I SEMESTER - Machine Design

Sl. No.	Course Area	Course Code	Course Name	Teaching Department	Contact Hours / week			Examination				Credits
					L	T	P	Duration (Hrs.)	CIE Marks	SEE Marks	Total	
1	PC	20MMD11	Advanced Mathematics	Mathematics	4	0	0	3	50	50	100	4
2	PC	20MMD12	Theory of Elasticity	Mechanical Engineering	4	0	0	3	50	50	100	4
3	PC	20MMD13	Advanced Machine Design	Mechanical Engineering	4	0	0	3	50	50	100	4
4	PC	20MMD14	Experimental Stress Analysis	Mechanical Engineering	4	0	0	3	50	50	100	4
5	PC	20MMD15	Fracture Mechanics	Mechanical Engineering	4	0	0	3	50	50	100	4
6	PC	20MMD16	Research Methodology	Mechanical Engineering /NPTEL	2	0	0	3	50	50	100	2
7	PC	20MMD17	Design Laboratory – I	Mechanical Engineering	1	0	2	3	50	50	100	2
TOTAL					**23**	**0**	**2**	**-**	**350**	**350**	**700**	**24**

II SEMESTER - Machine Design												
Sl. No.	Course Area	Course Code	Course Name	Teaching Department	Contact Hours / week			Examination				Credits
					L	T	P	Duration (Hrs.)	CIE Marks	SEE Marks	Total	
1	PC	20MMD21	Finite Element Analysis	Mechanical Engineering	4	0	0	3	50	50	100	4
2	PC	20MMD22	Mechanics of Composite Materials	Mechanical Engineering	4	0	0	3	50	50	100	4
3	PC	20MMD23	Theory of Plasticity	Mechanical Engineering	4	0	0	3	50	50	100	4
4	PE	20MMD24X	Professional Elective - I	Mechanical Engineering	4	0	0	3	50	50	100	4
5	PE	20MMD25X	Professional Elective - II	Mechanical Engineering	4	0	0	3	50	50	100	4
6	PC	20MMD26	Design Laboratory -II	Mechanical Engineering	1	0	2	3	50	50	100	2
7	PE	20MMD27	Career Elective-I	Mechanical Engineering/ NPTEL	0	4	0	-	50	-	50	2
TOTAL					**21**	**4**	**2**	**-**	**350**	**300**	**650**	**24**

Professional Elective – I		Professional Elective - II		Career Elective - I
20MMD241	Rotor Dynamics	20MMD251	Automobile System Design	Online course, Research Add on course, Foreign language, etc
20MMD242	Material Handling Equipment Design	20MMD252	Mechatronics System Design	
20MMD243	Dynamics and Mechanism Design	20MMD253	Robust Design	

III SEMESTER - Machine Design													
Sl. No.	Course Area	Course Code	Course Name	Teaching Department	Contact Hours / week			Examination				Credits
					L	T	P	Duration (Hrs.)	CIE Marks	SEE Marks	Total	
1	PC	20MMD31	Advanced Theory of Vibrations	Mechanical Engineering	4	0	0	3	50	50	100	4
2	PE	20MMD32x	Professional Elective III	Mechanical Engineering	4	0	0	3	50	50	100	4
3	PE	20MMD33x	Professional Elective IV	Mechanical Engineering	4	0	0	3	50	50	100	4
4	PRI	20MMD34	Field Work / Internship	Mechanical Engineering	0	0	12	3	50	50	100	6
5	PRI	20MMD35	Project Work (Phase – I)	Mechanical Engineering	0	2	2	-	50	-	50	2
6	PE	20MMD36	Career Elective-II	Mechanical Engineering/ NPTEL	0	4	0	-	50	-	50	2
TOTAL					**12**	**6**	**14**	**-**	**300**	**200**	**500**	**22**

Professional Elective – III		Professional Elective - IV		Career Elective - II
20MMD321	Tribology	20MMD331	Computer Applications in Design	Online course, Research Add on course, Foreign language, etc
20MMD322	Smart Materials and Structures	20MMD332	Design Optimization	
20MMD323	Design for Manufacture and Assembly	20MMD333	Acoustics and Noise Control Engineering	

IV SEMESTER - Machine Design												
Sl. No.	**Course Area**	**Course Code**	**Course Name**	**Teaching Department**	**Contact Hours / week**			**Examination**				**Credits**
					L	**T**	**P**	**Duration (Hrs.)**	**CIE Marks**	**SEE Marks**	**Total**	
1	PRI	20MMD41	Technical Seminar	Mechanical Engineering	0	4	0	-	50	-	50	2
2	PRI	20MMD42	Project Work (Phase –II)	Mechanical Engineering	0	16	16	3	50	50	100	16
TOTAL					**0**	**20**	**16**	**-**	**100**	**50**	**150**	**18**

NOTE:	**PC :** Professional Core	**CREDIT Definition**
BS : Basic Science	**PE :** Professional Electives	1 hour Lecture per week per semester = 1 credit
ES : Engineering Science	**OE :** Open Electives	2 hours Tutorials per week per semester = 1 credit
HS: Humanities & Social Science	**PRI:** Project & Internship	2 hours Practical / lab / drawing per week per semester = 1 credit

Syllabus

Semester – I

SEMESTER – I

Course Name	**: Advanced Mathematics**	**Course Code**	**: 20MMD11**
Number of Lecture Hours / Week	**: 04**	**CIE Marks**	**: 50**
Number of Tutorial/Practical Hours / Week	**: 0/0**	**SEE Marks**	**: 50**
Total Number of Lecture + Tutorial/Practical Hours	**: 50+ 0/0**	**SEE Duration**	**: 03 hours**
L:T:P	**: 4:0:0**	**CREDITS**	**: 04**

COURSE OVERVIEW :

Linear algebra, numerical methods, probability, statistics and sampling theory techniques are the more advanced areas of Mathematics which are intensively used engineering disciplines. A major focus of the course is linear algebra and probability theory which is most important tool for simulations and machine learning. Numerical methods plays vital role in find most fitting and best approximate solutions. Sampling theory plays important role indecision making. The course aims to show the relevance of Mathematics to engineering and applied sciences.

COURSE LEARNING OBJECTIVES (CLO) :

To enable the students to apply the knowledge of Mathematics in various engineering fields by making them to learn the following:

1. Understand and apply the concept linear algebra for better design.
2. Understand and apply the concept advance Numerical Methods predicting the best solution.
3. Understand and apply the concept of probability theory and sampling theory for decision making.
4. Understand and apply the concept of statistical methods for data analysis

MODULES	TEACHING HOURS
MODULE 1: Linear Algebra-1 Vector Space and Basis, linear Transformation (LT), Matrix representation of LT, Change of Basis, Rank-Nullity Theorem, Inverse linear transformation.	**10**
MODULE 2: Advance Linear Algebra-2 Curve fitting of Nonlinear curve, Eigenvalues and Eigenvectors, Gram-Schmidt Orthogonalization Singular value decomposition, Q-R Decomposition.	**10**
MODULE 3: Advance Numerical Method Solving Algebraic Equation by Graeffe's root squaring method and Lin Bairstow Method, Eigenvalues by Jacobi and Given's Method, Numerical Solution of Partial Differential Equation , boundary and initial conditions	**10**
MODULE 4: Probability and Random Process, joint distribution Random Variable-discrete and continuous, Random processes, definitions, Poisson's, Gaussian random process. Joint distribution, correlation and coefficient of correlation.	**10**

MODULE 5: Sampling theory and statistics Introduction to sampling theory , chi-square test, student t-test and ANOVAs test Reliability(MTBF,MTTR, MTBF, MTTF) moments, skewness, Karl Pearson's coefficient of skewness, Bowley's method to find skewness using third moment, Kurtosis	**10**
Other Assessment Tools: Quiz and Seminar.	

Text Books:

1. B.S. Grewal, Higher Engineering Mathematics, Latest edition, Khanna Publishers.
2. Erwin Kreyszig, Advanced Engineering Mathematics, Latest edition, Wiley Publications.
3. Gilbert Strang, Linear Algebra and its Applications, Wellesley Publishers.
4. Sheldon M. Ross, Introduction to probability and statistics for engineers and scientists, 3rd edition academic press Elsevier.

Reference Books:

1. Numerical Methods by M.K. Jain, S.R.K. Iyengar , R.K. Jain, 6th edition
2. Numerical Analysis for Scientists and Engineers , Madumangal Pal
3. Linear Algebra and its applications, David. C. Lay, 3rd edition, Pearson Education, 2002.
4. Probability Random Process by Natarajan, Tamilarasan, New age international publications.

COURSE OUTCOMES (COs):

CO1	Understand Linear Algebra, probability, numerical methods and statistics
CO2	Apply the concept of advanced Mathematics to solve the problems in engineering domain
CO3	Analyze the solutions of engineering problems using advanced Mathematics
CO4	Using modern tool to solve/analyze engineering problems

CO – PO Matrix

CO	**PO1**	**PO2**	**PO3**
C01	2	-	2
CO2	2	-	2
CO3	2	-	2
C04	2	-	2
CO	**2**	**-**	**2**

SEMESTER – I			
Course Name	**: Theory of Elasticity**	**Course Code**	**: 20MMD12**
Number of Lecture Hours	**: 4**	**CIE Marks**	**: 50**
Number of Tutorial/Practical Hours / Week	**: 0/0**	**SEE Marks**	**: 50**
Total Number of Lecture + Tutorial/Practical Hours	**: 50+ 0/0**	**SEE Duration**	**: 03 hours**
L:T:P	**: 4:0:0**	**CREDITS**	**: 4**

COURSE OVERVIEW :

The objective of this course is to introduce to the student the analysis of linear elastic solids under mechanical and thermal loads. The material presented in this course will provide the foundation for pursuing other solid mechanics courses such as theory of plates and shells, elastic stability, composite structures and fracture mechanics. This course will introduce basic definitions of strain and stress tensors, derive strain deformation relationships for finite and small deformations, derive compatibility conditions for strain tensors, equilibrium equations, and formulate constitutive properties of orthotropic and isotropic elastic materials; then introduce the Airy stress functions for 2-D plane stress and plane strain problems in Cartesian and cylindrical coordinate systems. A few examples in 3-D stress analysis will be provided. The subject also deals with experimental and numerical analysis on application of stresses and strain.

COURSE LEARNING OBJECTIVES (CLO) :

This course will facilitate the students:

1. To expose the students to the field of Continuum Mechanics
2. To understand elastic behavior of materials (hyper elasticity, linear elasticity) and plasticity (basic concepts of small strain and large strain plasticity).
3. Introduce student to basic notion and rules of tensor calculus as well as basic idea and laws of continuum mechanics.

MODULES	TEACHING HOURS
MODULE 1: Analysis of Stress Definition and notation for forces and stresses. Body force, surface force, components of stresses, equations of equilibrium, specification of stress at a point. Principal stresses, maximum and minimum shear stress, Mohr's diagram in three dimensions. Boundary conditions. Stress components on an arbitrary plane, stress invariants, octahedral stresses, decomposition of state of stress, deviator and spherical Stress tensors, stress transformation. Mohr's circle for three-dimension.	**10**
MODULE 2: Deformation and Strain Deformation, strain Displacement relations, strain components, The state of strain at a point, Principal strain, strain invariants, s train transformation, c ompatibility equations, cubical dilatation, spherical and deviator strains, plane strain, Mohr's circle, and compatibility equation Relations and the g eneral equations of Elasticity, Generalized Hooke's law in terms of engineering constants.	**10**
MODULE 3: Two Dimensional Problems in Cartesian Co-Ordinates	**10**

Airy's stress function, investigation of 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, Existence and uniqueness of solution, Saint -Venant's principle, Principle of super position and reciprocal theorem.	
MODULE 4: Two Dimensional Problems in Polar Coordinates General equations, stress distribution symmetrical about an axis, strain components in polar coordinates, Rotating 9 disk and cylinder, concentrated force on semi-infinite plane, stress concentration around a circular hole in an infinite plate. Thermal Stresses: Introduction, Thermo-elastic stress-strain relations, thin circular disc, long circular cylinder.	**10**
MODULE 5: Torsion of Prismatic Bars Introduction, Torsion of circular cross section bars, Torsion of elliptical cross section bars, Soap film analogy, Membrane analogy, Torsion of thin walled open tubes. Elastic Stability: Axial compression of prismatic bars, Elastic stability, buckling load for column with constant cross section.	**10**
Other Assessment Tools: Quiz and Seminar.	

