessary and Sufficient Conditions, Constrained and Unconstrained Problems, Lagrange Multipliers and Kuhn Tucker Conditions	**11**
UNIT-3	**Sensitivity Analysis, Linear And Non Linear Approximations:** Gradient Based Optimization Methods – Dual and Direct. **Optimization Disciplines:** Conceptual Design Optimization and Design Fine Tuning, Combined Optimization, Optimization of Multiple Static and Dynamic Loads, Transient Simulations, Equivalent Static Load Methods	**10**
UNIT-4	**Manufacturability In Optimization Problems:** Design For Manufacturing, Manufacturing Methods and Rules, Applying Manufacturing Constraints to Optimization Problems. **Design Interpretation:** Unbound Problems, Over Constrained Problems, Problems with No of Multiple Solutions, Active and Inactive Constraints, Constraint Violations and Constraint Screening, Design Move Limits, Local and Global Optimum.	**10**
UNIT-5	**Dynamic Programming:** Introduction, Multistage decision processes, Principle of optimality, Computational Procedure in dynamic programming, Initial value problem, Examples. **Applications of Optimization in Engineering Design:** Automotive, Aerospace and General Industry Applications, Optimization of Metallic and Composite Structures, Minimization and Maximization Problems, MDO and MOO.	**10**

NOTE: the students are advised to prepare the report in the form of assignment to understand the subject and its relevance in the industry

TEXT BOOKS:

1. S.S.Rao, Engineering Optimization: Theory and Practice, John Wiley, 2009
2. JasbirArora, Introduction to Optimum Design, McGraw Hill, 2011.

REFERENCE BOOKS:

1. Optimisation and Probability in System Engg - Ram,Van Nostrand.
2. Optimization methods -K.V.Mital and C. Mohan,New age International Publishers, 1999.

3. Optimization methods for Engg. Design - R.L Fox, Addison – Wesley, 1971.

COURSE OUTCOME: At the completion of this course, students will be able to:

CO1	It provides the student with knowledge required to optimize an existing design with single or multiple objective functions.
CO2	Skills acquired through commercial optimization programs
CO3	Acquire the knowledge of engineering system design
CO4	Apply the concept of manufacturing constraint and design interpretation to optimization problems
CO5	Understand the concept of dynamic programming and apply the concept of optimization in engineering design

MAPPING OF COs WITH POs												
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	1		1		1				1			
CO2		1	1		1				1		1	
CO3	1	1			1				1		1	
CO4		1			1				1		1	
CO5	1		1						1		1	

QUESTION PAPER PATTERN (SEE)										
Q. No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
UNIT	1		2		3		4		5	
1. Two full questions (each of 20 Marks) are to be set from each unit.										
2. Student shall answer five full questions selecting one full question from each unit.										

ADMISSION YEAR : 2021-22 **ACADEMIC YEAR: 2021-22**
SEMESTER : FIRST

COURSE TITLE: PRODUCT DESIGN FOR QUALITY		
Sub Code: 20MMD164	**No of Credits : L-T-P-SS 3:0:0:0=3**	**No. of Lecture hours/week :04**
Exam Duration:3 hours	**CIE Marks: 50**	**SEE Marks :50**

COURSE OBJECTIVES:

1. Apply the principles of product design to modify existing engineering systems or to develop new artifacts.
2. Design a system taking into consideration the concepts of ease of production, maintenance, handling, installation etc.
3. Translate the concepts of economics in design, optimization of design and human factors approach to product design.

#	CONTENTS	Hrs
UNIT-1	**Design for quality**: Taguchi's Approach to Quality, On-line and Off-line Quality Control, Quality Loss Function, System Design, Parameter Design, Design for Environment, Human factor design, Design for casting and forging, Causes of Variation.	**11**
UNIT-2	**Quality Function Deployment –**Introduction, QFD team, benefits, voice of customer, organisation of information, house of quality, QFD process **Design of Experiments**: Basic methods- Two factorial experiments-Extended method reduced tests and fractional experiments, orthogonality, base design method, higher dimensional fractional factorial design	**11**
UNIT-3	**Failure Mode Effect Analysis:** Refining geometry and layout, Failure tree analysis, Defects and failure modes Techniques of failure analysis, Filed inspection of failure, Macroscopic and Microscopic examination, Additional tests, Analysis of data and report of failure.	**10**
UNIT-4	**Statistical Consideration in Product Design and Development** 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	**10**
UNIT-5	**Six Sigma** – Overview, Basics and history of the approach for six sigma, Methodology and focus, the application of Six Sigma in production and in-service industries, Relationship of Six Sigma and Lean Management, linking Six Sigma project goals with organizational strategy	**10**

REFERENCE BOOKS:

1. Total quality Management Kevin Otto & Kristin Wood, Product Design Techniques in Reverse
2. Engineering and New Product Development, Pearson Education (LPE), 2001. ISBN10: 0130212717
3. Product Design and Development, Karl T. Ulrich, Steven D. Eppinger, TATA McGraw - HILL - 3rd Edition, 2003. ISBN:13: 978-0073404776
4. The Management and control of Quality, James R. Evens, William M Lindsay,6th edition- South-Western Publishers ISBN: 0314062157
5. Engineering Design, George E Dieter, 3rd Edition, McGraw hill International Edition, ISBN: 0-07- 116204-6

COURSE OUTCOMES: After the completion of this course, student will be able to:

CO1	Apply a system based approach for quality management
CO2	Identify the importance of various principles of quality in product or service
CO3	Use statistical tools in product development
CO4	Apply basic risk analysis and experiment design techniques into practical cases
CO5	Demonstrate knowledge about Six sigma, Design of Experiments

MAPPING OF COs WITH POs												
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	1		1		1				1		1	
CO2	1	1		1					1			
CO3		1			1				1		1	
CO4	1		1						1		1	
CO5		1			1				1		1	

QUESTION PAPER PATTERN (SEE)										
Q. No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
UNIT	1		2		3		4		5	
1. Two full questions (each of 20 Marks) are to be set from each unit.										
2. Student shall answer five full questions selecting one full question from each unit.										

ADMISSION YEAR : 2021-22 ACADEMIC YEAR: 2021-22
SEMESTER : FIRST

COURSE TITLE : COMPUTER AIDED ENGINEERING DEIGN WORK TOOL -LAB		
Sub Code: 20MMDL17	**No of Credits : L-T-P-SS 0:0:3:0 =2**	**No. of lecture hours/week :03**
Exam Duration : 3 hours	**CIE Marks: 50**	**SEE Marks : 50**

COURSE OBJECTIVES:

1. The objective of this lab is to acquaintance students with knowledge in the interface of 3-D software and to make students efficient to produce CAED designs.
2. By the end of course one should also be able to understand what a machine drawing is and will also be able to produce machine drawings.
3. To gain knowledge about all symbols used in production drawings and how they are inserted in production drawings using design software's.

PART –A **COMPUTER AIDED ENGINEERING DESIGN- CAED BASICS**		Hours
1	Introduction about CAED and different workbenches in it.	4
2	Interface, Sketch Tools, View Tool bar, Profile Tool bar, Operation Tool bar, Tools , Constrain tool bar, Transformation Tool bar, User Selection Filter,.	4
3	Sketch Based Features, Dress up Features, Transformation Features, Reference Elements, Measure, Thickness, Boolean Operations.	4
4	Walls, Cutting and Stamping, Bending, Rolled Walls	4
5	Visualizations Surface, Operations	4
6	Wireframe, Replication. Standards Product Structure Tools, Constrains	4
PART –B **DESIGN AND DEVELOPMENT OF A PRODUCT USING CAD WORK TOOL**		Hours
1	Introduction to Geometric Dimensioning and Tolerance, Weld Symbols, GD&T Symbols, Types of Tolerances, Types of views, Roughness Symbols	4
2	Views, Annotations, Sheet Background.	4
3	Design of any two types of Aircraft structures	4
4	Design of fuselage with internal components	4
5	Design of Nose cone structures	4
6	Design of Main landing gear and nose landing gear	6

TEXT BOOKS:

1. 3D Modelling and practices , Engineering , Prof P. Krishnakumar
2. Introduction to CATIA V5 Release 19, Book by Kirstie Plantenberg
3. CATIA V5 Design Fundamentals Jaecheol Koh

REFERENCE BOOKS:

1. CATIA V5 Workbook Release 19, **Book by Richard Cozzens**

COURSE OUTCOMES: After the completion of this course, student will be able to:

CO1	Understand the concepts and various tools used in design module.

CO2	Understand the design of typical structural components
CO3	Understand the techniques and standards of designing a component in CAD Software
CO4	Understand the design of three view diagram of a typical aircraft.
CO5	Analyze and evaluate CAD models

MAPPING OF COs WITH POs												
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	1	1			1				1			
CO2		1		1	1				1		1	
CO3	1		1		1						1	
CO4	1		1		1				1			
CO5	1		1						1		1	

CONTINOUS INTERNAL EVALUATION (CIE)	
Evaluation of lab manual	30 Marks
Internal evaluation	10 Marks
Viva-voce	10 Marks
Total	50 Marks

SEMESTER END EXAMINATION (SEE)					
Sl. No.	**Particulars**	**Max. Marks**	**Break Up of Max. Marks**		
			Write Up	**MODELLING**	**ANALYSIS**
1	PART -A	**15**	05	05	05
2	PART-B	**25**	05	10	10
3	Viva Voce	**10**	--	--	--
TOTAL MARKS		**50**	**10**	**25**	**15**

- Two Full Questions to be set.
- Students shall be to be answered two full Questions.
- Each question(Experiments contains different Marks and it is clearly mentioned in the above table)
- Changing of Experiments is not allowed from any unit
- Viva Voce is compulsory

ADMISSION YEAR : 2021-22 **ACADEMIC YEAR: 2021-22**
SEMESTER : FIRST

COURSE TITLE: TECHANICAL SEMINAR		
Sub Code: 20MMDS18	**No of Credits : L-T-P-SS 0:0:2:0=02**	**No. of Lecture hours/week :**

Exam Duration: 3Hrs.	**CIE Marks: 50**	

COURSE OBJECTIVES:

1. Exposure of students to a variety of research projects and activities in order to enrich their academic experience.
2. An opportunity for students to develop skills in presentation and discussion of research topics in a public forum.
3. To identify good journals and journal papers; study the papers and understand, analyze, interpret and explain the contents of the paper.

