Curriculum

M. Tech. Mechanical (Design) Program

School of Technology

Pandit Deendayal Energy University

Course Structure of M. Tech. Mechanical (Design) Approved in 2020-21 and w.e.f. Admission Batch: 2020

Program Educational Objectives (PEOs):

1. To prepare graduates with sound fundamental knowledge and futuristic research in field of thermal engineering and to make them capable of effectively analyzing and solving the problems associated in this field.
2. To prepare the graduates with core competency to be successful in industry or academia or research laboratory and motivate them to pursue higher studies in interrelated areas.
3. To prepare lifelong learner graduates by providing an academic and research environment for their successful professional career as well as to peruse higher education.
4. To prepare graduates with leadership qualities, effective communication skills, professional and ethical values.

Program Outcomes (POs)

1. **Engineering Knowledge:** Acquire advanced knowledge of thermal engineering principles and modelling methodologies commonly used in the development and analysis of Thermal systems.
2. Problem Solving Skills: Graduates will demonstrate an ability to identify, formulate and solve thermal engineering problems.
3. **Design/ Development of solutions:** An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, health and safety, manufacturability, and sustainability.
4. **Multidisciplinary Approach:** An ability to function on multidisciplinary teams.
5. **Modern tool usage:** An ability to identify, formulate, and solve engineering problems using modern tools and techniques.
6. **Communication:** An ability to communicate effectively.
7. **The Engineer and Society:** The broad education necessary to understand the impact of mechanical engineering solutions in a local, global, economic, environmental, and societal context.
8. **Life-long learning:** A recognition of the need for, and an ability to engage in life-long learning.
9. **Investigations of complex problem:** Use of Applied research including design of experiments, analysis and interpretation of data, synthesis of the information to provide valid solutions with the knowledge of contemporary issues.
10. **Project Management:** An ability to apply engineering knowledge and management principles skills to manage engineering projects.
11. **Environment and Sustainability:** An ability to design sub-systems, systems, components and processes to fulfil demand of environmental sustainability.
12. **Ethics:** Apply engineering principles toward the professional values and ethics.

Program Specific Outcomes (PSOs): At the end of the program, student will be able

1. To **analyse the problems** and **create solution** by applying engineering knowledge with a multidisciplinary approach in the area of thermal engineering, manufacturing systems and product design.
2. To analyze, interpret and provide solutions to the real life mechanical engineering problems **using engineering software/tools.**
3. **To work effectively in a team** to address **complex issues** by engaging in **lifelong learning** and following **ethical and environmental** practices

Sem I, Sem II, Sem III, Sem IV

Course Structure of M. Tech. in Mechanical Engineering

COURSE STRUCTURE FOR M.TECH. DESIGN FIRST YEAR

SEMESTER I (Subjects)				M.TECH. FIRST YEAR (Mechanical Engineering)											
Sr. No.	Category code	Course Code	Course Name	Teaching Scheme					Exam Scheme						
									Theory			Practical		Total Marks
				L	T	P	C	Hrs/wk	CE	MS	ES	CE	ES	
1	PCC	20MED501T	Advanced Mechanics of Solids	3	0	0	3	3	25	50	25	--	--	100
2	PCC	20MED502T	Finite Element and Mesh Free Methods	3	0	0	3	3	25	50	25	--	--	100
3	PCC	20MED503T	Materials Design and Selection	3	0	0	3	3	25	50	25	--	--	100
4	PCC	20MED504P	Design Lab-I	0	0	4	2	4	--	--	--	50	50	100
5	PCE		Elective I	3	0	0	3	3	25	50	25	--	--	100
6	PCE		Elective II	3	0	0	3	3	25	50	25	--	--	100
Total				**15**	**0**	**4**	**17**	**19**						**600**