Text Books:

1. Timoshenko and Goodier, "Theory of Elasticity"-'Tata McGraw Hill, New Delhi, 3rd edition, 1970.
2. L S Srinath "Advanced Mechanics of Solids"- Tata McGraw Hill, New Delhi, 3rd edition, 2010.
3. 3. G. Thomas Mase, Ronald E. Smelser, George. E. Mase, Continuum Mechanics for Engineers, 3rd Edition, CRC Press, Boca Raton, 2010

Reference Books:

1. Batra, R. C., Elements of Continuum Mechanics, Reston, 2006.
2. George E. Mase, Schaum's Outline of Continuum Mechanics, McGraw-Hill, 1970.
3. Dill, Ellis Harold, Continuum Mechanics: Elasticity, Plasticity, Viscoelasticity, CRC Press, 2006.
4. Sadhu Singh," Theory of Elasticity"- Khanna publisher, 4th edition, 2013

COURSE OUTCOMES (COs):

CO1	Analyze and solve the basic problems in continuum mechanics of solids by applying the concepts of mechanics of materials.
CO2	Evaluate stresses and strain by applying the equations of continuum mechanics.
CO3	Investigate the given problem for the safe design.
CO4	Evaluate, design, analyze and optimize using commercial CAD, CAE softwares for required mass properties/ stress, deflection / temperature distribution etc. under realistic loading and constraining conditions.

CO – PO Matrix

CO	PO		
	PO1	PO2	PO3
CO1	-	-	2
CO2	2	-	3
CO3	2	2	
CO4	-	2	3
CO	**2**	**2**	**2.67**

SEMESTER – I

Course Name	**: Advanced Machine Design**	**Course Code**	**: 20MMD13**
Number of Lecture Hours /Week	**: 04**	**CIE Marks**	**: 50**
Number of Tutorial/Practical Hours / Week	**: 0/0**	**SEE Marks**	**: 50**
Number of Lecture + Tutorial/Practical Hours	**: 50+ 0/0**	**SEE Duration**	**: 03 hours**
L:T:P	**: 4:0:0**	**CREDITS**	**: 04**

COURSE OVERVIEW :

Design of Machine Elements involves proper sizing of a machine member(s) to safely withstand the maximum stress which is induced within the member when subjected to individual or combination of load (s). The course emphasizes the importance of stress and strain there by to analyze and design elements for life estimation using various methods. Different failure theories are highlighted to evaluate strength of members.

COURSE LEARNING OBJECTIVES (CLO) :

This course will facilitate the students to:

1. Identify failure modes and evolve design by analysis methodology.
2. Design against fatigue failure.

MODULES	TEACHING HOURS
MODULE 1: Introduction Role of failure prevention analysis in mechanical design, Modes of mechanical failure, modified Mohr's theory, Basquin's equation, 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.	**10**
MODULE 2: Stress and Strain Life 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. 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, Total fatigue life.	**10**
MODULE 3: LEFM Approach LEFM concepts, Crack tip plastic zone, Fracture toughness, Fatigue crack growth, Mean stress effects. Notches and their effects: Concentrations and gradients in stress and strain, S-N approach for notched membranes, mean stress effects and Haigh's diagrams, Numerical Problems.	**10**
MODULE 4: Fatigue from Variable Amplitude Loading Spectrum loads and cumulative damage, Damage quantification and the concepts of damage fraction and accumulation, Cycle counting methods, Life estimation using stress life approach. Numerical Problems. Notch strain analysis: Strain – life approach, Neuber's rule, Glinka's rule, applications of	**10**

fracture mechanics to crack growth at notches, Cumulative damage theories. Numerical Problems.	
MODULE 5: Surface and Fatigue Failure Introduction, Surface geometry, Mating surface, Friction, Adhesive wear, Abrasive wear, Corrosion wear. Surface: spherical contact, Cylindrical contact, General contact, Surface fatigue failure modes, Design to avoid Surface failures.	**10**
Other Assessment Tools : Quiz and Seminar	

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

Design Data Handbook :-

1. Design Data Hand Book, K. Lingaiah, McGraw Hill, 2nd Ed.
2. Design Data Hand Book, K. Mahadevan and Balaveera Reddy, CBS Publication, 4th Ed.
3. Design Data Hand Book, S C Pilli and H. G. Patil, I. K. International Publisher, 2010.

Reference Books:

1. Machine Design, Robert L. Norton, Pearson Education Asia, 2001.
2. Engineering Design, George E. Dieter, Linda C Schmidt, McGraw Hill Education, Indian Edition, 2013.
3. Design of Machined Elements, S C Pilli and H. G. Patil, I. K. International Publisher, 2017.
4. Machine Design, Hall, Holowenko, Laughlin (Schaum's Outline series) adapted by S.K Somani, tata McGraw Hill Publishing company Ltd., New Delhi, Special Indian Edition, 2008

COURSE OUTCOMES (COs):

CO1	Apply fundamentals of stress analysis, theories of failure, in the design of machine components and demonstrate fatigue testing methods, design models and design methods
CO2	Calculate the fatigue life using stress life, strain life and LEFM models and analysis of fatigue from variable amplitude loading.
CO3	Conduct analysis of surface failure and surface fatigue and also Identify the modes of fatigue fracture surfaces.
CO4	Demonstrate the understanding of principles of machine design by fabricating a gear with complete design of the same.

CO – PO Matrix

CO	PO		
	PO1	**PO2**	**PO 3**
CO1	-	3	-
CO2	3	-	-
CO3	-	-	3
CO4	2	2	3
CO	**2.5**	**2.5**	**3**

SEMESTER – I

Course Name	: Experimental Stress Analysis	Course Code	: 20MMD14
Number of Lecture / Hours/Week	: 4	CIE Marks	: 50
Number of Tutorial/Practical Hours / Week	: 0/0	SEE Mark	: 50
Number of Lecture + Tutorial/Practical Hours	: 50+ 0/0	SEE Duration	: 03 hours
L:T:P	: 4:0:0	CREDITS	: 4

COURSE OVERVIEW: This course introduces the basics of dynamic measurement system and analysis of experimental data using some statistical methods. This course deals with different experimental stress analysis methods like using strain rosettes, Polariscope, Brittle coating methods and so on

COURSE LEARNING OBJECTIVES (CLO) :

1. To understand the measurement of stain using electrical strain gauges.
2. To analyze stress and strains induced mechanical systems using electrical strain gauges.
3. To understand the photo elastic techniques to characterize the elastic behavior of solids.
4. To understand elastic behavior of solid bodies using coating techniques

MODULES	TEACHING HOURS
MODULE 1: Introduction to measurement systems and Strain Gages: Definition of terms, Calibration, Standards, Dimension and units generalized measurement system. Basic concepts in dynamic measurements, system response, distortion, impedance matching, Analysis of experimental data, cause and types of experimental errors. General consideration in data analysis. **Electrical Resistance Strain Gages:** Strain sensitivity in metallic alloys, Gage sensitivity and gage factor, Performance Characteristics, Environmental effects, Strain Gage circuits. Potentiometer, Wheatstone's bridges, Constant current circuits. Gage construction, adhesives and mounting	10
MODULE 2: Strain Analysis Methods Two element, three element rectangular and delta rosettes, Correction for transverse strain effects, Stress gage, Plane shear gage, Stress intensity factor gage.	10
MODULE 3: Two Dimensional Photo-elasticity Nature of light, Wave theory of light - optical interference, Stress optic law – effect of stressed model in plane and circular Polariscope, Isoclinics & Isochromatics, Fringe order determination Fringe multiplication techniques, Calibration photo-elastic model materials. Separation methods: Shear difference method, Analytical separation methods, Model to prototype scaling, Properties of 2D photo-elastic model materials, and Materials for 2D	10
MODULE 4: Three Dimensional Photo-elasticity Stress freezing method, Scattered light photo-elasticity, Scattered light as an interior analyzer and polarizer, Scattered light Polariscope and stress data Analyses. Photo-elastic (Birefringent) Coatings: Birefringence coating stresses,	10

Poisson's Stress separation techniques: Oblique incidence. Effects of coating thickness: Reinforcing effects	
MODULE 5: Brittle Coatings and Moire's Methods Coatings stresses, Crack patterns, Refrigeration techniques, Load relaxation techniques, Crack detection methods. **Moire's Methods:** Moire's fringes produced by mechanical interference. Geometrical approach, Displacement field approach to Moire's fringe analysis, Out of plane displacement measurements, Out of plane slope measurements.	**10**
Other Assessment Tools: Quiz and Seminar.	

Text Books:

1. Holman,"ExperimentalMethodsforEngineers"7thEdition,TataMcGraw-Hill Companies, Inc, New York, 2007.
2. ExperimentalStressAnalysis-Srinath,Lingaiah,Raghavan,Gargesa,Ramachandraand Pant,TataMcGrawHill,1984.

Reference Books:

1. R.S.Sirohi, H.C.Radha Krishna, "Mechanical measurements" New Age International Pvt.Ltd.,NewDelhi,2004.
2. ExperimentalStressAnalysis-DallyandRiley,McGrawHill,1991.
3. Instrumentation ,Measurement And Analysis-Nakra & Chaudhry, B C Nakra K K Chaudhry, TataMcGraw-Hill Companies, Inc, New York, SeventhEdition,2006.
4. Experimental Stress Analysis by U C Jindal,Pearson 2017

COURSE OUTCOMES (COs):

CO1	Analyze the experimental data using statistical methods.
CO2	Determine the stress and strain using strain rosettes
CO3	Determine the stress and strain using photo-elastic methods.
CO4	Identify and design the different methods of stress analysis for engineering problems.

CO – PO Matrix

CO	PO		
	PO1	PO2	PO3
CO1	-	3	-
CO2	3	-	-
CO3	-	-	3
CO4	2	2	3
CO	**2.5**	**2.5**	**3**

SEMESTER – I			
Course Name	**: Fracture Mechanics**	**Course Code**	**: 20MMD15**
No. of Lecture Hours / Week	**: 4**	**CIE Marks**	**: 50**
Number of Tutorial/Practical Hours / Week	**: 0/0**	**SEE Marks**	**: 50**
Number of Lecture + Tutorial/Practical Hours	**: 50+ 0/0**	**SEE Duration**	**: 03 hours**
L:T:P	**: 4:0:0**	**CREDITS**	**:04**

COURSE OVERVIEW :

Fracture mechanics is the mechanical analysis of materials containing one or more cracks to predict the conditions when failure is likely to occur. Fracture mechanics offers a powerful tool for characterizing failure of both monolithic materials and bonded systems. Based on the concept that all real material systems contain (or may develop) flaws that can significantly alter the resulting stress state, fracture mechanics has proven uniquely appropriate for characterizing the structural integrity of a wide array of materials and structures.

COURSE LEARNING OBJECTIVES (CLO) :

1. To understand the fracture behavior of materials
2. To examine the concept of failure in members with pre-existing flaws.
3. To calculate stress areas and the ''energy release rate'' around crack tips and crack growth due to fatigue.