GUIDELINES
1.Each student, under the guidance of a Faculty, is required to • Choose, preferably through peer reviewed journals, a recent topic of his/her interest relevant to the Course of Specialization. • Carryout literature survey, organize the Course topics in a systematic order. • Prepare the report with own sentences. • Type the matter to acquaint with the use of Micro-soft equation and drawing tools or any such facilities. • Present the seminar topic orally and/or through power point slides. • Answer the queries and involve in debate/discussion. • Submit two copies of the typed report with a list of references. 2. All students should attend the seminars of other students of their specialization.
SCHEME FOR CONTINUOUS INTERNAL EVALUATION (CIE)
Each presentation shall be evaluated for 50 marks. Average marks obtained for three best presentations will be the student's CIE marks. **Marks distribution** Seminar Report: 20 marks Presentation skill:20 marks Question and Answer:10 marks

COURSE OUTCOMES: After the completion of this course, student will be able to:

CO1	To identify good journals and journal papers
CO2	study the papers and understand, analyze, interpret and explain the contents of the paper

CO3	understand the shortcomings and plus points of published papers
CO4	To develop overall skills for technical communication and help technical decision making.
CO5	To understand the latest research in their field of study

MAPPING OF COs WITH POs												
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	1			1					1		1	
CO2	1		1						1			
CO3	1			1					1		1	
CO4		1		1	1				1			
CO5	1			1					1			1
High-3 Medium-2 Low-1												

ADMISSION YEAR : 2021-22 ACADEMIC YEAR: 2021-22

SEMESTER : FIRST

COURSE TITLE: INDUSTRY VISIT

Sub Code: 20MMDM19	No of Credits : L-T-P-SS 0:0:0:2=02	No. of Lecture hours/week : --------
	CIE Marks: 50	

COURSE OBJECTIVES:

1. An opportunity to get exposure to the real workstations, plants, machines and systems.
2. to understand the end-to-end process at all levels
3. to understand the company policies in terms of production, quality, and service management.
4. Expert briefing about the functioning of machines and systems.

GUIDELINES

1. Iindustrial visit shall be arranged according to the academic requirements and as per the norms of the college.
2. HOD must certify that the tour is required for the students or is related to their curriculum.
3. The visiting companies shall be relevant and suitable ones to the specialization and academic requirements.
4. Industrial visit shall fall within the stipulated period set by the college.
5. The stipulated period shall be informed to the Faculty in-charge and Students through HOD well in advance to enable go through a diligent process including communicating to the potential companies and obtaining permission to visit.
6. The entire plan including permission letter from the visiting companies, permission letter, route map, list of students with their contact no. (Preferably mobile phone), list of faculty with their contact details, undertaking letter from student and parent and permit shall be available in the file and be checked by HOD.
7. The bus shall carry a banner exhibiting the college name and Industrial Visit.
8. Students must carry security ID cards with details of their parents or local guardians and their contact numbers.
9. Participating students must be given an undertaking that they will abide by the rules and guidelines throughout the tour.

SCHEME FOR CONTINUOUS INTERNAL EVALUATION (CIE)

CIE marks for the Industrial visit report (30 marks), seminar (10 marks) and viva voce (10 marks) shall be awarded (based on the quality of report and presentation skill, participation in the question and answer session by the student) by the committee constituted for the purpose by the Head of the Department, The committee shall consist of three faculty from the department.

COURSE OUTCOMES: After the completion of this course, student will be able to:

CO1	Students' exposure to industrial environments and experiences is undeniably one way for students to appreciate their theoretical learning to a more practical learning.
CO2	Acquaint Students with Interesting Facts and Newer Technologies.
CO3	Using the case study approach within the visit brings out critical thinking among students.
CO4	Practical application of instruments handled during course curriculum.
CO5	Students Aware with Industry Practices.

MAPPING OF COs WITH POs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1		1				1		1		1	1
CO2		1	1		1				1			
CO3	1		1		1				1		1	
CO4		1	1		1		1				1	
CO5	1		1		1						1	
High-3 Medium-2 Low-1												

ADMISSION YEAR : 2021-22 **ACADEMIC YEAR: 2021-22**
SEMESTER : SECOND

COURSE TITLE:ADVANCED THEORY OF VIBRATIONS

Sub Code: 20MMD21	No of Credits : L-T-P-SS 3:0:0:0=3	No. of Lecture hours/week :04
Exam Duration:3 hours	CIE Marks: 50	SEE Marks: 50

COURSE OBJECTIVES:

1. To acquainting the learners the importance of vibrations in design of machine parts subject to vibrations.
2. To explore the concepts of transient and Non-linear vibrations.
3. To acquire the skill of vibration measurements and its applications.
4. To evaluate the results of Transient and Nonlinear vibrations.

#	CONTENTS	Hrs
UNIT-1	**Review of Mechanical Vibrations:** Basic concepts; free vibration of single degree of freedom systems with and without damping, forced vibration of single DOF-systems, Natural frequency. Transient Vibration of single Degree-of freedom systems: Impulse excitation, Arbitrary excitation.	**11**
UNIT-2	**Vibration Control:** Introduction, Vibration isolation theory, Vibration isolation and motion isolation for harmonic excitation, practical aspects of vibration analysis, shock isolation, Dynamic vibration absorbers, and Vibration dampers. Vibration Measurement and applications: Introduction, Transducers, Vibration pickups, Frequency measuring instruments, Vibration exciters, Signal analysis.	**11**
UNIT-3	**Modal analysis:** Dynamic Testing of machines and Structures, Experimental Modal analysis. **Vibrations of beams:** equation of motion, modal analysis, approximate methods, initial value problem, forced vibrations, special problems, wave propagation Vibrations of membranes: equations of motion, modal analysis, and approximate methods. **Vibrations of plates:** equations of motion, modal analysis, approximate methods.	**10**
UNIT-4	**Random Vibrations :** Random phenomena, Time averaging and expected value, Frequency response function, Probability distribution, Correlation, Power spectrum and power spectral density, Fourier transforms, FTs and response.	**10**
UNIT-5	**Signature analysis** and preventive maintenance, Vibration testing equipment, signal generation, measuring and conditioning instruments. **Vibration testing equipment:** Signal analysis instruments, Vibration signatures and standards.	**10**

TEXT BOOKS:

1. S. S. Rao, “ Mechanical Vibrations” , Pearson Education,4TH Edition.
2. S. Graham Kelly,“ Fundamentals of Mechanical Vibration” -McGraw-Hill, 2000 .

REFERENCES BOOKS:

1. Mechanical Vibrations, S. Graham Kelly, Schaum's Outlines, Tata McGraw Hill, 2007.ISBN-10:
2. 1439062129
3. Theory of Vibration with Application, William T. Thomson, Marie Dillon Dahleh, Prentice Hall
4. Edition, ISBN, 0748743804, 2011
5. Vibrations & Acoustics, Sujatha, Tata McGraw Hill Edition, ISBN: 9780070148789, 2013
6. Mechanical Vibrations, S.S.Rao, Pearson Education, 4th ed., ISBN 978-0-13-212819-3, 2012

COURSE OUTCOMES: After the completion of this course, student will be able to:

CO1	Construct Equations of motion based on free body diagrams
CO2	Analyse systems under free and forced vibrations for natural frequency of vibration.
CO3	Evaluate Mechanical Systems are using modal analysis.
CO4	Develop solutions through testing for vibrations and signature analysis techniques.
CO5	Apply the fundamentals of vibration to its measurement and Analysis.

MAPPING OF COs WITH POs												
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	1									1		1
CO2		1			1				1		1	
CO3	1		1									
CO4	1			1						1		1
CO5		1				1					1	1
High-3 Medium-2 Low-1												

QUESTION PAPER PATTERN (SEE)										
Q. No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
UNIT	1		2		3		4		5	
1. Two full questions (each of 20 Marks) are to be set from each unit.										
2. Student shall answer five full questions selecting one full question from each unit.										

ADMISSION YEAR : 2021-22 ACADEMIC YEAR: 2021-22
SEMESTER : SECOND

COURSE TITLE:DESIGN FOR FATIGUE LOADING		
Sub Code: 20MMD22	**No of Credits : L-T-P-SS 3:0:0:0=3**	**No. of Lecture hours/week :04**
Exam Duration:3 hours	**CIE Marks: 50**	**SEE Marks: 50**

COURSE OBJECTIVES:

1. To identify failure modes and evolve design by analysis methodology.
2. To understand the concept of fatigue testing of materials including criteria for fatigue design and different fatigue life models.
3. To understand the concept of crack nucleation, crack growth and fracture of materials using fundamentals of linear elastic fracture mechanics.
4. To understand the different surface failure mechanisms with stress distribution of various contact surfaces.

#	CONTENTS	Hrs
UNIT-1	**Introduction:** Role of failure prevention analysis in mechanical design, Modes of mechanical failure, Review of failure theories for ductile and brittle materials including Mohr's theory and modified Mohr's theory, Numerical examples. Fatigue of Materials: Introductory concepts, High cycle and low cycle fatigue, Fatigue design models, Fatigue design methods ,Fatigue design criteria, Fatigue testing, Test methods and standard test specimens, Fatigue fracture surfaces and macroscopic features, Fatigue mechanisms and microscopic features	11
UNIT-2	**Stress-Life (S-N) Approach:** S-N curves, the statistical nature of fatigue test data, General S-N behaviour, Mean stress effects, Different factors influencing S-N behaviour, S-N curve representation and approximations, Constant life diagrams, Fatigue life estimation using SN approach. Strain-Life(ε- N)approach: Monotonic stress-strain behaviour ,Strain controlled test methods, Cyclic stress-strain behaviour, Strain based approach to life estimation, Determination of strain life fatigue properties,Mean stress effects, Effect of surface finish, Life estimation by ε-N approach.	11
UNIT-3	**LEFM Approach**: LEFM concepts, Crack tip plastic zone, Fracture toughness, Fatigue crack growth, Mean stress effects, Crack growth life estimation. Notches and their effects: Concentrations and gradients in stress and strain, S-N approach for notched membranes, mean 30 stress effects and Haigh diagrams, Notch strain analysis and the strain – life approach, Neuber's rule, Glinka's rule, and applications of fracture mechanics to crack growth at notches.	10
UNIT-4	**Fatigue from Variable Amplitude Loading:** Spectrum loads and cumulative damage, Damage quantification and the concepts of damage fraction and accumulation, Cumulative damage theories, Load interaction and sequence effects, Cycle counting methods, Life estimation using stress life approach.	10
UNIT-5	**Surface Failure:** Introduction, Surface geometry, Mating surface, Friction, Adhesive wear, Abrasive wear, Corrosive wear, Surface fatigue spherical contact, Cylindrical contact, General contact, Dynamic contact stresses, Surface fatigue strength.	10

TEXT BOOKS:

1. RalphI. Stephens,Ali Fatemi, Robert, Henryo. Fuchs, “MetalFatiguein engineering” , John WileyNew York, Second edition. 2001.
2. FailureofMaterials in Mechanical Design, Jack.A. Collins,John Wiley,New York 1992.
3. RobertL.Norton , “ Machine Design” , Pearson EducationIndia, 2000.