CE = Continuous Evaluation MS = Mid Semester Exam ES = End Semester Exam

Elective : (i) MEDXXXT: Mechanical Design Optimization, (ii) MEDXXXT: Robotics (iii) MEDXXXT: Automotive Design, (iv) MEDXXXT: Design of Material Handling Equipment (v) MEDXXXT: Fault Diagnosis and Condition Monitoring, (vi) ME XXT: Mechanics of Smart Materials (vii) MEDXXXT: Rapid Product Development, (viii) MEDXXXT: Theory of Elasticity and Plasticity, (ix) MEDXXXT: Vehicle Dynamics, (x) MEDXXXT: Machine Learning Applications in Design and Manufacturing (xi) MEDXXXT: Theory of Plates and Shells, (xii) MEDXXXT: Design of Light Weight Structures, (xiii) MEDXXXT: Industrial Tribology and Lubrication, (xiv) MEDXXXT: Fracture Mechanics (xv) MEDXXXT: Bicycle Design and Frame-Building

20MED501T					ADVANCED SOLID MECHANICS					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To identify the methodology for 4nalysing the theory of stress and strain concepts and the relationship between them.
- To be able to understand and solve the solid mechanics problems using classical and energy methods
- To get familiar with the theories of failure and design components for safe operation
- To design different beams under various loading conditions and evaluate the critical load for beams

UNIT 1: Theory of stresses and Strains **12 hrs.**

Theory of stresses : Introduction, stress at a point, stress tensor, stress components in rectangular and polar coordinate systems, Cauchy's equations, stress transformation, principal stresses and planes, hydrostatic and deviatoric stress components, octahedral shear stress, equations of equilibrium.

Theory of strains: Introduction, deformations, strain components in rectangular and polar coordinates, state of strain at a point, Principal strains, and compatibility conditions.

Stress-strain relations for elastic solids: Introduction, generalized Hookes's law, Stress-strain relations for Isotropic materials, relation among elastic constants, displacement equation of equilibrium.

UNIT 2 : Energy methods **10 Hrs.**

Theories of failures, Introduction to Ideally Plastic solid

Energy methods: Introduction, Reciprocal relation, generalized forces and displacements, First theorem of Castigliano, Theorem of virtual work, Second theorem of Castigliano, statically indeterminate structures.

UNIT 3 : Bending of Beams **12 Hrs**

Bending of Beams: Introduction, straight beams and Asymmetrical bending, shear center, bending of curved beams, Elastic stability, Euler's buckling load, beam column with a different loads.

UNIT 4 Thick cylinder **11 Hrs.**

Thick cylinder: Application to thick cylinders, rotating discs, curved beams, beams on elastic foundations, torsion of non-circular cross-sections

Max. <45> Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: Define the fundamental concepts of stress and strain at a point
CO2: Use theories of failure for safe designing of components
CO3: Estimate the deflection of beam by using energy methods
CO4: Interpret the Stresses developed at various points of the section due to unsymmetrical bending
CO5: Evaluate the critical load for beam-column
CO6: Analyze the various stress in thick cylinder

TEXT/REFERENCE BOOKS

1. L. S. Srinath, Advanced Mechanics of Solids, 2nd Edition, TMH Publishing Co. Ltd., New Delhi, 2003.
2. R. G. Budynas, Advanced Strength and Applied Stress Analysis, 2nd Edition, McGraw Hill Publishing, 1999.
3. A. P. Boresi, R. J. Schmidt, Advanced Mechanics of Materials, 5th Edition, John Willey and Sons Inc, 1993.
4. S. P. Timoshenko, J. N. Goodier, Theory of Elasticity, 3rd Edition, McGraw Hill Publishing Co. 1970.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 8 questions of 2 marks each 16 Marks
Part B/Question: 6 questions of 14 marks each 84 Marks

Course code: 20MED502T				**Finite Element and Mesh Free Methods**					
Teaching Scheme				**Examination Scheme**					
L	**T**	**P**	**C**	**Hrs/Week**	**Theory**			**Practical**		**Total Marks**
					MS	**ES**	**IA**	**LW**	**LE/Viva**	
3	**-**	**-**	**3**	**3**	**25**	**50**	**25**	**--**	**--**	**100**

COURSE OBJECTIVES

- To learn the theory and characteristics of finite element and meshfree methods.
- To formulate the stiffness matrix for linear, quadratic and higher order elements for 1D, 2D and 3D cases.
- To learn and solve problems of beam, truss, frame, grid, plates, dynamic, thermal and fluid using variational and displacement methods.