MODULES	TEACHING HOURS
MODULE 1: Introduction to Fracture mechanics Introduction and historical review of failure of mechanical systems, Sources of micro and macro cracks. Stress concentration due to elliptical hole, Strength of ideal materials, Griffith's energy balance approach. The energy release rate, Energy Criteria for crack growth. Fracture mechanics approach to design, NDT and Various NDT methods used in fracture mechanics	**10**
MODULE 2: Stress Analysis of cracked bodies Stress strain field ahead of crack, Solution to crack problems, the Airy's stress function. Complex stress function. Effect of finite size. Special cases, Elliptical cracks, Numerical problems. Plasticity effects, Irwin plastic zone correction. Dugdale's approach. The shape of the plastic zone for plane stress and plane strain cases, Plastic constraint factor. The Thickness effect, numerical problems, Effect of plasticity on crack growth, shape plastic zone ahead of crack tip.	**10**
MODULE 3: Determination of Stress intensity factors 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. The crack resistance (R curve).Compliance, J integral. Tearing modulus Stability, R-Curve and J-Integral	**10**
MODULE 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,	**10**

Application of elastic plastic parameters	
MODULE 5: Crack arrest & Fatigue crack propagation **Dynamic crack propagation and crack arrest:** Crack speed and kinetic energy. Dynamic stress intensity factor and elastic energy release rate. Crack branching. Principles of crack arrest. Crack arrest in practice. Dynamic fracture toughness. **Fatigue crack propagation:** Factors affecting crack propagation. variable amplitude service loading, Means to provide fail-safety, fracture mechanics approach for fatigue life, Crack arrest, Dynamic fracture toughness	**10**
Other Assessment Tools: Quiz and Seminar.	

Text Books:
1. Elements of Fracture Mechanics, Prashanth Kumar, McGraw hill
2. Fracture Mechanics: Fundamentals and Applications, Fourth Edition, 2017

Reference Books:
1. Elementary Engineering Fracture Mechanics- David Brock, Noordhoff.
2. Advanced Fracture mechanics - Kaninan and Popellor

COURSE OUTCOMES (COs): At the end of the course, student will be able to

CO1	Describe effects of crack like defects on the performance of aerospace, civil, and mechanical engineering systems and structures
CO2	Compute the relationship between crack characterization parameters for ductile and brittle materials
CO3	Analyze for critical crack sizes and fatigue crack propagation rates in engineering structures
CO4	Write a research problem statement and a detailed technical report on failure case studies through literature survey

CO – PO Matrix

CO	**PO**		
	PO1	**PO2**	**PO3**
CO1	-	-	2
CO2	-	-	3
CO3	2	2	-
CO4	-	3	-
CO	**2**	**2.5**	**2.5**

SEMESTER – I

Course Name	**: Research Methodology**	**Course Code**	**: 20MMD16**
Number of Lecture Hours /Week	**: 2**	**CIE Marks**	**: 50**
Number of Tutorial/Practical Hours / Week	**: 0/0**	**SEE Marks**	**: 50**
Number of Lecture + Tutorial/Practical Hours	**: 25+0/0**	**SEE Duration**	**: 03 hours**
L:T:P	**: 2:0:0**	**CREDITS**	**: 2**

COURSE OVERVIEW :

The course will emphasize on techniques of defining research. This course explains the functions of the literature review in research. It involves developing theoretical and conceptual frameworks and writing a review. It sheds light on sampling designs and methods of data collections. This course develops a skill of interpreting results and preparation of research reports and also highlights on writing research proposals

COURSE LEARNING OBJECTIVES (CLO) :

1. To give an overview of the research methodology and explain the technique of defining a research problem.
2. To explain the functions of the literature review in research.
3. To explain various research designs and their characteristics.
4. To explain the details of sampling designs and different methods of data collections.
5. To explain the art of interpretation and the art of writing research reports and research proposals.

MODULES	TEACHING HOURS
MODULE 1: Research Methodology Introduction, Meaning of Research, Objectives of Research, Motivation in Research, Types of Research, Research Approaches, Significance of Research, Research Methods versus Methodology, Research and Scientific Method, Importance of Knowing How Research is Done, Research Process, Criteria of Good Research, and Problems Encountered by Researchers in India. Defining research problem, Selecting the Problem, Technique involved in Defining a Problem.	5
MODULE 2: Review of Literature & Research Design Introduction, place of the literature review in research, Bringing clarity and focus to your research problem, Improving research methodology, Broadening knowledge base in research area, enabling contextual findings, how to review the literature, searching the existing literature, reviewing the selected literature, developing a theoretical framework, developing a conceptual framework, Writing about the literature reviewed. Research Design - Meaning of Research Design, Need for Research Design, Features of a Good Design, Important Concepts Relating to Research Design, Different Research Designs. Basic Principles of Experimental Designs.	5
MODULE 3: Sampling Design & Measurement Techniques Census and Sample Survey, Implications of a Sample Design, Steps in Sampling Design, Criteria of Selecting a Sampling Procedure, Characteristics of a Good Sample Design, Different Types of Sample Designs. Measurement and Scaling Techniques: Measurement in Research, Measurement Scales,	5

Sources of Error in Measurement, Tests of Sound Measurement, Technique of Developing Measurement Tools, Important Scaling Techniques.	
MODULE 4: Data Collection & Interpretation and Report Writing Data Collection: Collection of Primary Data, Collection of Secondary Data, Selection of Appropriate Method for Data Collection, Case Study Method. Interpretation and Report Writing: Meaning of Interpretation, Technique of Interpretation, Precaution in Interpretation, Significance of Report Writing, Different Steps in Writing Report, Layout of the Research Report, Precautions for Writing Research Reports, Oral Presentation, Types of Reports, Mechanics of Writing a Research Report.	**5**
MODULE 5: Writing a Research Proposal Introduction, Quantitative and qualitative research proposal, Contents of a research proposal- Preamble/introduction, problem identification, Objectives of the study, Hypotheses, ,Study design, Measurement procedures, Sampling, Analysis of data, Structure of the report, limitations, Ethical issues.	**5**
Other Assessment Tools: Quiz and Seminar.	

Text Books:

1. Research Methodology: Methods and Techniques, C.R. Kothari, Gaurav Garg, New Age International (P) Limited, Second Edition 2019
2. Research Methodology a step-by step guide for beginners, Ranjit Kumar, SAGE Publications Ltd., Fourth Edition.

Reference Books:

1. Research Methods: the concise knowledge base, Trochim Atomic Dog Publishing, 2004
2. Conducting Research Literature Reviews: From the Internet to Paper Fink A Sage Publications, 2010.

COURSE OUTCOMES (COs):

CO1	Define a research problem and carry-out a research independently.
CO2	Demonstrate the art of interpretation and writing research reports.
CO3	Identify, analyze and provide solutions to engineering problems with due considerations to society, environment and safety.
CO4	Investigate the problems using research-based methods, appropriate techniques, resources and engineering tools to provide valid conclusions.

CO – PO Matrix

CO	PO		
	PO1	**PO2**	**PO3**
CO1	2	-	-
CO2	-	2	-
CO3	-	-	3
CO4	-	-	2
CO	**2**	**2**	**2.5**

SEMESTER – I

Course Name	**: Design Laboratory-I**	**Course Code**	**: 20MMD17**
Number of Lecture Hours /Week	**: 01**	**CIE Marks**	**: 50**
Number of Tutorial/Practical Hours / Week	**: 0/2**	**SEE Marks**	**: 50**
Total Number of Lecture+ Tutorial/Practical Hours	**: 14+0/28**	**SEE Duration**	**: 03 hours**
L:T:P	**: 1:0:2**	**CREDITS**	**: 02**

COURSE OVERVIEW :

In this lab student conduct experiments using standard test rigs to demonstrate and validate design knowledge. Topics covered are Vibration, Stress analysis, theory of machines. Some of the major experiments are Tensile Test, Flexural Test, four point bending and Vibration Characteristics of a Spring Mass Damper System. This helps the students to take up projects, research work related to design Engineering.

COURSE LEARNING OBJECTIVES (CLO) :

1. To conduct experimental and numerical analysis of tensile test and flexural test.
2. To conduct numerically analysis and MATLAB Simulation of principal stresses and principal strains
3. To conduct experiment on stress concentration and contact stresses.
4. To conduct experimental and numerical analysis four point bending and torsion of prismatic bar.
5. To determine the vibrational characteristics of Spring Mass Damper System, Analytically and simulate the results using MATLAB.

List of Experiments

Sl No	Name of Experiment	Test/Simulation to be carried
1	Experimental and Numerical Analysis of Tensile Test	Part A: Experimental study of Tensile Test
		Part B: Numerical Analysis of Tensile Test
2	Experimental and Numerical Analysis of Flexural Test	Part A: Experimental study of Flexural Test
		Part B: Numerical Analysis of Flexural Test
3	Numerically Calculation and MATLAB Simulation	Part A: Invariants, Principal stresses and strains with directions
		Part B: Maximum shear stresses and strains and planes, Von-Mises stress
		Part C: Calculate and Plot Stresses in Thick-Walled Cylinder
4	Stress analysis of rectangular plate with circular hole under i. Uniform Tension and ii. Shear	Part A: MATLAB simulation for Calculation and Plot of normalized hoop Stress at hole boundary in Infinite Plate
		Part B: Modeling of plate geometry under chosen load conditions and study the effect of plate geometry
		Part C: Numerical Analysis using FEA package
5	Single edge notched beam in four point bending	Part A: Modeling of single edge notched beam in four point bending
		Part B: Numerical Studies using FEA
		Part C: Correlation Studies
6	Torsion of Prismatic bar with Rectangular cross-section	Part A: Elastic solutions, MATLAB Simulation
		Part B: Finite Element Analysis of any chosen geometry.
		Part C: Correlation studies.

7	Contact Stress Analysis of Circular Disc under diametrical compression	Part A: 3-D Modeling of Circular Discs with valid literature background, supported with experimental results on contact stress
		Part B: Numerical Analysis using any FEA package
		Part C: 2D Photo Elastic Investigation
8	Vibration Characteristics of a Spring Mass Damper System	Part A: Analytical Solutions
		Part B: MATLAB Simulation
		Part C: Correlation Studies

COURSE OUTCOMES (COs)

CO1	Experimentally and numerically analyze the tensile, bending and torsion tests.
CO2	Validate the analytical results using MATLAB.
CO3	Conduct stress analysis.
CO4	Analytically and numerically analyze the vibration characteristics of spring mass damper

CO – PO Matrix

CO	PO		
	PO1	PO2	PO3
CO1	3	2	3
CO2	3	2	3
CO3	3	2	3
CO4	3	2	3
CO	**3**	**2**	**3**

Syllabus

Semester – II

SEMESTER – II			
Course Name	**: Finite Element Analysis**	**Course Code**	**: 20MMD21**
Number of Lecture Hours/Week	**: 4**	**CIE Marks**	**: 50**
Number of Tutorial/Practical Hours / Week	**: 0/0**	**SEE Marks**	**: 50**
Number of Lecture + Tutorial/Practical Hours	**: 50+ 0/0**	**SEE Duration**	**: 03 hours**
L:T:P	**: 4:0:0**	**CREDITS**	**: 4**

COURSE OVERVIEW :

Finite Element Method (FEM) is a numerical technique for solving differential equations that describe many engineering problems. Main reason for its popularity is that the method results in computer codes which are versatile in nature that can solve many practical problems with minimum training. Obviously, there is danger in using commercially available computer software without proper understanding of the theory behind them, and that is one of the reasons to have a thorough understanding of the theory behind FEM. The course presents the FEM as a tool to find approximate solution of differential equations and thus can be used by students from a variety of disciplines.

COURSE LEARNING OBJECTIVES (CLO) : This course will facilitate the students:

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.
4. Learn to model complex geometry problems and technique of solutions.