REFERENCES BOOKS:

1. Metal Fatigue in engineering, Ralph I. Stephens, Ali Fatemi, Robert, Henry o. Fuchs, John wiley Newyork, Second edition. 2001. ISBN: 978-1-933489-67-4
2. Failure of Materials in Mechanical Design, Jack. A. Collins, John Wiley, Newyork 1992. ISBN: 988-3-955783-62-2
3. Machine Design, Robert L. Norton, Pearson Education India, 2000, ISBN 0-06-00849-3
4. Fatigue of Materials, S.Suresh, Cambridge University Press, -1998

COURSE OUTCOMES: After the completion of this course, student will be able to:

CO1	Distinguish different design criteria and their procedure to carry out the design of mechanical components.
CO2	Design machine components which are subjected to fluctuating loads.
CO3	Design machine components using techniques like stress life approach, Strain life approach and Fracture mechanics approach.
CO4	Define the various statistical aspects of fatigue using different probability distribution plots.
CO5	Explain the contact stresses and implementation of Hertz contact phenomenon to the real field problem.

MAPPING OF COs WITH POs												
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	1		1						1		1	
CO2	1	1		1		1				1		
CO3		1	1		1				1		1	
CO4	1			1	1					1	1	
CO5		1	1		1					1	1	
High-3 Medium-2 Low-1												

QUESTION PAPER PATTERN (SEE)										
Q. No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
UNIT	1		2		3		4		5	
1. Two full questions (each of 20 Marks) are to be set from each unit.										
2. Student shall answer five full questions selecting one full question from each unit.										

ADMISSION YEAR : 2021-22 **ACADEMIC YEAR: 2021-22**
SEMESTER : SECOND

COURSE TITLE: TRIBOLOGY & BEARING TECHONOLOGY		
Sub Code: 20MMD23	**No of Credits : L-T-P-SS 3:0:0:0=3**	**No. of Lecture hours/week :04**
Exam Duration:3 hours	**CIE Marks: 50**	**SEE MARKS:50**

COURSE OBJECTIVES:

1. To understand the fundamental principles of lubrication for reduction of friction and wear.
2. To understand the principles of hydrodynamic and hydrostatic lubrication and their design and applications.
3. To learn the computations required for selecting and designing bearings in machines.
4. To understand the factors influencing the design and selection of Porous and Magnetic bearings.

#	CONTENTS	Hrs
UNIT-1	**Introduction to Tribology:** Introduction, Friction, Wear, Wear Characterization, Regimes of lubrication, Classification of contacts, lubrication theories, Effect of pressure and temperature on viscosity. Newton's Law of viscous forces, Flow through stationary parallel plates. Hagen's poiseuille's theory, viscometers. Numerical problems, Concept of lightly loaded bearings, Petroff's equation, Numerical problems	**11**
UNIT-2	**Hydrodynamic Lubrications:** Pressure development mechanism. Converging and diverging films and pressure induced flow. Reynolds's 2D equation with assumptions. Introduction to idealized slide bearing with fixed shoe and Pivoted shoes. Expression for load carrying capacity. Location of center of pressure, effect of end leakage on performance, Numerical problems. **Journal Bearings:** Introduction to idealized full journal bearings. Load carrying capacity of idealized full journal bearings, Somerfield number and its significance, partial bearings, Comparison between lightly loaded and heavily loaded bearings, effects of end leakage on performance, Numerical problems.	**11**
UNIT-3	**Hydrostatic Bearings:** Hydrostatic thrust bearings, hydrostatic circular pad, annular pad, rectangular pad bearings, expression for discharge, load carrying capacity and condition for minimum power loss, numerical problems **Antifriction bearings:** Advantages, selection, nominal life, static and dynamic load bearing capacity, probability of survival, equivalent load, cubic mean load, bearing mountings.	**10**
UNIT-4	**EHL Contacts:** Introduction to Elasto - hydrodynamic lubricated bearings. Introduction to 'EHL' constant. Grubin type solution. **Porous Bearings:** Introduction to porous and gas lubricated bearings. Governing differential equation for gas lubricated bearings, Equations for porous bearings and working principal, Fretting phenomenon and its stages.	**10**
UNIT-5	**Magnetic Bearings:** Introduction to magnetic bearings, Active magnetic bearings. Different equations used in magnetic bearings and working principal. Advantages and disadvantages of magnetic bearings,,Electrical analogy, Magneto-hydrodynamic bearings.	**10**

TEXT BOOKS:

1. Mujamdar.B.C "Introduction to Tribology of Bearing", Wheeler Publishing, New Delhi 2001
2. Radzimovsky, "Lubrication of Bearings - Theoretical principles and design" Oxford press organization 2000.

REFERENCES BOOKS:

1. Theory and practice of Lubrication for Engineers, Dudley D.Fuller, New YorkCompany.1998
2. Principles and applications of Tribology, Moore, Pergamon press, 1975
3. Engineering Tribology, G W Stachowiak, A W Batchelor, Elsevier publication 1993.
4. Lubrication of Bearings - Theoretical principles and design, Radzimovsky, Oxford press Company, 2000.

COURSE OUTCOMES: After the completion of this course, student will be able to:

CO1	Demonstrate fundamentals of tribology, lubricants and methods of lubrication
CO2	Analyze bearings for load carrying capacity, frictional force and power loss.
CO3	Illustrate the different modes of lubrication system for various applications.
CO4	Design the different bearing system such as antifriction bearings for various applications
CO5	Explain the concepts advanced bearings like magnetic bearings, porous bearings and gas lubricated bearings.

MAPPING OF COs WITH POs												
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	1		1			1			1		1	
CO2		1		1	1		1	1		1	1	
CO3	1		1	1					1		1	
CO4			1	1			1		1		1	
CO5												
High-3 Medium-2 Low-1												

QUESTION PAPER PATTERN (SEE)										
Q. No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
UNIT	1		2		3		4		5	
1. Two full questions (each of 20 Marks) are to be set from each unit.										
2. Student shall answer five full questions selecting one full question from each unit.										

ADMISSION YEAR : 2021-22 **ACADEMIC YEAR: 2021-22**
SEMESTER : SECOND

COURSE TITLE:FRACTURE MECHANICS		
Sub Code: 20MMD24	**No of Credits : L-T-P-SS 3:0:0:0=3**	**No. of Lecture hours/week :04**
Exam Duration:3 hours	**CIE Marks: 50**	**SEE MARKS:50**

COURSE OBJECTIVES:

1. To understand the design principle of materials and structures using fracture mechanics approaches.
2. To introduce the mathematical and physical principles of fracture mechanics and their applications to engineering design.
3. To develop the ability in students to compute the stress intensity factor, strain energy release rate and the stress and strain fields around a crack tip for linear and non linear materials.
4. To prepare the students for broader applications of fracture mechanics in material testing, evaluation, characterization, and material selection.

#	CONTENTS	Hrs
UNIT-1	**Fracture Mechanics Principles:** Introduction and historical review, sources of micro and macro cracks, stress concentration due to elliptical hole, strength ideal materials, Griffith's energy balance approach. Fracture mechanics approach to design. NDT and Various NDT methods used in fracture mechanics, numerical problems. The Airy stress function, complex stress function, solution to crack problems, effect of finite size, special cases, elliptical cracks, numerical problems.	**11**
UNIT-2	Plasticity effects, Irwin plastic zone correction, and Dugdale approach. The shape of the plastic zone for plane stress and plane strain cases, plastic constraint factor. The thickness effect, and numerical problems. **Determination of stress intensity factors and plane strain fracture toughness**: Introduction, analysis and numerical methods, experimental methods, estimation of stress intensity factors. **Plane strain fracture toughness test;** standard test, and specimen size requirements.	**11**
UNIT-3	The energy release rate, and criteria for crack growth. The crack resistance (R curve), compliance, J integral, tearing modulus and stability. **Elastic Plastic Fracture Mechanics (EPFM)**: Fracture beyond general yield. The crack-tip opening displacement, the use of CTOD criteria, and experimental determination of CTOD. Parameters affecting the critical CTOD, use of J integral, and limitation of J integral.	**10**
UNIT-4	**Dynamics and crack arrest:** Crack speed and kinetic energy. Dynamic stress intensity and elastic energy release rate. Crack branching. Principles of crack arrest. Crack arrest in practice. Dynamic fracture toughness.	**10**
UNIT-5	**Fatigue crack propagation and applications of fracture mechanics:** Crack growth and the stress intensity factor. Factors affecting crack propagation. Variable amplitude service loading, means to provide fail-safety, required information for fracture mechanics approach, mixed mode (combined) loading and design criteria.	**10**

TEXT BOOKS:

1. David Broek, “Elementary Engineering Fracture Mechanics”, Springer Netherlands,2011
2. Anderson , “Fracture Mechanics-Fundamental and Application”, T.L CRC press1998.

REFERENCES BOOKS:

5. Karen Hellan , “Introduction to fracture mechanics”, McGraw Hill, 2nd Edition.
6. S.A. Meguid , “Engineering fracture mechanics” Elsevier Applied Science, 1989.
7. Jayatilaka, “Fracture of Engineering Brittle Materials”, Applied Science Publishers, 1979.
8. Rolfe and Barsom , “Fracture and Fatigue Control in Structures” , Prentice Hall, 1977.
9. Knott , “Fundamentals of fracture mechanisms”, Butterworths, 1973.

COURSE OUTCOMES: After the completion of this course, student will be able to:

CO1	Develop basic fundamental understanding of the effects of crack like defects on the performance of aerospace, civil, and mechanical engineering structures.
CO2	Be able to select appropriate materials for engineering structures to insure damage tolerance.
CO3	Learn to employ modern numerical methods to determine critical crack sizes and fatigue crack propagation rates in engineering structures.
CO4	Understanding of experimental techniques to determine the critical values of parameters at crack tip.
CO5	Understand and appreciate of the status of academic research in field of fracture mechanics.