UNIT 1 Introduction **12 Hrs.**

Introduction to Finite Element Method, Basic Concepts and Steps in FEM formulations, Discretization, General Applications of the Method, Comparison with other numerical methods, Integral formulations and Variation methods: Need of weighted Integral forms, Differential equations and Functional forms, Galerkin Methods, Point Collocation methods, Weak Formulations, Rayligh-Ritz Methods, Concept of Interpolation

UNIT 2 Finite Element Analysis of One and two Dimensional problems **11 Hrs.**

Linear, Quadratic and Higher order Elements, Beam Elements, Truss, Frame and Grid Elements, Triangular, Quadrilateral and rectangular element, Natural Coordinates and Coordinates transformations, Connectivity of Elements

UNIT 3 Applications of Finite Element Analysis **8 Hrs.**

Dynamic Analysis using Finite Elements, Plane Elasticity Problem using FEM

UNIT 4 Meshless Finite Element Methods **8 Hrs.**

Introduction to Meshfree Methods, Comparison with FEM, Solution procedure of Meshfree methods, Meshfree Shape function constructions: Polynomial shape functions, Application to some simple problem

Max. 39 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – **Recall** the fundamental theory of FEM and concepts behind formulation methods in FEM.

CO2 – **Explain** the role and significance of variational methods considering linear, quadratic, and cubic shape functions and theory of mesh free methods.

CO3 – **Modify** the real world problems to 1D, 2D and 3D cases of finite element analysis by applying various FEA elements such as bars, beams, plane and iso-parametric elements.

CO4 – **Analyse** the bars, trusses, beams, heat transfer, fluid flow, and dynamic problems using suitable boundary conditions to a local as well as global equations.

CO5 – **Estimate** the deflections, stresses, and strains induced during failure of various components.

CO6 – **Formulate** and **simulate** various mechanical components subjected to different loading conditions using FEM.

TEXT/REFERENCE BOOKS

1. J.N. Reddy, An Introduction to Finite Element Method, McGraw Hill Publication(2003)
2. L.S. Segerlind, Applied Finite Element Analysis, John Wiley & Sons
3. S.S. Rao, The Finite Element Method in Engineering, Pergamon
4. G.R.Liu and Y.T.Gu, An introduction to Meshfree Methods and their programming, Springer.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100	**Exam Duration: 3 Hrs**
5 Questions of 2 marks each-No choice	10 Marks
4 Questions of 5 marks each-No choice	20 Marks
5 Questions of 10 marks each-one choice and 1 question of 20 marks	70 Marks

Course Code:20MED503T				Materials Design and Selection						
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	-	-	3	3	25	50	25	--	--	100

Prerequisites: Materials Science or its equivalent course, Metallurgy, Machine Design 1 and 2

COURSE OBJECTIVES

- To gain knowledge of materials like metals, polymers, ceramics and composites used in daily life
- To gain an insight of various NDT and Corrosion techniques influencing Design of materials
- To gain the knowledge of Material selection criteria for systematic Design process

UNIT 1 Introduction to Material Science and Polymers **8 Hrs.**

Introduction to Material Science, Introduction to Fracture, Types of fracture, crack, creep, fatigue. Polymeric Materials: Polymer Chemistry, Structure, Configurations. Polymers Relaxation, T_g, T_m, Time-dependent, Elastic and Plastic behavior. Strengthening Mechanism: Thermal stability, T_g, T_m,, crystallinity, strength and stiffness.

UNIT 2 Ceramic Materials **10 Hrs.**

Introduction to Ceramics, Mechanisms of Plastic Deformation, Glasses, Glass-Ceramics, Abrasives, Advanced Ceramics, Mechanisms of crack propagation, Crack deflection, Crack bridging, Microcrack formation and crack branching, Stress-induced phase transformations, Stable crack growth. Strengthening mechanisms: Reducing defect size, Crack deflection, Microcracks, Transformation toughening, Adding ductile particles

UNIT 3 Composite Materials, NDT and Corrosion **12 Hrs.**

Large-Particle Composites, Dispersion-Strengthened Composites, FRP, Fiber and Matrix Phase, Type of Composites, Processing, applications, Design Criteria. Nondestructive Testing Techniques: Types, advantages and limitations, applications. Corrosion: Forms, Corrosion Environments, Corrosion Prevention, Design Criteria

UNIT 4 Materials Selection and Design **10 Hrs.**

Materials in design, Process, Types, Material property charts, material properties. Materials selection: Selection Strategy, Attribute limits and material indices, selection procedure, Case studies. Economic, Environmental & social Issues: Recycling, Biodegradable, and Bio-renewable Polymers/Plastics

Max. 40 Hrs.