MODULES	TEACHING HOURS
MODULE 1: Introduction to Finite Element Method Basic steps in FEM, Types of Elements and Nodes, Coordinate systems, principle of Minimum Potential Energy/Rayleigh Ritz Approach, weighted residual method/Galerkin's Approach, problems on Cantilever Beam and Simply supported beams. Shape/Interpolation functions, Polynomials in Global and Local Coordinates. Analysis of stress and strains in elastic bodies, C^0, C^1 and C^n Elements, Compatibility and convergence criteria, Pascal triangle.	**10**
MODULE 2: One Dimensional Formulation Linear and quadratic bar element, shape functions, stiffness matrix and load vectors. Numerical problems on Bars, Planar trusses, Truss element, direction cosines, stiffness matrix for truss element and, Element properties and load vectors, Temperature effects on Bars and Trusses, Numerical problems.	**10**
MODULE 3: Formulation of Beam Elements Two-dimensional stress strain relations, plane stress plane strain, Euler Bernoulli beam theory, Hermit's shape function, Beams subjected to point, UDL, UVL and external moments, Numerical Problems.	**10**
MODULE 4: Two-Dimensional Analysis Constant Strain Triangle (CST), displacement functions, Jacobian and B matrix,	**10**

expression for element stiffness and load vectors, boundary conditions and stress Calculations-Simple problems, Gauss Elimination and Gauss Seidel Technique, One point and Two point Numerical Integration, numerical problems.	
MODULE 5: Dynamic Considerations Governing differential equation, Finite Element Formulation, Consistent mass matrix, Lumped mass matrix, and stiffness matrix of one-dimensional bar, truss and beam elements, Evaluation of Eigen values and Eigen vectors, Theory of Plates and Shells numerical problems.	**10**

Other Assessment Tools: Quiz and Seminar.

Text Books:

1. T. R. Chandrupatla and A. D. Belegundu, Introduction to Finite Elements in Engineering, Pearson, 4th Ed., 2015.
2. Lakshminarayana H. V., Finite Elements Analysis– Procedures in Engineering, Universities Press, 2004.

Reference Books:

1. Rao S. S, Finite Elements Method in Engineering- 5th Edition, Elsevier, 2010
2. P. Seshu, Textbook of Finite Element Analysis, PHI, 2004.
3. J. N. Reddy, Introduction to Finite Element Method, Mcgraw –Hill, 3rd edition, 2017.
4. Bathe K J, Finite Element Procedures, Prentice-Hall, 2006.
5. R D Cook, Finite Element Modeling for Stress Analysis, Wiley, 4th edition, 2007

COURSE OUTCOMES (COs):

CO1	Apprehend the principles of variation and integral forms of solution to formulate finite element problems
C02	Apply interpolation models for evaluation of field variables
CO3	Evaluate static analysis through finite element methods
CO4	Conduct structural analysis on machine/ automobile/ aerospace associated problems using Finite element analysis

CO – PO Matrix

CO	PO		
	PO1	**PO2**	**PO3**
CO1	2	-	-
CO2	-	2	-
CO3	-	-	2
CO4	-	-	3
CO	**2**	**2**	**2.5**

SEMESTER – II

Course Name	: Mechanics of Composite Materials	Course Code	: 20MMD22
No. of Lecture Hours / Week	: 04	CIE Marks	: 50
Number of Tutorial/Practical Hours / Week	: 0/0	SEE Marks	: 50
Number of Lecture + Tutorial/Practical Hours	: 50+ 0/0	SEE Duration	: 03 hours
L:T:P	:4:0:0	CREDITS	: 04

COURSE OVERVIEW :

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 LEARNING OBJECTIVES (CLO) :

1. To impart a basic understanding of micro-mechanics of layered composites, analysis and design of composite structures and failure analysis of laminated panels.
2. To understand the principles, matrix and reinforcement material options, advantages and disadvantages of different manufacturing techniques of composites.
3. To comprehend recent developments in composites, including metal, ceramic and polymer matrix composites.
4. To know the use of composites in engineering applications.

MODULES	TEACHING HOURS
MODULE 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. Stress-Strain relations for lamina of arbitrary orientation, Numerical problems.	**10**
MODULE 2: Micro Mechanical Analysis of a Lamina Introduction, Evaluation of the four elastic moduli, Rule of mixtures, Numerical problems. Failure Criteria: Failure criteria for an elementary composite layer or Ply, Maximum Stress and Strain Criteria, Approximate strength criteria, Inter-laminar Strength, Tsai-Hill theory, Tsai, Wu tensor theory, Numerical problem, practical recommendations.	**10**
MODULE 3: Macro Mechanical Analysis of Laminate Introduction, code, Kirchhoff's hypothesis, Classical Lamination Theory, A, B, and D matrices (Detailed derivation), Numerical problems. Shear Deformation Theory, A, B, D and E matrices (Detailed derivation).	**10**

MODULE 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.	**10**
MODULE 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, NDT tests– Purpose, Types of defects, NDT method – Ultrasonic inspection, Radiography.	**10**

Other Assessment Tools: Quiz and Seminar.

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.
3. Composite Material Science and Engineering, Krishan K. Chawla, Springer, 3e, 2012.

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. Ochoa, O.O., Reddy, J.N., Finite Element Analysis of Composite Laminates, Springer, 1992.
5. George Z Voyiadjis, Peter I. Kattan, Mechanics of Composite Materials with MATLAB, Springer, 2005.

COURSE OUTCOMES (COs):

CO1	Apply the basic micro/macro-mechanics theories in the design of composites.
C02	Analyze the performance of composites in engineering applications.
C03	Develop a basic understanding of composite materials, its analysis and design for structures including failure analysis.
CO4	Demonstrate the use of composites (FRP or MMC) in structural applications.

CO – PO Matrix

CO	PO		
	PO1	**PO2**	**PO3**
CO1	3	-	-
CO2	2	3	-
CO3	-	3	-
CO4	2	2	3
CO	**2.33**	**2.66**	**3**

SEMESTER – II

Course Name	**: Theory of Plasticity**	**Course Code**	**: 20MMD23**
Number of Lecture Hours /Week	**: 4**	**CIE Marks**	**: 50**
Number of Tutorial/Practical Hours / Week	**: 0/0**	**SEE Marks**	**: 50**
Number of Lecture + Tutorial/Practical Hours	**: 50+ 0/0**	**SEE Duration**	**: 03 hours**
L:T:P	**: 4:0:0**	**CREDITS**	**: 4**

COURSE OVERVIEW: Theory of plasticity is the basis for calculating the stresses, strains and hence forces needed to perform a forming operation. Plastic deformation begins with the process of yielding and the yield surfaces change shape during forming on account of mixed hardening. Yield criteria exert significant influence on yielding, stable deformation and occurrence of instability. The corresponding associated flow rules, therefore, influence significantly the strains and stress calculations. Friction plays a significant role in forming of metals. This is because of significant contact pressure between the tools and the work piece resulting in a small layer of material deformed by shear close to the surface. The frictional effects, which influence a narrow region between the tool and the body of the deforming work piece, contribute to forming loads and local strains developed at the tool-work piece interface. The theory of plasticity provides a means to analyze these effects. It also provides methods for the design of tools of simple geometries and provides the basis for the calculation of forming loads and strains for complex geometries using the FEM. The present course, however, does Not include FEM.

COURSE LEARNING OBJECTIVES (CLO) :

This course will facilitate the students:

1. To analyze stress and strain transformation in a 3D elastic body including principal stresses and principal strains.
2. To know the yield criteria and stress strain curve for different material models.
3. To analyze the plastic stress strain relations for different models.
4. To determine the stresses in bending of beams and torsion of rods.
5. To develop analytical skills of slip line theory and continuity equations.

MODULES	TEACHING HOURS
Module-1 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.	**10**
Module-2 Plastic stress-strain relations, Prandtl- Rouss Saint Venant, Levy-Von Mises, Experimental verification of the Prandtl- Rouss's equation Upper and lower bound theorems and corollaries, Application to problems: Uniaxial tension and compression, Stages of plastic yielding.	**10**

Module-3 Bending of beams, Torsion of rods and tubes, nonlinear bending and torsion equations.	**10**
Module-4 Application of metal forming: Drawing and Extrusion process, stresses in drawing and extruding with and without friction.	**10**
Module-5 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, Computational Plasticity- Finite element method, Formulations, Plasticity Models.	**10**
Other Assessment Tools: Quiz and Seminar.	

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 (COs):

CO1	Adapt the basic concepts of plasticity like stress strain diagram, yield criteria, stress
CO2	Apply equations in the theory of plasticity for large deformations and established
CO3	Develop basic concepts of various theoretical elements of plasticity and the
CO4	Analyze and Solve the basic problems for bending of beams, torsion of rods, stresses

CO – PO Matrix

CO	PO		
	PO1	**PO2**	**PO3**
CO1	-	-	2
CO2	-	-	3
CO3	2	-	2
CO4	2	-	3
CO	**2**	**-**	**2.5**

SEMESTER – II			
Course Name	**: Rotor Dynamics**	**Course Code**	**: 20MMD241**
No. of Lecture Hours / Week	**: 04**	**CIE Marks**	**: 50**
Number of Tutorial/Practical Hours / Week	**: 0/0**	**SEE Marks**	**: 50**
Number of Lecture + Tutorial/Practical Hours	**: 50+ 0/0**	**SEE Duration**	**: 03 hours**
L:T:P	**: 4:0:0**	**CREDITS**	**: 04**

COURSE OVERVIEW :

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 coriolis's effect.

COURSE LEARNING OBJECTIVES (CLO) :

1. To understand the rotor dynamics phenomena with the help of simple rotor models and subsequently the modern analysis methods for real life rotor systems.
2. To understand modeling of bearings, shafts and rotor stages (compressors, turbines including blades) to predict instability like whirling including gyroscopic and Coriolis Effect.

MODULES	TEACHING HOURS
MODULE 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. **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. Two lobe journal bearings, instability of rotors in magnetic field.	**10**
MODULE 2: 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 Critical Speed: Dunkerley's method, Rayleigh's method Stodola's method.	**10**
MODULE 3: **Turbo rotor System Stability by Transfer Matrix Formulation:** General turbo rotor system, development of element transfer matrices, the matrix differential equation, the elastic rotors supported in bearings, numerical solutions. Effect of shear and rotary inertia.	**10**
MODULE 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	**10**

journal bearings, System dynamic equations, Fix stability analysis, non dimensional stability analysis. Unbalance response and Transient analysis.	
MODULE 5: **Blade Vibration:** Centrifugal effect, Transfer matrix approaches. FE Approach.	**10**

Other Assessment Tools: Quiz and Seminar.

Text Books:

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

Reference Books:

1. J S Rao, "Rotor Dynamics", New Age International; Third edition,2018
2. Rajiv Tiwari , "Rotor Systems: Analysis and Identification", CRC Press; 1 edition , 2017

COURSE OUTCOMES (COs):

CO1	Demonstrate independently by carrying research/investigation/develop the theoretical modeling of rotating machine to solve practical problems.
CO2	Test/examine modeling of rotating machine elements and there by write technical report/document.
CO3	Decide on the design, application and reliability of bearings in rotating machinery, thereby demonstrating mastery in the area of bearing for rotating machinery.

CO – PO Matrix

CO	**PO**		
	PO1	**PO2**	**PO3**
CO1	3	-	-
CO2	-	2	-
CO3	-	-	3
CO	**3**	**2**	**3**

SEMESTER – II			
Course Name	**: Material Handling Equipment Design**	**Course Code**	**: 20MMD242**
Number of Lecture Hours /Week	**: 4**	**CIE Marks**	**: 50**
Number of Tutorial / Practical Hours / Week	**: 0/0**	**SEE Marks**	**: 50**
Number of Lecture + Tutorial/Practical Hours	**: 50+ 0/0**	**SEE Duration**	**: 03 hours**
L:T:P	**: 4:0:0**	**CREDITS**	**: 4**

COURSE OVERVIEW: The course introduces the student to the study of the requirement of material handling for any specific industrial or business scenario and recommends a comprehensive handling system. The course focuses on overall selection and design of Hoisting mechanisms, Gear systems and Transport system for comprehensive material handling. It also deals with overall selection and design of Cranes, Elevators, AGV's and Industrial Robots for comprehensive material handling.