MAPPING OF COs WITH POs												
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	1	1		1					1		1	
CO2	1		1	1		1			1		1	
CO3	1		1	1	1				1		1	
CO4		1	1	1		1					1	
CO5	1	1		1	1						1	
High-3 Medium-2 Low-1												

QUESTION PAPER PATTERN (SEE)										
Q. No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
UNIT	1		2		3		4		5	
1. Two full questions (each of 20 Marks) are to be set from each unit.										
2. Student shall answer five full questions selecting one full question from each unit.										

ADMISSION YEAR : 2021-22 **ACADEMIC YEAR: 2021-22**
SEMESTER : SECOND

COURSE TITLE:ADVANCED SYSTEM DESIGN		
Sub Code: 20MMD251	**No of Credits : L-T-P-SS 3:0:0:0=3**	**No. of Lecture hours/week :04**
Exam Duration:3 hours	**CIE Marks: 50**	**SEE MARKS:50**

COURSE OBJECTIVES:

1. To understand the design principle of materials and structures using fracture mechanics approaches.
2. To introduce the mathematical and physical principles of fracture mechanics and their applications to engineering design.
3. To develop the ability in students to compute the stress intensity factor, strain energy release rate and the stress and strain fields around a crack tip for linear and nonlinear materials.
4. To prepare the students for broader applications of fracture mechanics in material testing, evaluation, characterization, and material selection.

#	CONTENTS	Hrs
UNIT-1	**INTRODUCTION**: What is designing, Man as a designer: Design by evolution, inadequacies of traditional design method: System approach of engineering problems: Need models: design history of large scale existing system. Morphology of Design: The three phases of design projects, the structure of design process, decision making and iteration.	**10**
UNIT-2	**IDENTIFICATION, NEED ANALYSIS &DESIGN CONCEPT:** Preliminary need statement, analysis of need, specifications, and standards of performance and constraints. Process of idealization, mental fixity, analysis, AIDA, brain storming etc.	**10**
UNIT-3	**PRELIMINARY DESIGN:** Mathematical modeling for functional design: concept of sensitivity, compatibility and stability analysis. Evaluation Of Alternatives And Design Decisions.	**10**
UNIT-4	**DESIGN TREE:** Quality of design, Concept of utility, multi criteria decisions, decisions under uncertainty and risk (Numerical), Bath tub curve, exponential reliability function, system reliability concept. (Numerical)	**10**
UNIT-5	**ECONOMICS AND OPTIMIZATION IN ENGINEERING DESIGN**: Economics in Engineering Design, Fixed and variable costs, break-even analysis. (Numerical) Optimization: Introduction to LPP. Man Machine Interaction, Designing for use and maintenance, Man-Machine Cycle, Design of displays and controls. Factors influencing displays and controls.	**12**

REFERENCES BOOKS:

1. Mechanical System Design by: W. E. Ederlecturer In Mechanical Engineering And'w. Gosling

2. Harrison Kim,Dept. of Industrial and Enterprise Systems Engineering (ISE) - 2 - 1. Papalambros, P.Y. and Wilde, D., Principles of Optimal Design (2nd Ed.), Cambridge University Press, New York, 2000. 2.

COURSE OUTCOMES: After the completion of this course, student will be able to:

CO1	Analyze the types of design and concepts
CO2	Applying the concept of need based design.
CO3	Implement preliminary design concept in real life.
CO4	Analyzing the process of design in the form of sequence of actions.
CO5	Implement economics during engineering Design and study Man-Machine Cycle.

MAPPING OF COs WITH POs												
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	1		1	1		1			1	1		
CO2	1	1	1			1			1		1	
CO3	1		1	1								1
CO4		1		1			1					
CO5	1				1	1		1		1		
High-3 Medium-2 Low-1												

QUESTION PAPER PATTERN (SEE)										
Q. No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
UNIT	1		2		3		4		5	
1. Two full questions (each of 20 Marks) are to be set from each unit.										
2. Student shall answer five full questions selecting one full question from each unit.										

ADMISSION YEAR : 2021-22 **ACADEMIC YEAR: 2021-22**
SEMESTER : SECOND

COURSE TITLE:AUTOMOBILE SYSTEM DESIGN		
Sub Code: 20MMD252	**No of Credits : L-T-P-SS 3:0:0:0=3**	**No. of Lecture hours/week :04**
Exam Duration:3 hours	**CIE Marks: 50**	**SEE MARKS:50**

COURSE OBJECTIVES:

1. To understand of the stages involved in automobile system design.
2. To expose the industrial practices in design of various systems of automobile.
3. To study importance and features of different systems like axle, differential, brakes, Steering, suspension, and balancing etc.
4. To study working of various Automobile Systems.

#	CONTENTS	Hrs
UNIT-1	**Body Shapes**: Aerodynamic Shapes, drag forces for small family cars. **Fuel Injection**: Spray formation, direct injection for single cylinder engines (both SI & CI), energy audit.	**10**
UNIT-2	**Design of I.C. Engine I:** Combustion fundamentals, combustion chamber design, cylinder head design for both SI & C. I. Engines.	**10**
UNIT-3	**Design of I.C. Engine II:** Design of crankshaft, camshaft, connecting rod, piston & piston rings for small family cars (max up to 3 cylinders).	**10**
UNIT-4	**Transmission System:** Design of transmission systems – gearbox (max of 4-speeds), differential. **Suspension System**: Vibration fundamentals, vibration analysis (single & two degree of freedom, vibration due to engine unbalance, application to vehicle suspension.	**10**
UNIT-5	**Cooling System**: Heat exchangers, application to design of cooling system (water cooled). **Emission Control**: Common emission control systems, measurement of missions, exhaust gas emission testing.	**12**

REFERENCES BOOKS:

1. **Mechanical System Design** by: W. E. Ederlecturer in Mechanical Engineering And'w. Gosling
2. Harrison Kim,Dept. of Industrial and Enterprise Systems Engineering (ISE) - 2 - 1. Papalambros, P.Y. and Wilde, D., **Principles of Optimal Design** (2nd Ed.), Cambridge University Press, New York, 2000. 2.

COURSE OUTCOMES: After the completion of this course, student will be able to:

CO1	Gain an insight into aspects of vehicle design, operation and maintenance, which will be useful for taking up a position in the automotive industry.
CO2	Apply the knowledge in creating a preliminary design of Automobile sub systems.
CO3	Identify construction, working, preventive maintenance, trouble shooting and diagnosis of various Automobile Systems.
CO4	Identify Modern technology and safety measures used in Automotive Vehicles.
CO5	Analyse the cooling and Emission control in automotive vehicles.

MAPPING OF COs WITH POs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1		1		1	1			1		1	
CO2		1		1		1				1	1	
CO3	1			1	1				1		1	
CO4	1		1		1				1		1	
CO5		1		1					1		1	
High-3 Medium-2 Low-1												

QUESTION PAPER PATTERN (SEE)

Q. No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
UNIT	1		2		3		4		5	
1. Two full questions (each of 20 Marks) are to be set from each unit.										
2. Student shall answer five full questions selecting one full question from each unit.										

ADMISSION YEAR : 2021-22 **ACADEMIC YEAR: 2021-22**
SEMESTER : SECOND

COURSE TITLE: DESIGN OF HYDRAULIC & PNEUMATIC SYSTEMS		
Sub Code: 20MMD253	**No of Credits : L-T-P-SS 3:0:0:0=3**	**No. of Lecture hours/week :04**
Exam Duration:3 hours	**CIE Marks: 50**	**SEE MARKS:50**

COURSE OBJECTIVES:

1. To understand of the stages involved in Hydraulic & Pneumatic design.
2. To expose the maintenance practices in various systems of hydraulics.
3. To study and analyze the hydraulic circuit design.
4. To study working of Pneumatic Systems.

#	CONTENTS	Hrs
UNIT-1	**Introduction to Hydraulic System**: Introduction, Basic hydraulic system, classification of hydraulic motors, hydraulic pumps, Performance of hydraulic motors, Hydraulic actuators, types of hydraulic actuators. **Control Components in Hydraulic Systems:** Introduction, Direction control valves, Solenoid actuated valve, Pilot operated valve, Rotary spool DCV, Pressure control valves, Hydraulic fuse, Flow control valve, graphic symbols.	**10**
UNIT-2	**Maintenance of Hydraulic Systems:** Prime function of hydraulic fluids, desirable properties of hydraulic fluids, general types of fluids, factors affecting the selection of fluids, sealing devices, reservoir systems, filters and strainers, heat exchangers, pressure switch, wear of moving parts, troubleshooting of hydraulic systems. Maintainance of Pumps	**10**
UNIT-3	**Hydraulic circuit Design and Analysis:** Control of a single acting cylinder, double acting cylinder, regenerative circuit, counter balance valve applications, Hydraulic cylinder sequencing circuits, automatic cylinder reciprocating systems, Locked cylinder using pilot check valves, cylinder synchronizing circuits, fail safe circuits..	**10**
UNIT-4	**Pneumatic Concepts:** Introduction, comparison of hydraulics/pneumatics/and electrical system, air compressor system, types of compressors, compressed air behavior, pneumatic actuators, direction control valves, building a pneumatic circuits, application of logic valves. **Design of Pneumatic Circuits:** Speed control circuits, Application of time delay valves. Position sensing in pneumatic cylinders, roller lever valve, pressure sensing in pneumatic circuits, pressure sequence valve, two cylinder movement, cascade method.	**10**
UNIT-5	**Electro-Pneumatics:** Introduction, Pilot operated solenoid valve, Electrical connection to the solenoid, Electro-pneumatic circuit, Electrical limit switches and proximity switches, Relays, Solenoid, PE converter, Concept of latching. **Servo System and PLC Applications in Pneumatics**: Closed loop control with servo system, Hydro- mechanical servo system, Electro-hydraulic servo system, Conventional valve vs proportional valve, Proportional valve in hydraulic circuits, characteristics of proportional valve and servo valve. PLC application in fluid power, logic in ladder logic diagram and Mnemonics, Timer- on delay and of delay.	**12**

REFERENCES BOOKS:

1. Introduction to Hydraulics and Pneumatics, S Ilango, V Soundararajan, PHI Publication, ISBN-978-
2. 81-203-3079-5.
3. Hydraulics and Pneumatics, Jagadeesha T, I K International Publication, ISBN: 978-93-84588-90-8
4. Introduction to fluid power, James L Johnson, Cengage Learning, First Edition 2003, ISBN- 981- 243-661-8
5. Hydraulic and pneumatic controls, R Srinivasan, Tata McGraw hill, second edition,2010 ISBN – 978-81-8209-138-2.

COURSE OUTCOMES: After the completion of this course, student will be able to:

CO1	Describe the constructional features of hydraulic and pneumatic components.
CO2	Apply hydraulic and pneumatic controls in the design of automated controls.
CO3	Evaluate the design of hydraulic and pneumatic components for building a circuit.
CO4	Design the hydraulic and pneumatic based systems for industrial applications.
CO5	Analyze the PLC applications in Pneumatics.

MAPPING OF COs WITH POs												
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	1		1			1			1		1	
CO2	1	1		1					1			1
CO3	1		1		1	1					1	
CO4		1	1	1			1				1	
CO5	1	1		1	1						1	
High-3 Medium-2 Low-1												

QUESTION PAPER PATTERN (SEE)										
Q. No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
UNIT	1		2		3		4		5	
1. Two full questions (each of 20 Marks) are to be set from each unit.										
2. Student shall answer five full questions selecting one full question from each unit.										

SEMESTER : SECOND

COURSE TITLE: ADVANCED FINITE ELEMENT ANALYSIS		
Sub Code: 20MMD254	**No of Credits : L-T-P-SS 3:0:0:0=3**	**No. of Lecture hours/week :04**
Exam Duration:3 hours	**CIE Marks: 50**	**SEE MARKS:50**

COURSE OBJECTIVES:

1. To understand of the stages involved in Hydraulic & Pneumatic design.
2. To expose the maintenance practices in various systems of hydraulics.
3. To study and analyze the hydraulic circuit design.
4. To study working of Pneumatic Systems.

#	CONTENTS	Hrs
UNIT-1	**Basics of Finite Element Analysis**: Shape function of the linear bar element, quadratic bar element, 2-D Constant strain triangular element, 2-D linear triangular element, 4 noded quadrilateral element, 9- noded quadrilateral element and scrindipidy elements. Stiffness, traction and body force equations for1-D 2 noded element, 2-D truss element, CST element and 4 noded quadrilateral elements and related problems.	**11**
UNIT-2	**Axisymmetric Solids**: Structures of Revolution, Axisymmetric Solid Iso-P Elements,Iso-P Quadrilateral Ring Elements, Benchmark Problems.A Complete Axisymmetric FEM Program. Axisymmetric Solid.	**11**
UNIT-3	**General Solids**: Solid Elements: Overview. The Linear Tetrahedron, The Quadratic Tetrahedron.The 8-Node Hexahedron. The 20-Node Hexahedron. Pyramid solid elements: a successful application of morphing.	**10**
UNIT-4	**Dynamic Analysis using Finite Element Method**: Introduction – vibrational problems – equations of motion based on weak form – longitudinal vibration of bars – transverse vibration of beams – consistent mass matrices – element equations –solution of eigenvalue problems – vector iteration methods – normal modes – transient vibrations – modeling of damping – mode superposition technique – direct integration methods.	**10**
UNIT-5	**Applications in Heat Transfer & Fluid Mechanics**: One dimensional heat transfer element –application to one-dimensional heat transfer problems- scalar variable problems in 2-Dimensions– Applications to heat transfer in 2- Dimension – Application to problems in fluid mechanics in 2-D	**10**

REFERENCES BOOKS:

1. Introduction to Finite Elements in Engineering, Chandrupatla T. R., and Belegundu, A.D., Prentice
2. Hall, 2003.
3. An Introduction to the Finite Element Method, Reddy, J. N. 3rd Edition, McGraw-Hill
4. Science/Engineering/Math, 2005.
5. The Finite Element Method in Engineering, S. S. Rao, Fifth Edition, Elsevier Publications.
6. Advanced Finite Element Methods and Applicatons, Thomas Apel and Olaf Steinbach, Springer
7. Publications, ISBN 978–3–642–30315–9, 2013

COURSE OUTCOMES: After the completion of this course, student will be able to:

CO1	Explain the fundamentals of finite element methods
CO2	Develop the knowledge to analyses, structures under static and dynamic conditions.
CO3	Selection of numerical techniques for solving engineering problems
CO4	Explore the use of finite element method knowledge to implement industrial project.
CO5	Analyze the applications of Finite Element Analysis in Heat transfer.

MAPPING OF COs WITH POs												
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	1	1		1					1		1	
CO2		1	1		1				1		1	
CO3	1		1		1						1	
CO4	1		1	1		1			1			
CO5	1		1			1					1	
High-3 Medium-2 Low-1												

QUESTION PAPER PATTERN (SEE)										
Q. No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
UNIT	1		2		3		4		5	
1. Two full questions (each of 20 Marks) are to be set from each unit.										
2. Student shall answer five full questions selecting one full question from each unit.										

ADMISSION YEAR : 2021-22 **ACADEMIC YEAR: 2021-22**

SEMESTER : SECOND

COURSE TITLE: PRESSURE VESSEL DESIGN		
Sub Code: 20MMD261	**No of Credits : L-T-P-SS**	**No. of Lecture hours/week :04**

	3:0:0:0=3	
Exam Duration:3 hours	**CIE Marks: 50**	**SEE Marks: 50**

COURSE OBJECTIVES:

1. Apply the principles of product design to modify existing engineering systems or to develop new artifacts.
2. Design a system taking into consideration the concepts of ease of production, maintenance, handling, installation etc.
3. Translate the concepts of economics in design, optimization of design and human factors approach to product design.

#	CONTENTS	Hrs
UNIT-1	**General Introduction:** 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.	**11**
UNIT-2	**Classical Theory Of Plates:** 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	**11**
UNIT-3	**Buckling Analysis of Rectangular Plates:** 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	**10**
UNIT-4	**Vibration of Plates:** 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.	**10**
UNIT-5	**Analysis of Thin Elastic Shells of Revolution:** 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.	**10**

REFERENCE BOOKS:

1. Theory and Analysis of Elastic Plates & Shells, Reddy,J.N., C.R.C. Press, NY, USA, 2nd Edition, ISBN 9780849384158

2. Theory and Analysis of Plates, Szilard, R., Prentice Hall Inc., 1999,ISBN 0-12-9353336-2

3. Theory of Plates and Shells, Timoshenko, S. and Krieger S.W, McGraw Hill Book Company, New York 1990, ISBN 0-13-913426-3
4. Stresses in shells, Wilhelm Flügge, Springer –Verlag, *ISBN* 978-3-662-01028-0.

COURSE OUTCOMES: After the completion of this course, student will be able to:

CO1	Review the equations of elasticity.
CO2	Apply the structural mechanics approximations of membrane, plates and shells.
CO3	Develop simple modifications to the membrane plate and shell theories.
CO4	Describe the static, dynamic, and non-linear motion of membrane, plate and shell structures.
CO5	Analyze numerical problems in shells of revolution.

MAPPING OF COs WITH POs												
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	1		1		1				1			
CO2		1	1		1				1		1	
CO3	1		1	1					1			
CO4	1	1		1							1	
CO5	1		1		1				1		1	

QUESTION PAPER PATTERN (SEE)										
Q. No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
UNIT	1		2		3		4		5	
1. Two full questions (each of 20 Marks) are to be set from each unit.										
2. Student shall answer five full questions selecting one full question from each unit.										

ADMISSION YEAR: 2021-22 **ACADEMIC YEAR: 2021-22**
SEMESTER : SECOND

COURSE TITLE: DESIGN FOR MANUFACTURE AND ASSEMBLY		
Sub Code: 20MMD262	**No of Credits : L-T-P-SS**	**No. of Lecture hours/week :04**

	3:0:0:0=3	
Exam Duration:3 hours	**CIE Marks: 50**	**SEE Marks: 50**

COURSE OBJECTIVES:

1. To understand various general design rules for manufacturability and criteria for material selection
2. To study various machining process and tolerance aspects in machining.
3. To know the design considerations for casting, forging and welding process.
4. To study the general design guidelines for manual assembly and development of DFMA Methodology.

#	CONTENTS	Hrs
UNIT-1	**Introduction to Design for Manufacture & Assembly:** Steps in DFMA, Advantages of DFMA, Design guidelines for Manual Assembly and High-Speed Automatic and Robotic Assembly. **Geometrical Dimensioning & Tolerance** – Dimensions & Tolerance, Limits, Fits and Tolerances, Hole and Shaft Basis, Three datum – functional, machining and manufacturing, geometrical and form tolerance, conventional and advanced tools and techniques for measurements, numerical.	**11**
UNIT-2	**Metal Casting Processes – Gravity Die Casting :** compute the dimensions for Pattern, Mould, based on materials to be cast – ferrous and non-ferrous alloys, influence of parting line, cast holes, special sand cores, shrinkage compensation, numericals, **Pressure Die Casting:** Die casting alloys, machine selection,operation, sub-systems, post-processing equipments, mould design, number of cavities, manufacturing and assembly of moulds, design principles.	**11**
UNIT-3	**Design for Injection Molding –** Injection moulding systems – injection subsystem, ejection system, clamping and feeding system, machine sizing, materials for injection moulding and its properties, injection mould design – cavity and core, manufacturing processes for moulds, operation and cycle time.	**10**
UNIT-4	**Design for Powder Metallurgy Processes**: Introduction to PM process, blending and mixing, compaction, sintering processes. Tooling materials, heat treatment, surface treatments and preparation of green compacts, Press tools for PM process – load, tooling layout, capacity; sintering furnace and influence of process and materials parameters on shrinkage.	**10**
UNIT-5	**Design for Sheet Metal Processing:** Design of moulds for shearing, piercing, bending, deep drawing, progressive die operation, selection of press – hydraulic and electric, sub-systems, turret operation, cycle time calculation, laser cutting of sheet metals. **Cost Estimation** for sand casting, pressure die casting, injection moulding, PM process and sheet metal processes.	**10**

REFERENCE BOOKS:

1. A.K. Chitale and R. C. Gupta, Product Design and Manufacturing, PHI 2007.

2. G.Boothroyd, P.Dewhurst and W.Knight, Product Design for Manufacture and Assembly, Marcell Dekker, 2002.
3. R.Bryan , Fischer, Mechanical Tolerance stackup and analysis, Marcell Dekker, 2004.