COURSE LEARNING OBJECTIVES (CLO) :

1. To explore basic understanding of material handling facilities and the fundamental principles of material handling
2. To comprehend quantitative techniques for designing material handling systems and their limitations
3. To understand the safety issues and regulations in material handling

MODULES	TEACHING HOURS
MODULE 1: Introduction to Selection of Material Handling Elements of Material Handling System, Importance, Terminology, Objectives and benefits of better Material Handling; Principles, Interrelationships between material handling and plant layout, physical facilities and other organizational functions; Classification of Material Handling Equipment. Factors affecting for selection; Material Handling Equation; Choices of Material Handling Equipment; General analysis Procedures; 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.	**10**
MODULE 2: Conveyor Design Introduction to apron conveyors, Pneumatic conveyors, Screw conveyors and vibratory conveyors and their applications, Design of Belt conveyor-Belt selection procedure and calculation of drop energy, Idler design.	**10**
MODULE 3: Design of hoisting elements Welded and roller chains -Hemp and wire ropes - Design of ropes, pulleys, pulley systems, sprockets and drums. Design of forged hooks and eye hooks – crane grabs- lifting magnets - Grabbing attachments -Design of arresting gear -Brakes: shoe, band and cone types.	**10**
MODULE 4: Design of cranes Hand-propelled and electrically driven E.O.T overhead Traveling cranes; Traveling mechanisms of cantilever and monorail cranes; fixed post and overhead traveling cranes; Stability of stationary rotary and traveling rotary cranes.	**10**

MODULE 5: Design of Bucket Elevators, Packaging and storage of bulk materials Introduction, Types of Bucket Elevator, Design of Bucket Elevator - loading and bucket arrangements. Steps for design of packages, protective packaging, testing the physical characteristics of packaging, container testing, types of storage and industrial containers, Automatic guided vehicles, Automatic storage and retrieval system.	**10**

Other Assessment Tools: Quiz and Seminar.

Text Books:

1. Conveyor Equipment Manufacturer' s Association, " Belt conveyors for bulk materials" 6th edition, The New CEMA Book
2. Rudenko N., " Materials handling equipment " , Elnvee Publishers, 1970

Reference Books:

1. Siddhartha Ray, "Introduction to Material Handling", New Age International Publishers.
2. Ishwar G Mulani and Mrs.Madhu I Mulani, "Engineering Science and application design for belt conveyor", Madhu I. Mulani, 2002.
3. Spivakovsy A.O. and Dyachkov V.K., "Conveying Machines, Volumes I and II", MIR Publishers, 1985.
4. Alexandrov, M., "Materials Handling Equipments", MIR Publishers, 1981.
5. Boltzharol, A., " Materials Handling Handbook" , The Ronald press company 1958
6. Kulwiac R. A., 'Material Handling Hand Book', 2nd edition, JohnWilley Publication, NewYork.
7. James M. Apple, 'Material Handling System Design', John-Willey and Sons Publication,

COURSE OUTCOMES (COs):

CO1	Apply appropriate techniques for improving existing material handling systems and applications of optimization technique to material handling.
CO2	Analyze and produce a report on upcoming technology in material handling domain.
CO3	Design components and subsystems of material handling like chain, rope, pulley, sheaves sprockets etc.
CO4	Select appropriate equipment for material handling.

CO – PO Matrix

CO	**PO**		
	PO1	**PO2**	**PO3**
CO1	2	-	-
CO2	-	3	-
CO3	-	-	2
C04	-	-	2
CO	**2**	**3**	**2**

SEMESTER – II			
Course Name	**:Dynamics and Mechanism Design**	**Course Code**	**: 20MMD243**
Number of Lecture Hours /Week	**: 4**	**CIE Marks**	**: 50**
Number of Tutorial / Practical Hours / Week	**: 0/0**	**SEE Marks**	**: 50**
Number of Lecture + Tutorial/Practical Hours	**: 50+ 0/0**	**SEE Duration**	**: 03 hours**
L:T:P	**: 4:0:0**	**CREDITS**	**: 4**

COURSE OVERVIEW :

This course introduces types of mechanisms and also the analysis of mechanisms .It also includes the formulation of equation of motion for mechanical system .Synthesis of different mechanisms using both graphical and analytical methods will be discussed.

COURSE LEARNING OBJECTIVES (CLO) :

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 considerations in the design of mechanisms for engineering applications

MODULES	TEACHING HOURS
MODULE 1: Geometry of Motion and Kinematic analysis Introduction, analysis and synthesis Mechanism terminology, planar, Spherical and spatial mechanisms, mobility, Grashoff's law, Equivalent mechanisms, unique mechanisms. Auxiliary point method using rotated velocity vector, Hall - Ault auxiliary point method, Numerical examples.	**10**
MODULE 2: Generalized Principles of Dynamics: and Lagrange's Equation: Generalized coordinates, configuration space, constraints, virtual work, principle of virtual work, energy angular momentum generalized momentum. 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, numerical examples.	**10**
MODULE 3: Synthesis of Linkages and Motion Generation: 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. Poles and relative poles, Location of poles and relative poles, numerical examples.	**10**
MODULE4: Graphical and Analytical Methods of Dimensional Synthesis Two position synthesis of crank and rocker mechanisms, three position synthesis, four position synthesis (point precision reduction), Overlay method. Freudenstein's equation for four bar mechanism and slider crank mechanism, examples, Bloch's method of synthesis.	**10**
MODULE 5: System Dynamics and Spatial Mechanisms	**10**

Gyroscopic action in machines, Euler's equation of motion, Phase Plane representation, Phase plane Analysis, Response of Linear Systems to transient disturbances Introduction, Position analysis problem, Velocity and acceleration analysis, numerical problems	

Other Assessment Tools: Quiz and Seminar.

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, 1997
3. Mechanism Design (Analysis and Synthesis) Volume1 Arthur G Erdman George N Sandor Sridhar Kota 2001

Reference 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 Mechines and Mechanisms", East West press 2007.
4. David H. Myszka , "Machines and Mechanisms", Pearson Education, 2005

COURSE OUTCOMES (COs):

CO1	Analyze the kinematics of the mechanism
CO2	Formulate the equation of motion of a mechanical system
CO3	Determine the velocity and acceleration of a vibrating system and Design the mechanisms using both graphical and analytical methods
CO4	Construct the simple mechanism for different applications.

CO – PO Matrix

CO	**PO1**	**PO2**	**PO3**
CO1	3	-	-
CO2	3	-	-
CO3	-	-	3
CO4	-	2	
CO	**3**	**2**	**3**

SEMESTER – II			
Course Name	**:Automobile System Design**	**Course Code**	**: 20MMD251**
Number of Lecture Hours /Week	**: 4**	**CIE Marks**	**: 50**
Number of Tutorial / Practical Hours/Week	**: 0/0**	**SEE Marks**	**: 50**
Number of Lecture + Tutorial/Practical Hours	**: 50+ 0/0**	**SEE Duration**	**: 03 hours**
L:T:P	**: 4:0:0**	**CREDITS**	**: 4**

COURSE OVERVIEW :

The course emphasizes the aerodynamic body shapes, cooling system, emission control systems, fuel injection system for SI and CI engines, design of IC engine and transmission systems.

COURSE LEARNING OBJECTIVES (CLO) :

1. To understand of the stages involved in automobile system design.
2. To expose the industrial practices in design of various systems of an 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.
5. To know some modern trends in Automotive Vehicles.

MODULES	TEACHING HOURS
MODULE 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**
MODULE 2: **Design of I.C. Engine I:** Combustion fundamentals, combustion chamber design, cylinder head design for both SI & C. I. Engines.	**10**
MODULE 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**
MODULE 4: **Transmission System:** Design of transmission systems – gearbox (max of 4- speeds), differential. Suspension System: Vibration analysis (single & two degree of freedom, vibration due to engine unbalance, application to vehicle suspension.	**10**
MODULE 5: **Cooling System:** Heat exchangers, application to design of cooling system (water cooled). Emission Control: Common emission control systems, measurement of emissions, exhaust gas emission testing.	**10**

Other Assessment Tools: Quiz and Seminar.

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 Fobert, 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. 6. Design of I.C.Engines -John Heywood, TMH	
COURSE OUTCOMES (COs):	
CO1	Adapt the basic concepts of vehicle design, operation and maintenance in the automotive industry.
CO2	Apply the knowledge in construction, working, preventive maintenance, trouble shooting and diagnosis of various automobile systems.
CO3	Analyze the applications of sub systems in automobile system design.
CO4	Design and solve problems of automobile sub systems in identify modern technology and safety measures used in Automotive Vehicles.

CO – PO Matrix

CO	**PO**		
	PO1	**PO2**	**PO3**
CO1	-	-	2
CO2	-	-	2
CO3	3	-	3
CO4	3	2	3
CO	**3**	**2**	**2.5**

SEMESTER – II			
Course Name	**: Mechatronics System Design**	**Course Code**	**: 20MMD252**
Number of Lecture Hours/Week	**: 4**	**CIE Marks**	**: 50**
Number of Tutorial / Practical Hours / Week	**: 0/0**	**SEE Marks**	**: 50**
Number of Lecture + Tutorial/Practical Hours	**: 50+ 0/0**	**SEE Duration**	**: 03 hours**
L:T:P	**: 4:0:0**	**CREDITS**	**: 4**

COURSE OVERVIEW :

Mechatronics system design provides integration of Mechanical Engineering, Electronics and computers in the design of CNC machine tools, Robots, etc. It gives insight regarding Sensors and their role in design of mechatronics system. Also special emphasis is given to micro-electro mechanical systems which form the core of any Mechatronics system.

COURSE LEARNING OBJECTIVES (CLO) :

1. Familiarize with Mechatronics design process.
2. Describe working and applications of light sensors, proximity sensors and Hall effect sensors.
3. Present the working of Electrical actuation systems, Mechanical switches, solid- state switches, solenoids, DC & AC motors, Stepper motors.
4. To learn about micro electro mechanical systems.

MODULES	TEACHING HOURS
MODULE 1: Introduction Definition and Introduction to Mechatronics Systems, Measurement Systems, Control Systems, Microprocessors Based Controllers and Applications, Real time interfacing and hardware, components for Mechatronics, Definition and classification of transducers, Difference between transducer and sensor, Definition and classification of sensors, Principle of working and applications of light sensors, proximity switches and Hall Effect sensors, Electrical systems, Mechanical switches, Solenoids, Relays, DC/AC Motors, Stepper Motors.	**10**
MODULE 2: Microprocessor & Microcontrollers Introduction, Microprocessor systems, Basic elements of control systems, Microcontrollers, Difference between Microprocessor and Microcontrollers, Microprocessor architecture and terminology-CPU, memory and address, I/O and Peripheral devices, ALU, Instruction and Program, Assembler, Data, Registers, Program Counter, Flags, Fetch cycle, write cycle, state, bus interrupts. Intel's 8085A Microprocessor, basic structure of PLC, Principle of operation, Programming and concept of ladder diagram, concept of latching & selection of a PLC, Industrial Robot, different parts of a Robot-Controller, Drive, Arm, End Effectors, Sensor & Functional requirements of a robot.	**10**
MODULE 3: MEMS and Microsystems Over view of MEMS and Microsystems, Working Principles of Microsystems Micro sensors, Micro actuation, MEMS With Micro actuators. Materials for MEMS: Substrate and wafers, Active substrate, material, Silicon, Silicon	**10**

compound, Silicon Piezoresisters, Gallium Arsenide, Quartz, Piezoelectric crystals, Polymers.	
MODULE 4: Micro System Fabrication Process Photolithography, Ion Implantation, Diffusion, Oxidation, CVD, PVD, Epitaxy, Etching, Bulk Micro Manufacturing, Surface, Micromachining, The LIGA Process, Micro system Design.	**10**
MODULE 5: Advanced Applications in Mechatronics Fault– Detection Techniques, Watch Dog Timer, Parity and Error Coding Checks, Common Hardware Faults, Microprocessor Systems, Emulation and Simulation, PLC Systems, Design arrangements and practical case studies, Possible Mechatronics design solutions.	**10**

Other Assessment Tools: Quiz and Seminar.