4. M. F. Spotts, Dimensioning and Tolerance for Quantity Production, Prentice Hall Inc., 1999.

COURSE OUTCOMES: After the completion of this course, student will be able to:

CO1	Explain the concept of DFMA and GD&NT.
CO2	Apply engineering products and suggest suitable manufacturing process.
CO3	Evaluate the influence of design, material and manufacturing processes on product assembly.
CO4	Develop appropriate manufacturing and assembly processes for a given product.
CO5	Analyze cost estimation of various metal processes.

MAPPING OF COs WITH POs												
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	1		1	1					1		1	
CO2		1	1					1			1	
CO3	1		1		1				1		1	
CO4	1		1	1					1			
CO5	1			1	1				1		1	

QUESTION PAPER PATTERN (SEE)										
Q. No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
UNIT	1		2		3		4		5	
1. Two full questions (each of 20 Marks) are to be set from each unit.										
2. Student shall answer five full questions selecting one full question from each unit.										

ADMISSION YEAR : 2021-22 **ACADEMIC YEAR: 2021-22**
SEMESTER : SECOND

COURSE TITLE : SMART MATERIALS AND STRUCTURES		
Sub Code: 20MMD263	**No of Credits : L-T-P-SS 3:0:0:0 =3**	**No. of lecture hours/week :04**
Exam Duration : 3 hours	**CIE Marks: 50**	**SEE Marks: 50**

COURSE OBJECTIVES:

1. To study the basic sources of smart materials and structures.
2. To acquaint with the effects of Shape memory Alloy, ER and MR fluids.
3. To study the usefulness of vibration absorbers and control of structures.
4. To gain knowledge of MEMS and devices.

#	CONTENTS	Hrs
UNIT-1	**SMART STRUCTURES**: Types of Smart Structures, Potential Feasibility of Smart Structures, Key Elements Of Smart Structures, Applications of Smart Structures. Piezoelectric materials, Properties, piezoelectric Constitutive Relations, Depoling and Coercive Field, field strain relation. Hysteresis, Creep and Strain Rate effects, Inchworm Linear Motor.	11
UNIT-2	**BEAM MODELING:** Beam Modeling with induced strain Rate effects, Inchworm Linear Motor Beam Modeling with induced strain Actuation-single Actuators, dual Actuators, Pure Extension, Pure Bending harmonic excitation, Bernoulli-Euler beam Model, problems, Piezoelectric Applications.	11
UNIT-3	**SHAPE MEMORY ALLOY:** Experimental Phenomenology, Shape Memory Effect, Phase Transformation, Tanaka's Constitutive Model, testing of SMA Wires, Vibration Control through SMA, Multiplexing. Applications Of SMA and Problems. **ER and MR Fluids:** Mechanisms and properties, Fluid Composition and behavior, The Bingham Plastic and Related Models, Pre-Yield Response. Post-Yield flow applications in Clutches, Dampers and Others	10
UNIT-4	**VIBRATION ABSORBERS:** series and Parallel Damped Vibrations (Overview), Active Vibration Absorbers, Fiber Optics, Physical Phenomena. Characteristics, Sensors, Fiber Optics in Crack Detection, applications. **Control of Structures:** Modeling, Control Strategies and Limitations, Active Structures in Practice.	10
UNIT-5	**MEMS** – Mechanical Properties of MEMS Materials, Scaling of Mechanical Systems, Fundamentals of Theory, The Intrinsic Characteristics of MEMS, Miniaturization, Microelectronics Integration. **Devices:** Sensors and Actuators, Conductivity of Semiconductors, Crystal Planes and Orientation, (Stress and Strain Relations, Flexural Beam Bending Analysis Under Simple Loading Conditions), Polymers in MEMS, Optical MEMS Applications.	10

TEXT BOOKS:

1. Smart Materials and Structures -M. V. Gandhi and B.SoThompson, Chapman and Hall, London; New York, 1992 (ISBN: 0412370107).
2. Smart Structures and Materials - B.Culshaw, Artech House, Boston, 1996 (ISBN :0890066817).
3. Smart Structures:Analysis & Design - A. V.Srinivasan, Cambridge University Press, Cambridge; New York, 2001 (ISBN: 0521650267).

REFERENCE BOOKS:

1. Electroceramics: Materials, Properties and Applications - A. J. Moulson and J. M. Herbert. John Wiley & Sons, ISBN: 0471497429
2. Piezoelectric Sensories: Force, Strain, Pressure, Acceleration and Acoustic Emission Sensors. Materials and Amplifiers, Springer, Berlin; New York, 2002 (ISBN: 3540422595).
3. Piezoelectric Actuators and Wtrasonic Motors -K.Uchino, Kluwer Academic Publishers, Boston, 1997 (ISBN: 0792398114).

COURSE OUTCOME: At the completion of this course, students will be able to:

CO1	Understand the behaviour and applicability of various smart materials.
CO2	Design Simple models for smart structures and materials.
CO3	Understanding the concepts of shape memory, ER and MR fluids and their characteristics.
CO4	To get knowledge about vibration absorbers and controlling of structures.
CO5	The fundamentals of MEMS and their intrinsic characteristics and devices.

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1		1		1	1				1		1	
CO2	1	1	1		1				1			
CO3		1		1	1						1	
CO4	1	1			1				1			
CO5	1		1		1						1	

QUESTION PAPER PATTERN (SEE)										
Q. No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
UNIT	1		2		3		4		5	
1. Two full questions (each of 20 Marks) are to be set from each unit.										
2. Student shall answer five full questions selecting one full question from each unit.										

ADMISSION YEAR : 2021-22 **ACADEMIC YEAR: 2021-22**
SEMESTER : SECOND

COURSE TITLE: INDUSTRIAL AUTOMATION AND ROBOTICS		
Sub Code: 20MMD264	**No of Credits : L-T-P-SS 3:0:0:0=3**	**No. of Lecture hours/week :04**
Exam Duration:3 hours	**CIE Marks: 50**	**SEE Marks: 50**

COURSE OBJECTIVES:

1. To develop the student's knowledge in various robot structures and their workspace.
2. To develop student's skills in perform kinematics analysis of robot systems.
3. To provide the student with some knowledge and analysis skills associated with trajectory planning.
4. To provide the student with some knowledge and skills associated with robot control and automation.

#	CONTENTS	Hrs
UNIT-1	**Automation and Robotics -** Historical Development, Definitions, Basic Structure of Robots, Robot Anatomy, Complete Classification of Robots, Fundamentals about Robot Technology, Factors related to use Robot Performance, Basic Robot Configurations and their Relative Merits and Demerits, Types of Drive Systems and their Relative Merits, the Wrist & Gripper Subassemblies. Concepts and Model about Basic Control System, Control Loops of Robotic Systems, PTP and CP Trajectory Planning, Control Approaches of Robots	**11**
UNIT-2	**Kinematics of Robot Manipulator**: Introduction, General Description of Robot Manipulator, Mathematical Preliminaries on Vectors & Matrices, Homogenous Representation of Objects, Robotic Manipulator Joint Co-Ordinate System, Euler Angle & Euler Transformations, Roll-Pitch-Yaw(RPY) Transformation, Relative Transformation, Direct & Inverse Kinematics' Solution, D H Representation & Displacement Matrices for Standard Configurations, Geometrical Approach to Inverse Kinematics. Homogeneous Robotic Differential Transformation: Introduction, Jacobian Transformation in Robotic Manipulation	**11**
UNIT-3	**Robotic Workspace & Motion Trajectory**: Introduction, General Structures of Robotic Workspaces, Manipulations with n Revolute Joints, Robotic Workspace Performance Index, Extreme Reaches of Robotic Hands, Robotic Task Description. Robotic Motion Trajectory Design: – Introduction, Trajectory Interpolators, Basic Structure of Trajectory Interpolators, Cubic Joint Trajectories. General Design Consideration on Trajectories: 4-3-4 & 3-5-3 Trajectories, Admissible Motion Trajectories.	**10**
UNIT-4	**Dynamics of Robotic Manipulators**: Introduction, Bond Graph Modeling of Robotic Manipulators, Examples of Bond Graph Dynamic Modeling of Robotic Manipulator. Brief Discussion on Lagrange–Euler (LE) Dynamic Modeling of Robotic Manipulators: - Preliminary Definitions, Generalized Robotic Coordinates, Dynamic Constraints, Velocity & Acceleration of Moving Frames, Robotic Mass Distribution & Inertia Tensors, Newton's Equation, Euler Equations, The Lagrangian& Lagrange's Equations. Application of Lagrange–Euler (LE) Dynamic Modeling of Robotic Manipulators: - Velocity of Joints, Kinetic Energy T of Arm, Potential Energy V of Robotic Arm, The Lagrange L, Two Link Robotic Dynamics with Distributed Mass,	**10**

	Dynamic Equations of Motion for A General Six Axis Manipulator.	
UNIT-5	**Autonomous Robot**: Locomotion Introduction, Key issues for locomotion Legged Mobile Robots Leg configurations and stability Examples of legged robot locomotion Wheeled Mobile Robots Wheeled locomotion: the design space Wheeled locomotion: case studies Mobile Robot Kinematics Introduction Kinematic Models and Constraints Representing robot position Forward kinematic models Wheel kinematic constraints Robot kinematic constraints, Mobile Robot manoeuvrability Degree of mobility Degree of steerability Robot manoeuvrability.	**10**

REFERENCE BOOKS:

1. A Robot Engineering Textbook, Mohsen Shahinpoor, Harper & Row publishers, New York. ISBN:006045931X
2. Robotics, control vision and intelligence, Fu, Lee and Gonzalez, McGraw Hill International. ISBN:0070226253
3. Introduction to Robotics, John J. Craig, Addison Wesley Publishing, ISBN:0201543613

4. Autonomous mobile robots, Roland Illah R. Siegwart Nourbakhsh, The MIT Press Cambridge, Massachusetts London, England, 2004.ISBN:0262015358

COURSE OUTCOMES: After the completion of this course, student will be able to:

CO1	Analyze the manipulator design including actuator, drive and sensor issues.
CO2	Calculate the forward kinematics, inverse kinematics and jacobian industrial robots.
CO3	Solve trajectory and dynamic related robotic problems.
CO4	Evaluate the different configurations and stability of autonomous robots.
CO5	Understand the concept of autonomous robot.

MAPPING OF COs WITH POs												
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1		1		1	1				1		1	
CO2	1	1	1		1				1			
CO3		1		1	1						1	
CO4	1	1			1				1			
CO5	1		1		1						1	

QUESTION PAPER PATTERN (SEE)										
Q. No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
UNIT	1		2		3		4		5	
1. Two full questions (each of 20 Marks) are to be set from each unit.										
2. Student shall answer five full questions selecting one full question from each unit.										

ADMISSION YEAR : 2021-22 **ACADEMIC YEAR: 2021-22**
SEMESTER : SECOND

COURSE TITLE: ANALYSIS LAB		
Sub Code: 20MMDL28	**No of Credits : L-T-P-SS 0:0:3:0=2**	**No. of Lecture hours/week :03**
Exam Duration:3 hours	**CIE Marks: 50**	**SEE Marks: 50**

COURSE OBJECTIVES:

1. To be able to understand and handle design problems in systematic manner
2. To gain practical experience in 2D drafting and 3D modeling software systems.
3. To be able to apply CAD in real life applications.
4. To be able to understand various software used to solve the practical problems.

PART	CONTENTS	Hrs.
A	**I. Study of a FEA package and modelling stress analysis of** ➢ Bars of constant cross section area and stepped bar ➢ Trusses- (Minimum 6 exercises) ➢ Beams - Simply supported, cantilevr. beams with UDL, beams with varying load.etc (Minimum 10 exercises) .	**02** **08** **10**
B	**I. Thermal Analysis** - 2D problem with conduction and convection boundary conditions (Minimum 4 exercises) **II. Fluid flow Analysis** - Potential distribution in the 2 - D bodies **III. Dynamic Analysis** ➢ Fixed- fixed beam for natural frequency determination ➢ Bar subjected to forcing function ➢ Fixed- fixed beam subjected to forcing function	**6** **4** **12**

REFERENCE BOOKS:

1. **ANSYS Workbench Tutorial Release 14,** Structural and Thermal Analysis Using Ansys
2. Mechanical APDL Release 14 Environment, Kent Lawrence, Schroff Development Corporation,
3. Website: www.SDCpublications.com
4. **Practical Finite Element Analysis,** Nitin S. Gokhale, Sanjay S. Despande, Dr. Anand N. Thite,

COURSE OUTCOMES: After the completion of this course, student will be able to:

CO1	Apply basics of theory of elasticity to continuum problems.
CO2	Formulate finite elements like bar, truss and beam elements for linear static Structural analysis.
CO3	Formulate 2d and axis-Symmetric finite elements.
CO4	Develop finite element equations for 1d heat transfer elements and solve Numerical.
CO5	Apply finite element simulation tool to solve practical problems (lab and Self-study).

MAPPING OF COs WITH POs												
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	1	1		1					1			
CO2	1	1		1							1	
CO3	1		1	1					1			
CO4		1		1	1				1		1	
CO5	1			1	1				1			

SCHEME FOR CONTINOUS INTERNAL EVALUATION (CIE)	
Evaluation of lab manual	30 Marks
Internal evaluation	10 Marks
Viva-voce	10 Marks
Total	**50 Marks**

SEMESTER END EXAMINATION (SEE)					
Sl. No.	**Particulars**	**Max. Marks**	**Break Up of Max. Marks**		
			Write Up	**MODELLING**	**ANALYSIS**
1	PART -A	**15**	05	05	05
2	PART-B	**25**	05	10	10
3	Viva Voce	**10**	--	--	--
TOTAL MARKS		**50**	**10**	**25**	**15**

- Two Full Questions to be set.
- Students shall be to be answered two full Questions.
- Each question(Experiments contains different Marks and it is clearly mentioned in the above table)
- Changing of Experiments is not allowed from any unit
- Viva Voce is compulsory

ADMISSION YEAR : 2021-22 **ACADEMIC YEAR: 2021-22**
SEMESTER : SECOND

COURSE TITLE: PROJECT WORK PHASE -I		
Sub Code: 20MMDP29	**No of Credits : L-T-P-SS 0:0:0:12=06**	**No. of Lecture hours/week : -----**
Exam Duration:---------	**CIE Marks: 50**	**SEE Marks :---------**

COURSE OBJECTIVES:

1. Support independent learning.
2. A aim of identifying a problem in the area relevant to the program.
3. To formulate a research problem in the area relevant to the program
4. Guide to organize the work in the appropriate manner and present information (acknowledging the sources) clearly.

GUIDELINES
1. The Project Work will start in Third semester and should preferably be a problem with research potential and should involve scientific research, design, generation/collection and analysis of data, determining solution and must preferably bring out the individual contribution. **2.** The students are required to take up a project work relevant to the course, which involves ➢ Introduction ➢ literature review ➢ problem formulation ➢ methodology ➢ analysis of results and discussion ➢ future scope and conclusion **3.** The candidate has to be in regular contact with his guide and the topic of dissertation must be mutually decided by the guide and student. **4.** Extensive survey should be based on the area of specialization in which the candidate wish to do the dissertation work. **5.** The student should prepare a report consisting of a detailed problem statement and a literature review. The preliminary results (if available) of the problem may also be discussed in the report. **6.** Present the seminar on the selected project through power point slides. **7.** The work has to be presented in front of the examiners panel set by Head of Department.
Scheme for Continuous Internal Evaluation (CIE) : CIE marks for the report (20 marks), seminar (20 marks) and question and answer session (10 marks) shall be awarded (based on the quality of report and presentation skill, participation in the question and answer session by the student) by the committee constituted for the purpose by the Head of the Department, The committee shall consist of three faculty from the department in the area of specialization.

COURSE OUTCOMES: After the completion of this course, student will be able to:

CO1	Demonstrate a sound technical knowledge of their selected project topic.
CO2	Will be able to identify a problem in the area relevant to the program through literature survey.
CO3	The candidate would have prepare a consolidated report of the problem formulation.
CO4	Design engineering solutions to complex problems utilising a systems approach.
CO5	Demonstrate the knowledge, skills and attitudes of a design engineer.

MAPPING OF COs WITH POs												
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	1		1		1				1		1	
CO2		1		1		1			1		1	
CO3	1		1		1				1		1	
CO4	1		1			1				1		
CO5		1		1		1				1		

ADMISSION YEAR: 2020-21 **ACADEMIC YEAR: 2021-22**

SEMESTER: THIRD

COURSE TITLE: SELF STUDY – MASSIVE OPEN ONLINE COURSE (MOOC)		
Sub Code: 20MMD31	**No of Credits : L-T-P-SS 0:0:0:06=03**	**No. of Lecture hours/week :**
Exam Duration:3 Hrs.	**CIE Marks: 50**	**SEE Marks: 50**

GUIDELINES
➢ The student shall choose and register for any of the following NPTEL/SWAYAM core course amounting to a minimum of 16 weeks. ➢ List of Massive Open Online Courses (NPTEL/SWAYAM) will be decided in the Board of Studies meeting. ➢ Students shall register for MOOC during 1st /2nd /3rd semester and shall be completed before the last working day of the 3rd semester. ➢ The student shall choose a MOOC subject which is confined to his specialization and part of his final year thesis. ➢ The assignment and examination marks along with certificate should be submitted to the examination section.

Sl. No.	MOOC SUBJECT NAME
1.	Gas Dynamics and propulsion
2.	Nonlinear vibrations
3.	Modelling and control of Dynamic Electro Mechanical System
4.	Computer aided engineering design
5.	Kinematics of machines
6.	Finite Element Method: Variation Methods to Computer Programming
7.	Selection of Nanomaterials For Energy Harvesting And Storage Application
8.	Introduction to Mechanical Micro Machining
9.	Transport Phenomena in materials

ADMISSION YEAR: 2020-21 **ACADEMIC YEAR: 2021-22**
SEMESTER: THIRD

COURSE TITLE: INTERNSHIP		
Sub Code: 20MMDI32	**No of Credits : L-T-P-SS 0:0:0:16=08**	**No. of Lecture hours/week :**
Exam Duration:3 Hrs.	**CIE Marks: 50**	**SEE Marks :50**

COURSE OBJECTIVES:

1. Expose technical students to the industrial environment, which cannot be simulated in the classroom and hence creating competent professionals for the industry.
2. Provide possible opportunities to learn, understand and sharpen the real time technical / managerial skills required at the job.
3. Expose students to the engineer's responsibilities and ethics.
4. Understand the psychology of the workers and their habits, attitudes and approach to problem solving.

GUIDELINES
1. Internship must be related to the field of specialization. 2. The duration of the internship shall be for a period of 16 weeks on full time basis after II semester SEE exams. 3. Two guides will supervise the internship project work, one from the department and another one from industry. 4. The student must submit letters from the industry clearly specifying his / her name and the duration of the internship on the company letter head with authorized signature. 5. The candidate should submit a synopsis of the proposed work to be done during Internship programme. The synopsis received should be evaluated by the departmental committee. 6. The students shall report the progress of the internship to the internal guide twice in a month and seek internal guide advice. 7. Interim reports as required by the industry / organization can be submitted as per the format acceptable to the respective industry /organizations. 8. Students have to present the internship activities carried out to the departmental committee and only upon approval by the committee, the student can proceed to prepare and submit the hard copy of the final internship report. 9. The final project presentation is evaluated on the basis of the recommendation given by outside supervisor and Internal guide. 10. The external guide from the industry has to be an examiner for the viva voce on Internship. Viva-Voce on internship shall be conducted at the college and the date of Viva-Voce shall be fixed in consultation with the external Guide. The Examiners shall jointly award the Viva - Voce marks.
SCHEME FOR CONTINUOUS INTERNAL EVALUATION (CIE)
CIE marks for the Internship report (30 marks), seminar (10 marks) and question and answer session (10 marks) shall be awarded (based on the quality of report and presentation skill, participation in the question and answer session by the student) by the committee constituted for the purpose by the Head of the Department, The committee shall consist of three faculty from the department.

SCHEME FOR SEMESTER END EVALUATION (SEE)
The SEE examination shall be conducted by an external examiner (domain expert) and an internal examiner. Evaluation done in Individually.