Text Books:

1. W. Bolton, "Mechatronics" - Addison Wesley Longman Publication, 2009
2. HSU "MEMS and Microsystems design and manufacture"- Tata McGraw-Hill Education, 2002.

Reference Books:

1. Shetty and Kolk "Mechatronics System Design"- Cengage Learning, second edition, 2012
2. Mahalik "Mechatronics"- Tata McGraw-Hill Education, 2003
3. HMT "Mechatronics"- Tata McGraw-Hill Education, 1998
4. Michel.B. Histand& David. Alciatore, "Introduction to Mechatronics &

COURSE OUTCOMES (COs):

CO1	Apply the fundamentals of Mechatronics system to solve practical problems
CO2	Manage projects on mechatronics system by demonstrating the knowledge of engineering
CO3	Identify suitable components of mechatronics system for evolving technologies
CO4	Design a suitable Mechatronics system for a particular application

CO – PO Matrix

CO	PO		
	PO1	PO2	PO3
CO1	2	-	-
CO2	-	-	2
CO3	-	-	3
CO4	-	2	-
CO	**2**	**2**	**2.5**

SEMESTER – II			
Course Name	: Robust Design	Course Code	: 20MMD253
Number of Lecture Hours /Week	:4	CIE Marks	: 50
Number of Tutorial / Practical Hours/Week	: 0/0	SEE Mark	: 50
Number of Lecture + Tutorial/Practical Hours	: 50+ 0/0	SEE Duration	: 03 hours
L:T:P	: 4:0:0	CREDITS	: 4

COURSE OVERVIEW :

Diverse industries such as engineering, biotechnology, marketing, and advertising use Robust Design methodology to improve the quality of manufactured goods., Robust Design methodology also known as Taguchi methods, were developed to improve productivity by considering noise factors and cost of failure. This course will give you an in-depth understanding of the principles behind Taguchi methods that will greatly benefit any organization.

COURSE LEARNING OBJECTIVES (CLO) :

1. Create designs that have a minimal sensitivity to input variation
2. Reduce design costs
3. Determine which design parameters have the largest impact on variation
4. Optimize designs with multiple outputs

MODULES	TEACHING HOURS
MODULE 1: Quality by Robust Design Quality, western and Taguchi's quality philosophy, Elements of cost, Quadratic loss function and variation of quadratic loss functions. Noise factors causes of variation, Steps in robust design. Robust Design parameter and tolerance design, reliability improvement through experiments, illustration through numerical examples.	10
MODULE 2: Quality by 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, Illustration through numerical examples	10
MODULE 3: Measures of Variability Measures of variability, Ranking method, column effect method and plotting method, Concept of confidence level, Statistical distributions: normal, log normal and Weibull distributions. Probability plots, choice of sample size illustration through numerical examples	10
MODULE 4: Analysis and interpretation of experimental data Analysis of Variance (ANOVA), in factorial experiments: YATE's algorithm for ANOVA, Mathematical models from experimental data, Hypothesis testing, and Regression analysis. Illustration through numerical examples.	10
MODULE 5: Taguchi's Orthogonal Arrays and Signal to Noise ratio (S-N Ratios) 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. **:** Different Strategies for constructing orthogonal arrays. 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..	**10**

Other Assessment Tools: Quiz and Seminar.

Text Books:

1. Quality Engineering using Robust Design - Madhav S. Phadake: Prentice Hall, Englewood Clifts, New Jersey 07632, 1989.
2. Design and analysis of experiments - Douglas Montgomery: Willey India Pvt. Ltd.,2007.
3. Techniques for Quality Engineering - Phillip J. Ross: Taguchi 2nd edition.

Reference Books:

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

COURSE OUTCOMES (COs):

CO1	Design the experiments based on quality, reliability, tolerances etc.
CO2	Interpret the experimental results by measuring variability and plot the results.
CO3	Evaluate the S-N ratio to quantify quality and Orthogonal arrays to investigate quality
C04	Conduct investigation and illustrate the experimental design improvement through robust design.

CO – PO Matrix

CO	PO		
	PO1	PO2	PO3
CO1	2	-	-
CO2	-	-	2
CO3	-	-	2
CO4	-	2	-
CO	**2**	**2**	**2**

SEMESTER – II

Course Name	**: Design Laboratory-II**	**Course Code**	**: 20MMD26**
Number of Lecture Hours / Week	**: 01**	**CIE Marks**	**: 50**
Number of Tutorial / Practical Hours / Week	**: 0/2**	**SEE Marks**	**: 50**
Total Number of Lecture+ Tutorial/Practical Hours	**: 14+0/28**	**SEE Duration**	**: 03 Hrs.**
L:T:P	**: 1:0:2**	**CREDITS**	**: 02**

COURSE OVERVIEW :

In this lab student conduct FEA and experiments using standard test rigs to demonstrate and validate design knowledge on mechanical structures, mechanical parts and various joints. Some of the major experiments are Topology optimization and CFD analysis. This helps the students to take up projects, research work related to design Engineering.

COURSE LEARNING OBJECTIVES (CLO) :

1. To model and simulate various boundary conditions on mechanical components using software packages.
2. To conduct experiment on Journal bearing test rig for different lubricant.
3. To conduct experiment and simulations on permanent and temporary fasteners.

List of Experiments

Sl No	Name of Experiment	Test/Simulation to be carried
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.
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.
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.
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.
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.

6	Welded Joints	Part A: Fabrication and Testing. Part B: FE Modeling and Failure Analysis. Part C: Correlation Studies.
7	Bolted Joints	Part A: Fabrication and Testing. Part C: Correlation Studies.
8	Adhesive Bonded Joints.	Part A: Fabrication and Testing. Part B: FE Modeling and Failure Analysis . Part C: Correlation Studies.

COURSE OUTCOMES (C0s):	
CO1	Outline the importance of structural and thermal analysis in mechanical components.
CO2	Apply the principles of FEM to model and solve structural and thermal issues in the engineering domain.
CO3	Able to analyze and evaluate simple mechanical components for different boundary conditions through experimentation, simulation and correlation studies.

CO – PO Matrix

CO	**PO**		
	PO1	**PO2**	**PO3**
CO1	3		
CO2		2	
CO3			3
CO	**3**	**2**	**3**

Syllabus

Semester – III

SEMESTER –III

Course Name	**: Advanced Theory of Vibrations**	**Course Code**	**: 20MMD31**
No. of Lecture Hours /Week	**: 4**	**CIE Marks**	**: 50**
No. of Tutorial / Practical Hours/Week	**: 0/0**	**SEE Marks**	**: 50**
Total Number of Lecture + Tutorial/Practical Hours	**: 50+ 0/0**	**SEE Duration : 03 hours**	
L:T:P	**:4:0:0**	**CREDITS**	**: 04**

COURSE OVERVIEW :

Advanced Theory of Vibration builds on student's prior knowledge of vibration theory, and concentrates on the applications. The course helps to explore various types and systems of vibrations including multiple degrees of freedom systems. The course helps in graphical representation of characteristic roots and corresponding solutions. It also helps in developing the skills to interpret parameter variations and response under Coulomb and hysteretic damping.

COURSE LEARNING OBJECTIVES (CLO) :

1. To teach students how to use the theoretical principles of vibration, and vibration analysis techniques.
2. To enable students to understand the importance of vibrations in mechanical design of machine parts subject to vibrations.
3. To explore the concepts of transient and Non-linear vibrations.

MODULES	**TEACHING HOURS**
MODULE 1: Introduction: Review of Mechanical Vibrations Mechanical Vibrations: Basic concepts; free vibration of single degree of freedom systems with and without damping, forced vibration o single DOF-systems, Natural frequency. Vibration Control: Introduction, Vibration isolation theory, Vibration isolation and motion isolation for harmonic excitation, practical aspects of vibration analysis, vibration isolation.	**10**
MODULE 2: Vibration Measurement, Modal analysis &Condition Monitoring Vibration Measurement: Introduction, Transducers, Vibration pickups, Frequency measuring instruments, Vibration exciters, Signal analysis. Modal analysis &Condition Monitoring: Dynamic Testing of machines and Structures, Experimental Modal analysis, Machine Condition monitoring and diagnosis.	**10**
MODULE 3: Transient Vibration of single Degree-of freedom systems and Random Vibrations Transient Vibration of single DOF systems: Impulse excitation, arbitrary excitation, Laplace transforms formulation, Pulse excitation and rise time, Shock response spectrum. Random Vibrations: Random phenomena Time averaging and expected value, Frequency response function, Probability distribution, Correlation, Power spectrum and power spectral density, Fourier transforms and response.	**10**

MODULE 4: 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.	**10**
MODULE 5: Continuous Systems Vibration of string, longitudinal vibration of rods, Torsional vibration of rods, Euler equation for beams.	**10**

Other Assessment Tools: Quiz and Seminar.

Text Books:

1. Mechanical Vibrations by S. S. Rao, Pearson Education, 6th edition
2. Fundamentals of Mechanical Vibration by S. Graham Kelly, McGraw-Hill, 2000
3. Theory of Vibration with Application, by William T. Thomson, Marie Dillon Dahleh Chandramouli Padmanabhan, Pearson Education, 5th edition.

Reference Books:

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

COURSE OUTCOMES (COs):

CO1	Characterize transient response and solve undamped and damped system subjected to arbitrary forces
C02	Formulate and solve for linear, nonlinear and continuous vibrating systems
C03	Validate the results of modal analysis and solve problems on differential equations using analysis packages
CO4	Identify the role of absorbers, dampers and shock isolation systems for specific application

CO – PO Matrix

CO	PO		
	PO1	**PO2**	**PO3**
CO1	-	-	2
CO2	-	-	3
CO3	2	-	-
CO4	-	2	-
CO	**2**	**2**	**2.5**

SEMESTER – III			
Course Name	**: Tribology**	**Course Code**	**: 20MMD321**
No. of Lecture Hours /Week	**: 4**	**CIE Marks**	**: 50**
No. of Tutorial / Practical Hours/Week	**: 0/0**	**SEE Marks**	**: 50**
Total Number of Lecture + Tutorial/Practical Hours	**: 50+ 0/0**	**SEE Duration**	**: 03 hours**
L:T:P	**:4:0:0**	**CREDITS**	**: 04**

COURSE OVERVIEW :

This is an introductory course of principles of wear resistance in machine parts and tribology. This elective course aims at understanding various mechanisms of wear, erosion and friction to enhance strength against wear and tear. Tribology is the investigation of machine members/parts moving in relative to another machine member/part. In that context, this course will cover the regions of contact, wear and lubrication. Specifically surface properties, wear of materials, frictional contact, regimes of lubrication, materials commonly used to manufacture bearings and their properties. The purpose of this course is to improve students' skills on design and selection of bearings under various operating conditions involved in moving and rotating parts.

COURSE LEARNING OBJECTIVES (CLO) :

1. To familiarize the concepts of wear, friction and lubrication relative to rotary parts of machine.
2. To evaluate the performance of hydrodynamic bearings with and without leakage of lubricant.
3. To expose the students to the factors influencing the selection of bearing materials for different sliding applications.
4. To introduce the concepts of surface engineering and its importance in tribology.

MODULES	TEACHING HOURS
MODULE-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- Poiseuille's theory, viscometers, Regimes of lubrication, Numerical problems.	10
MODULE 2: Bearing Materials Commonly used bearings materials, and properties of typical bearing materials. Advantages and disadvantages of bearing materials. Introduction to Surface engineering: Concept and scope of surface engineering. Surface modification – transformation hardening, surface melting, thermo chemical processes. Surface Coating – plating, fusion processes, vapor phase processes. Selection of coating for wear and corrosion resistance.	10
MODULE 3: Hydrodynamic journal bearings Friction forces and power loss in a lightly loaded journal bearing, Petroff's equation, mechanism of pressure development in an oil film, and Reynold's	10

equation in 2D. Introduction to idealized journal bearing, load carrying capacity, condition for equilibrium, Sommerfeld's number and its significance; partial bearings, end leakages in journal bearing, numerical examples on full journal bearings only.	
MODULE 4: Plane slider bearings with fixed/pivoted shoe Expression for Pressure distribution and Load carrying capacity. No derivation for coefficient of friction, frictional resistance in a fixed/pivoted shoe bearing, center of pressure, numerical examples. Hydrostatic Lubrication: Introduction to hydrostatic lubrication, hydrostatic step bearings, load carrying capacity and oil flow through the hydrostatic step bearing, End leakage effect, numerical examples.	**10**
MODULE 5: Advanced Bearings Antifriction bearings: Advantages, selection, nominal life, static and dynamic load bearing capacity, probability of survival, equivalent load, cubic mean load, bearing mountings. Introduction to porous and gas lubricated bearings. Governing differential equation for gas lubricated bearings, Equations for porous bearings and magnetic bearings along with their working principal, Fretting phenomenon and its stages.	**10**

Other Assessment Tools: Quiz and Seminar.

Text Books:

1. "Introduction to Tribology in bearings", B. C. Majumdar, Wheeler Publishing
2. "Engineering Tribology", Prasanta Sahoo, PHI Learning Private Ltd, New Delhi, 2011.
3. "Engineering Tribology", J. A. Williams, Oxford Univ. Press, 2005.

Reference Books:

1. "Introduction to Tribology", B. Bhushan, John Wiley & Sons, Inc., New York, 2002.
2. "A Textbook of Tribology", Er. Arun Kumar, SK Kataria & Sons, Reprint 2017, ISBN13: 9789350145227
3. "Handbook of tribology: materials, coatings and surface treatments", B.Bhushan, B.K.
4. Gupta, McGraw-Hill, 1997.
5. "Engineering Tribology", G. W. Stachowiak and A. W. Batchelor, Butterworth-Heinemann, 1992.

OURSE OUTCOMES (COs):

CO1	Identify/Select the material of bearing for any given engineering application and apply the principles of surface engineering for different applications of tribology.
CO2	Apply the basic theories of friction, wear and lubrication to predict the frictional behavior between two surfaces which are in relative motion.
CO3	Develop mathematical relationship between the load carrying capacity, location of center of pressure and other related parameters in slider bearings.
CO4	Apply the fundamental principles of hydrostatic/hydrodynamic bearings to solve problems on lubrication

CO – PO Matrix

CO	PO		
	PO1	**PO2**	**PO3**
CO1	-	-	3
CO2	2	3	-
CO3	-	2	-
CO4	3	-	-
CO	**2.5**	**2.5**	**3**

SEMESTER – III			
Course Name	**: Smart Material and Structures**	**Course Code**	**: 20MMD322**
No. of Lecture Hours / Week	**: 4**	**CIE Marks**	**: 50**
Number of Tutorial / Practical Hours / Week	**: 0/0**	**SEE Marks**	**: 50**
Total Number of Lecture + Tutorial/Practical Hours	**: 50+ 0/0**	**SEE Duration**	**: 03 hours**
L:T:P	**: 4:0:0**	**CREDITS**	**: 04**

COURSE OVERVIEW :

This course offers insight regarding 'Smart technology,' a term extensively used in all branches of science and Engineering due to its immense potential in application areas of very high significance to mankind. It also highlights various ways to embed this technology to introduce 'smartness' in a system. Initially launched in more extensive systems in the bulk form, this science is increasingly leaning towards miniaturization with the popularization of Micro Electro Mechanical Systems (MEMS).

COURSE LEARNING OBJECTIVES (CLO) :

1. To comprehend the concepts of the functional requirement of smart material and structures.
2. To articulate the concepts of MEMs using smart materials.
3. To analyze various Microfabrication and Micromachining process for manufacturing MEMS.
4. To demonstrate design of smart structures employing MEMs for advanced engineering applications.

MODULES	TEACHING HOURS
MODULE 1: Introduction to Smart Systems Components of a smart system, 'Smartness,' Sensors, actuators, transducers, Microelectromechanical systems (MEMS), Control algorithms, Modeling approaches, Effects of scaling, Optimization schemes, Evolution of smart materials and structures, Application areas for smart systems.	**10**
MODULE 2: Processing of Smart Materials Introduction, Semiconductors and their processing, Silicon crystal growth from the melt, Epitaxial growth of semiconductors, Metals and metallization techniques, Ceramics, Bulk ceramics, Thick films, Thin films, Silicon micromachining techniques, Polymers and their synthesis, radiation curing of polymers, Relationship between wavelength and radiation energy, Mechanisms of UV curing, Basic kinetics of photo polymerization, Deposition techniques for polymer thin films, Properties and synthesis of carbon nanotubes.	**10**
MODULE 3: Sensors for Smart System Introduction, Conductometric sensors, Capacitive sensors, Piezoelectric sensors, Magneto strictive sensors, Piezoresistive sensors, Optical sensors, Resonant sensors, Semiconductor-based sensors, Acoustic sensors, Polymeric sensors. Actuators for Smart Systems, Introduction, Electrostatic transducers, Electromagnetic transducers, Electrodynamic transducers, Piezoelectric transducers, Electro strictive transducers, Magneto strictive transducers, Electrothermal actuators, Comparison of actuation schemes.	**10**
MODULE 4: Micro-Electro-Mechanical Systems	**10**

Introduction, Ultra Precision Engineering, Micro-sensors; Micro-actuators; Microelectronics.Fabrication; Micromachining; Mechanical MEMS; Thermal MEMS: MOEMS; Magnetic MEMS; RF MEMS; Microfluidic Systems; Bio and Chemo – Devices; MEMS Packages and Design Considerations; Micro-Instrumentation. Integrated Circuit Processes, Bulk Micromachining: Isotropic Etching and Anisotropic Etching, Wafer Bonding, High Aspect-Ratio Processes (LIGA).	
MODULE 5: Microsensors and Micro actuators Principles of Sensing and Actuation; Beam and Cantilever; Microplates; Capacitive Effects; Piezoelectric material as Sensing and Actuating Elements; Strain Measurement; Pressure measurement; Flow Measurement using Integrated Paddle – Cantilever Structure; Pressure Measurement by Microphone; ShearmodePiezoactuator; Gripping Piezo actuator; Inchworm Technology.	**10**

Other Assessment Tools: Quiz and Seminar.

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 Material Systems and MEMS: Design and Development Methodologies, Vijay K. Varadan University of Arkansas, USA K. J. Vinoy Indian Institute of Science, Bangalore, India S. Gopalakrishnan Indian Institute of Science, Bangalore, India, John Wiley & Sons Ltd, ISBN-13 978- 0-470-09361-0 (HB)
3. Smart Structures and Materials - B. Culshaw, ArtechHouse, Boston, 1996 (ISBN:0890066817).
4. 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
3. Sensors. Materials and Amplifiers, Springer, Berlin; New York, 2002 (ISBN: 3540422595).
4. Piezoelectric Actuators and Wtrasonic Motors - K. Uchino, Kluwer Academic Publishers, Boston, 1997 (ISBN: 0792398114).
5. Handbook of Giant Magnetostrictive Materials - G. Engdahl, Academic Press, San Diego, Calif.; London, 2000 (ISBN: 012238640X).
6. Shape Memory Materials - K. Otsuka and C. M. Wayman, Cambridge University Press, Cambridge; New York, 199~ (ISBN:052144487X).
7. Adaptronics – Smart Structures and Materials-Interdisciplinary and systematic presentation of adaptronics-Michael Sinapius, 2021, Springer publication.

COURSE OUTCOMES (COs):

C01	Comprehend the behavior and applicability of various smart materials and structures.
C02	Exemplify various processes for m anufacturing smart structures and MEMS using Smart materials.
C03	Analyze the elements involved in smart structures and Mems with respect to their application.
C04	Design advanced intelligent prototypes of smart structures for Industrial applications.

CO – PO Matrix

CO	PO1	PO2	PO3
C01	-	2	-
C02	-	-	2
C03	2	-	2
C04	2	2	-
C0	2	2	2

SEMESTER – III			
Course Name	**: Design for Manufacture and Assembly**	**Course Code**	**: 20MMD323**
Number of Lecture Hours /Week	**: 4**	**CIE Marks**	**: 50**
Number of Tutorial / Practical Hours / Week	**: 0/0**	**SEE Marks**	**: 50**
Total Number of Lecture + Tutorial/Practical Hours	**: 50+ 0/0**	**SEE Duration**	**: 03 hours**
L:T:P	**: 4:0:0**	**CREDITS**	**: 4**

COURSE OVERVIEW :

This course provides an overview of various types of materials, its classification, suitable materials for product design and various methods of material selection. It covers various design recommendations for die casting, Sheet Metal Working and Robot assembly.

COURSE LEARNING OBJECTIVES (CLO) :

1. Understand various general design rules for manufacturability and criteria for material selection
2. Explain the general design guidelines for Die casting, Sheet Metal Working, High-Speed Automatic and Robot Assembly

MODULES	TEACHING HOURS
MODULE 1:Introduction Role of Manufacturing in design, Manufacturing functions, Classification of Manufacturing Processes: Types of Manufacturing Processes, brief description of the classes of Manufacturing Processes, Types of Manufacturing Systems, Manufacturing Process Selection.	**10**
MODULE 2: Design for Manufacturing and Assembly Design for Manufacture: DFM guidelines, Specific Design Rules, Design for Assembly: DFA Guidelines, Computer Methods for DFMA: DFA Analysis, Concurrent Costing with DFM, Process Modeling and Simulation, Design for Reliability, Failure Mode and Effect Analysis, Defects and Failure Modes.	**10**
MODULE 3: Design for Die Casting Introduction, Die Casting Alloys, Die-Casting Cycles, Die-Casting Machines, Die-Casting Dies, Finishing, Auxiliary Equipment for Automation, Determination of Optimum Number of Cavities, Determination of Appropriate Machine Size, Die Cost Estimation, Problems.	**10**
MODULE 4: Design for Sheet Metalworking Introduction, Dedicated Dies: Individual Dies for Profile Shearing, Individual Dies for Piercing Operations, Individual Dies for Bending Operations, Individual Dies for Deep Drawing, Miscellaneous features, Progressive Dies, Problems.	**10**
MODULE 5:Design for High-Speed Automatic Assembly and Robot Assembly Introduction, Design of Parts for High-Speed Feeding and Orienting, Additional Feeding Difficulties, High-Speed Automatic Insertion, Analysis of an Assembly, General Rules for Product Design for Automation, Design of Parts for Feeding	**10**

and Orienting, Product Design for Robot Assembly, Problems.	

Other Assessment Tools: Quiz and Seminar.