COURSE OUTCOMES: After the completion of this course, student will be able to:

CO1	The purpose of the student internship program is to provide students with an opportunity to gain workplace skills
CO2	The internship will provide training that would be similar to that which would be given in an educational environment, including the Work Station and other hands-on training provided by educational institutions
CO3	Excellent opportunity to see how the theoretical aspects learned in classes are integrated into the practical world.
CO4	Opportunity to learn strategies like time management, multi-tasking etc. in an industrial setup.
CO5	Opportunity to learn new skills and supplement knowledge

MAPPING OF COs WITH POs

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1			1							1	
CO2		1		1								
CO3	1		1	1							1	
CO4		1										
CO5	1			1		1					1	

ADMISSION YEAR: 2020-21 **ACADEMIC YEAR: 2021-22**

SEMESTER: THIRD

COURSE TITLE: TECHNICAL SEMINAR		
Sub Code: 20MMDS33	**No of Credits : L-T-P-SS 0:0:2:0=02**	**No. of Lecture hours/week :**
Exam Duration: 3 Hrs.	**CIE Marks: 50**	

COURSE OBJECTIVES:

1. Exposure of students to a variety of research projects and activities in order to enrich their academic experience.
2. An opportunity for students to develop skills in presentation and discussion of research topics in a public forum.
3. To identify good journals and journal papers; study the papers and understand, analyze, interpret and explain the contents of the paper.

GUIDELINES

1.Each student, under the guidance of a Faculty, is required to

- Choose, preferably through peer reviewed journals, a recent topic of his/her interest relevant to the Course of Specialization.
- Carryout literature survey, organize the Course topics in a systematic order.
- Prepare the report with own sentences.
- Type the matter to acquaint with the use of Micro-soft equation and drawing tools or any such facilities.
- Present the seminar topic orally and/or through power point slides.
- Answer the queries and involve in debate/discussion.
- Submit two copies of the typed report with a list of references.

2. All students should attend the seminars of other students of their specialization.

SCHEME FOR CONTINUOUS INTERNAL EVALUATION (CIE)

Each presentation shall be evaluated for 50 marks. Average marks obtained for three best presentations will be the student's CIE marks.

Marks distribution

- Seminar Report: 20 marks
- Presentation skill:20 marks
- Viva Voce:10 marks

COURSE OUTCOMES: After the completion of this course, student will be able to:

CO1	To identify good journals and journal papers
CO2	study the papers and understand, analyze, interpret and explain the contents of the paper
CO3	understand the shortcomings and plus points of published papers
CO4	To develop overall skills for technical communication and help technical decision making
CO5	To understand the latest research in their field of study

MAPPING OF COs WITH POs												
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	1		1		1	1			1		1	
CO2		1		1					1		1	
CO3	1		1		1				1		1	
CO4		1		1					1		1	
CO5	1		1		1						1	

ADMISSION YEAR: 2020-21 **ACADEMIC YEAR: 2021-22**

SEMESTER: THIRD

COURSE TITLE: EVALUATION OF PROJECT WORK PHASE I		
Sub Code: 20MMDP34	**No of Credits : L-T-P-SS 0:0:0:14=07**	**No. of Lecture hours/week : -----**
Exam Duration:3 Hrs.	**CIE Marks: 50**	**SEE Marks :50**

COURSE OBJECTIVES:

1. Support independent learning.
2. The aim is to identify a problem in the area relevant to the program.
3. To formulate a research problem in the area relevant to the program
4. Guide to organize the work in the appropriate manner and present information (acknowledging the sources) clearly.

GUIDELINES

1. Evaluation of Project Work Phase I is continuation of Phase - I.
2. The duration of the Phase-II shall be of 16 weeks.
3. The student needs to complete the project work in terms of literature survey, objectives of the work and methodology.
4. The preliminary results (if available) of the problem may also be discussed in the report.
5. The student should prepare a report consisting of a detailed Literature Review and Methodology.
6. Present the seminar on the selected project through power point slides.

. The work has to be presented in front of the examiners panel set by Head of Department.

Scheme for Continuous Internal Evaluation (CIE) :

CIE marks for the report (20 marks), seminar (20 marks) and question and answer session (10 marks) shall be awarded (based on the quality of report and presentation skill, participation in the question and answer session by the student) by the committee constituted for the purpose by the Head of the Department, The committee shall consist of three faculty from the department in the area of specialization.

Semester End Examination (SEE) :

Project Report: 20 Marks.

- The basis for awarding the marks shall be the involvement of the student in the project and in the preparation of project report.
- To be awarded by the internal guide in consultation with external guide if any.

Project Presentation: 20 Marks.

- The Project Presentation marks of the **Evaluation Of Project Work Phase -I** shall be awarded by the committee constituted for the purpose by the Head of the Department.
- The committee shall consist of three faculty from the department with the senior most acting as the Chairperson.

Viva Voce: 10 Marks.

The student shall be evaluated based on the ability in the Question and Answer session for 10 marks.

COURSE OUTCOMES: After the completion of this course, student will be able to:

CO1	Make links across different areas of knowledge and to generate, develop and evaluate ideas and information so as to apply these skills to the project task.
CO2	Habituated to critical thinking and use problem solving skills.
CO3	The candidate would have applied the technical knowledge learnt to prepare a methodology to solve the research problem formulated.
CO4	The candidate would have conducted the experiments according the standards acceptable by the peers.
CO5	Understand experimental investigations to verify predictions by other methods.

MAPPING OF COs WITH POs												
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	1		1		1				1		1	
CO2		1		1				1	1			
CO3	1		1		1						1	
CO4		1			1				1		1	
CO5	1		1		1							

ADMISSION YEAR: 2020-21 **ACADEMIC YEAR: 2021-22**
SEMESTER: FOURTH

COURSE TITLE: PROJECT PHASE- II		
Sub Code: 20MMDP41	**No of Credits : L-T-P-SS 0:0:0:08=02**	**No. of Lecture hours/week: -----**
Exam Duration: 3 Hours	**CIE Marks: 100**	

COURSE OBJECTIVES:

1. To expand intellectual capacity, credibility, judgement, intuition.
2. To impart flexibility and adaptability.
3. The candidate should be able to prepare a comprehensive report of the project work.
4. To induce responsibilities to oneself and others.

GUIDELINES

1. Project Phase -II is continuation of Evaluation of Project Work Phase -I.
2. The duration of the Phase-II shall be of 16 weeks.
3. The student needs to complete the project work in terms of methodology (experimental set up or numerical details as the case may be) of solution and Results.
4. The student is expected to exert on design, development and testing of the proposed work.
5. The student should prepare a report consisting of a detailed report comprising of summary of literature survey, detailed objectives, project specifications, paper and/or computer aided design, proof of concept/functionality, part results, A record of continuous progress.
6. Present the seminar on the selected project through power point slides.
7. The work has to be presented in front of the examiners panel set by Head of Department.

Scheme of Continuous Internal Examination (CIE)

Evaluation shall be carried out in three reviews. The evaluation committee shall consist of Guide, Professor/Associate Professor and Assistant Professor.

	Activity	Marks
1.	Review and refinement of Objectives and Literature Review	20
2.	Project Specifications, Computer Aided Design	40
3.	Experimental Result & Analysis	40
	Total	100

COURSE OUTCOMES: After the completion of this course, student will be able to:

CO1	Work in a team to achieve common goal.
CO2	Learn on their own, reflect on their learning and take appropriate actions to improve it.
CO3	Communicate the solutions through presentations and technical reports.
CO4	Enhance presentation skills and report writing skills.
CO5	Develop alternative solutions which are sustainable.

MAPPING OF COs WITH POs												
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	1			1					1		1	
CO2		1		1					1			
CO3	1		1								1	
CO4	1	1		1								
CO5	1			1					1		1	

ADMISSION YEAR: 2020-21 **ACADEMIC YEAR: 2021-22**

SEMESTER: FOURTH

COURSE TITLE: PROJECT WORK EVALUATION AND VIVA VOCE		
Sub Code: 20MMDP42	**No of Credits : L-T-P-SS 0:4:0:24=18**	**No. of Lecture hours/week : -----**
Exam Duration:3 Hrs.	**CIE Marks: 100**	**SEE Marks :100**

COURSE OBJECTIVES:

1. To expand intellectual capacity, credibility, judgement, intuition.
2. To impart flexibility and adaptability.
3. The candidate should be able to prepare a comprehensive report of the project work.
4. To induce responsibilities to oneself and others.

GUIDELINES
1. Project Phase -II is continuation of Evaluation of Project Work Phase -I. 2. The duration of the Phase-II shall be of 16 weeks. 3. The student needs to complete the project work in terms of results and discussion of the Experimentation and Analysis of the defined problem. 4. The student should bring out the conclusions of the work and future scope for the study. 5. The student should prepare a report consisting of a detailed report comprising of summary of literature survey, detailed objectives, project specifications, paper and/or computer aided design, proof of concept/functionality, part results, A record of continuous progress. 6. The student should prepare the project report as per the norms avoiding plagiarism. 7. The student should present the seminar on the selected project through power point slides. 8. The work has to be presented in front of the examiners panel set by Head of Department.

SCHEME FOR SEMESTER END EVALUATION (SEE):

Major Project Phase-II SEE shall be conducted in two stages. This is initiated after fulfilment of submission of project report.

Stage-1:
<u>Evaluation of Report</u>

Evaluation of Project Report shall be done by guide and an external examiner.

Stage-2:
<u>Project Viva-voce</u>

Major Project Viva-voce examination is conducted after receipt of evaluation reports from guide and external examiner.

Both Stage-1 and Stage-2 evaluations shall be completed as per the evaluation formats.

SCHEME FOR SEMESTER END EVALUATION (SEE)			
Details	**Internal Guide**	**External Guide**	**Total**
Report Evaluation	100 Marks	100 Marks	**200 Marks**
Viva-Voce	Joint evaluation by Internal Guide & External Evaluator		**100 Marks**
		Total	**300 Marks**

COURSE OUTCOMES: After the completion of this course, student will be able to:

CO1	The student will develop attitude of lifelong learning
CO2	The student will learn to write technical reports and research papers to publish at national and international level
CO3	The Student will develop strong communication skills to defend their work in front of technically qualified audience
CO4	The student will be able to either work in a research environment or in an industrial environment
CO5	Synthesize self-learning, sustainable solutions and demonstrate life-long learning.

MAPPING OF COs WITH POs												
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	1		1						1		1	
CO2		1	1		1				1		1	
CO3	1		1		1				1		1	
CO4	1	1			1				1			
CO5		1			1				1		1	