Text Books:

1. George E. Dieter and Linda C. Schmidt 'Engineering Design', 4th Edition, McGraw Hill Education (India) 2013.
2. Geoffrey Boothroyd, Peter Dewhurst and Winston A. Knight 'Product Design for Manufacture and Assembly',3rd Edition, CRC Press, 2011

Reference Books:

1. Harry Peck, "Designing for Manufacturing", Pitman Publications, 1983.
2. Alan Redford and Chal, (1994) Design for Assembly-Principles and Procedures. McGraw Hill International
3. James G. Bralla, (1986) Hand Book of Product Design for Manufacturing. McGraw Hill Co.
4. Carlo Arnaldo Vezzoli, "Design for Environmental Sustainability", Springer, London, ISBN:
5. 978-1-4471-7364-9, 2018.

COURSE OUTCOMES (COs):

CO1	Select proper manufacturing processes for designing products/components by applying the relevant principles for ease and economic production.
CO2	Use the concepts of DFM for die casting and Sheet metal working processes.
CO3	Apply Boothroyd's method of DFM for product design and assembly.
CO4	Analyze the design factors for simplifying product structure through robust design.

CO – PO Matrix

CO	**PO**		
	PO1	**PO2**	**PO3**
CO1	2	-	-
CO2	-	-	2
CO3	-	-	3
CO4	-	2	-
CO	**2**	**2**	**2.5**

SEMESTER – III			
Course Name	**: Computer Applications in Design**	**Course Code**	**: 20MMD331**
Number of Lecture Hours /Week	**: 4**	**CIE Marks**	**: 50**
Number of Tutorial / Practical Hours / Week	**: 0/0**	**SEE Marks**	**: 50**
Total Number of Lecture + Tutorial/Practical Hours	**: 50+ 0/0**	**SEE Duration**	**: 03 hours**
L:T:P	**: 4:0:0**	**CREDITS**	**: 4**

COURSE OVERVIEW :

The course aims at exposing students to the application modules of CAD software, Graphic standards, curves and surface representation techniques in CAD environment. It provides knowledge on different methods of solid and mechanical assembly representation.

COURSE LEARNING OBJECTIVES (CLO) :

1. Acquire a broad understanding of Product cycle
2. Understand the various Graphic Standards of CAD and CAM.
3. Impart the state of the art knowledge in modeling for computer assisted design.
4. Explain the concepts of surface and solid representation.

MODULES	TEACHING HOURS
MODULE-1: **Introduction:** Definitions, Design Process, Product Cycle, Computer Aided Design (CAD, Hardware Integration and Networking. **CAd Software-** Data Structure, Database, Database Management System (DBMS) Database Coordinate System, Working Coordinate System, Screen Coordinate System, Modes of Graphics Operations, User Interface, Software Modules: Operating System (OS) Module, Graphics Module, Applications Module, Programming Module, Communications Module, Modeling and Viewing, Software Documentation and Development.	**10**
MODULE 2: **Computer Graphics:** Rasterscan Graphics, DDA Algorithm, Bresenham's Algorithm, AntiAliasing Lines. Database Structures-Data Structure-Organization, Data Models; Geometric Model Data, Engineering Data Management (EDM) System. **Transformations:** Translation, Scaling, Reflection or Mirror, Rotation, Concatenations, Homogeneous Transformation, 2D/3D Transformations-Translation, Scaling, Rotation about, X, Y and Z axes. Numerical. Mathematics of Projections- Orthographic and Isometric Projections. Clipping, Hidden Line or Surface removal.	**10**
MODULE 3: **Geometric Modeling:** Requirements of Geometric Modeling, Geometric Models, Geometric Construction Methods, Constraint- Based Modeling, Other Modeling Methods- Cell Decomposition, Variant Method, Symbolic Programming, form Features; Wireframe Modeling Definitions of Point lines, Circles, Arcs, etc. Modeling Facilities-Geometric Modeling Features, Editing or Manipulating, Display Control, Drafting, Programming, Analytical and Connecting Features. **Graphic Standards** -Standardization in Graphics,	**10**

Graphical Kernel System (GKS), Other Graphic Standards-GKS 3D, PHIGS, Exchange of Modeling Data-IGES, STEP.	
MODULE 4: Modeling Curves & Surfaces: Curve Representation-Line, Circle, Parabola, Hyperbola, Curve Fitting- Interpolation Techniques- Lagrangian Polynomial, B-Splines, Approximate Methods Method of Least Squares, Polynomial Curve Fitting, Synthetic Curves-Hermite Cubic Spline, Bermestine Polynomials, Bezier Curve, rational Curves, and NURBS. Surface Representation - Analytic Surfaces, Surfaces of Revolution, Ruled Surfaces, Synthetic Surfaces- Hermite Cubic Surface, Bezier Surface, B-Spline Surface, Coons Surface Patch, Tabulated Cylinder And Sculptured Surfaces.	**10**
MODULE 5: Solid Representation-Concepts, Boundary Representations (B-Rep), Constructive Solid Geometry (CSG), Half Space Method, sweep representation. Organization of solid modelers. Mechanical Assembly: Introduction, Assembly Modeling, Parts Modeling and Representation, Hierarchical Relationships, Mating Conditions, Inference of Position from Mating Conditions, Representation Schemes, Graph Structure, Location Graph, Virtual Link, Generation of Assembling Sequences, Precedence Diagram.	**10**

Other Assessment Tools: Quiz and Seminar.

Text Books:

1. P.N. Rao, "CAD/CAM Principles and Applications," Mc GrawHill, Education Pvt. Ltd., 3rd Edition, 2010, ISBN: 978-0070681934.
2. Ibrahim Zeid and R. Shivasubramanian, "CAD/CAM Theory &Practice," Tata McGraw Hill Education Pvt. Ltd., 2nd Edition, 2010, ISBN: 978-0070151345.

Reference Books:

1. M.P. Groover and E W Zimmers, "CAD/CAM Computer Aided Design and Manufacture," Prentice Hall, 1984, ISBN: 978-0131101302.
2. C. B. Besant and E.W.K. Lui, "Computer Aided design and Manufacture," Ellis Horwood Ltd., 1988, ISBN: 9780853129523.
3. Kunwoo Lee, "Principles of CAD/CAM/CAE Systems,"Pearson, US Edition, 1999, ISBN: 978-0201380361.
4. Anamika Prasad, Shakti S. Gupta and R.K. Tyagi, "Advances in Engineering Design", Springer Singapore, Springer Nature Singapore Pte Ltd., 2019, ISBN: 978-981-13-6469-3.

Other Assessment Tools: Quiz and Seminar.

COURSE OUTCOMES (COs):

CO1	Describe the different stages of the design process and modules of a software package and Apply algorithms of graphical entity generation.
CO2	Identify the hardware integration and networking in CAD process to manage the proper data flow across the domain.
CO3	Demonstrate the application of standard features in solid and surface modelling.
CO4	Use standard software tools to create engineering drawings, or other documents, to fully describe the geometries and dimensions of parts, as well as to document assemblies according to standard practice

CO – PO Matrix

CO	PO		
	PO1	**PO2**	**PO3**
CO1	-	-	2
CO2	-	-	3
CO3	2	-	-
CO4	-	2	-
CO	**2**	**2**	**2.5**

SEMESTER – III			
Course Name	**: Design Optimization**	**Course Code**	**: 20MMD332**
Number of Lecture Hours / Week	**: 4**	**CIE Marks**	**: 50**
Number of Tutorial / Practical Hours / Week	**: 0/0**	**SEE Marks**	**: 50**
Total Number of Lecture + Tutorial/Practical Hours	**: 50+ 0/0**	**SEE Duration**	**: 03 hours**
L:T:P	**: 4:0:0**	**CREDITS**	**: 4**

COURSE OVERVIEW :

Design optimization is an engineering design methodology using a mathematical formulation of a design problem to support selection of the optimal design among many alternatives.

COURSE LEARNING OBJECTIVES (CLO) :

1. To understand the fundamentals of optimization methods and their applications to manufacturing process and product design
2. To learn optimization models including design objectives, constraints and variables
3. To learn appropriate optimization techniques and programs.
4. To understand the limitations of solutions obtained from optimisation, and to use optimal design tools/software.

MODULES	TEACHING HOURS
MODULE 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.	10
MODULE 2: Optimum Design Problem Formulation and Optimization Theory 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. 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
MODULE 3: Sensitivity Analysis and Optimization Disciplines Linear and Non Linear Approximations. Gradient Based Optimization Methods– Dual and Direct. Conceptual Design Optimization and Design Fine Tuning Combined Optimization, Optimization of Multiple Dynamic Loads, Equivalent Static Load Methods. Internal and External Responses, Design Variables in Each Discipline, Optimization of Multiple Static Loads, Transient Simulations	10
MODULE 4: Manufacturability in Optimization Problems and Design Interpretation	10

Design For Manufacturing, Manufacturing Methods and Rules, Applying Manufacturing Constraints to Optimization Problems. 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.	
MODULE 5: Dynamic Programming Introduction, Multistage decision processes, Computational Procedure in dynamic programming, Initial value problem, Examples, Principle of optimality.	**10**

Other Assessment Tools: Quiz and Seminar.

Text Books:

1. Engineering Optimization, Theory and Practice, S.S.Rao, John Wiley, 2009
2. Introduction to Optimum Design, Jasbir Arora, 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 ageInternationalPublishers,1999
3. Optimization methods for Engg. Design -R.LFox, Addison –Wesley, 1971.

COURSE OUTCOMES (COs):

CO1	Identify and apply relevant problem solving methodologies
CO2	Design components, systems and/ or processes to meet required specification.
CO3	Apply decision-making methodologies to evaluate solutions for efficiency, effectiveness and sustainability
CO4	Optimize an existing design with single or multiple objective functions.

CO – PO Matrix

CO	PO		
	PO1	PO2	PO3
CO1	2	-	-
CO2	-	-	2
CO3	-	-	3
CO4		2	-
CO	**2**	**2**	**2.5**

SEMESTER – III			
Course Name	**:Acoustics and Noise Control Engineering**	**Course Code**	**:20MMD333**
No. of Lecture Hours / Week	**: 4**	**CIE Marks**	**: 50**
No. of Tutorial / Practical Hours/Week	**: 0/0**	**SEE Marks**	**: 50**
Total Number of Lecture + Tutorial/Practical Hours	**: 50+ 0/0**	**SEE Duration**	**: 03 hours**
L:T:P	**:4:0:0**	**CREDITS**	**: 04**

COURSE OVERVIEW :

A basic course on acoustics and noise control which provides information on measurement methods and reduction techniques to improve life of component/structure.

COURSE LEARNING OBJECTIVES (CLO) :

1. To provide introduction to 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

MODULES	TEACHING HOURS
MODULE 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. Propagation – Plane and spherical waves, near and far field, free and reverberant field - Anechoic and Reverberant chambers	**10**
MODULE 2: Acoustics Evaluation Techniques Room Acoustics, Reverberation time, Absorption and Absorption Coefficient, Evaluation techniques, Acoustic materials	**10**
MODULE 3: 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, and Machinery acoustics	**10**
MODULE 4: Sound level and intensity meters Octave analyzers, octave band filters, acoustic analyzers, 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	**10**
MODULE 5: Noise control At source and transmission path-Barriers and Enclosures- HVAC system noise,	**10**

Machinery acoustics and levels- Near field monitoring and diagnostics - Active noise control techniques. Noise control in rooms.	
Other Assessment Tools: Quiz and Seminar.	
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, B.J. Smith, R.J. Peters, Stephanie Owen, ISBN-13: 978-0273724681, Third edition 4. Harris, C.K.–Handbook of Noise Control.	
COURSE OUTCOMES (COs):	
CO1	Select appropriate noise control techniques for the solution of practical noise problems and evaluate their performance
CO2	Demonstrate the use of 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 and to become familiar with sound measurement instrumentation

CO – PO Matrix

CO	**PO**		
	PO1	**PO2**	**PO3**
CO1	3	-	-
CO2	-	2	-
CO3	-	-	2
CO4	-	2	3
CO	**3**	**2**	**2.5**