COURSE OUTCOMES: On completion of the course, student will be able to

CO1 – Comprehend metals and polymer materials for their mechanical behavior
CO2 – Design for fracture of materials
CO3 – Design of composite materials for strength criterion
CO4 – Comprehend the design of ceramic materials
CO5 – Compare the concepts of NDT for various different types of materials
CO6 – Analyze the concepts of materials selection

TEXT/REFERENCE BOOKS

1. William D Calister Jr. Materials Science and Engineering: An Introduction, John Wiley, 7th Edition
2. Michael F. Ashby Materials Selection in Mechanical Design Elsevier, India, Fourth Edition (2011)
3. Joachim Roesler and Co Mechanical Behavior of Engineering Materials India, Springer (2007)
4. Ravi Prakash Nondestructive Testing Techniques New Age, India, 2007.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100	**Exam Duration: 3 Hrs**
Part A/Question: 4 Questions (10 Marks each)	40 Marks
Part B/Question: 4 Questions (15 Marks each)	60 Marks

20MED504P					Design Lab I					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
-	-	4	2	4	-	-	-	50	50	100

COURSE OBJECTIVES

- To learn the modelling and Coding.
- To manufacture the advanced materials through composite manufacturing.
- To calculate the stresses using Digital Image Correlation.
- To study the standards used in Design.

Computer Aided Design **22 hrs.**

Introduction to CAD tool, User Interface, Sketching, 3D/Solid modelling and Assembly

Numerical Simulation **22 hrs.**

Introduction to tool, Coding of Matrix, Array Operations, If-else, switch command, for, while commands, Plotting commands, Function Files

Mini Project : Coding of any Design related problem

Manufacturing of Advanced Materials **8 hrs.**

Understanding of Composites and its manufacturing through had-layup and vacuum bagging system

Experimental Stress Analysis **4 hrs.**

Calculation of stresses in plate like structure subjected to in-plane loading using DIC (Digital Image Correlation)

Study of Standards **4 hrs.**

To study the ASME code for Design of Mechanical Components, Equipment and System, To Study the TEMA standard for Heat Exchanger Design, To Study the ASTM code for Testing the Various Materials and Joints

Max. 60 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1- Visualize the CAD tool, Numerical simulation, Composites, Stress analysis and Standards.

CO2- Explain coding, modelling, composites and some standards.

CO3- Apply various techniques of coding, modelling and standards to design different mechanical components.

CO4- Estimate the dimensions through coding and modelling and values of stresses induced in structural components subjected to loading.

CO5- Design mechanical components using numerical simulation, CAD tool and Standards.

CO6- Develop mechanical components manufactured through composites.

TEXT/REFERENCE BOOKS

1. Tutorial Provided during Lab sessions
2. Lab Manual
3. A. Brent Strong, Fundamentals of Composites Manufacturing: Materials, Methods, and Application, Society of Manufacturing Engineers.
4. ASTM, ASME, TEMA standards.

END SEMESTER (LAB EXAM) EXAMINATION PATTERN

Max. Marks: 50	**Exam Duration: 3 Hrs**
Performance based exam for Modelling and Numerical Simulation	25
Viva for others not mentioned above	25

COURSE STRUCTURE FOR M.TECH. DESIGN FIRST YEAR

SEMESTER II (Subjects)				M.TECH. FIRST YEAR (Mechanical Engineering)											
Sr. No.	Category code	Course Code	Course Name	Teaching Scheme					Exam Scheme						
									Theory			Practical		Total Marks
				L	T	P	C	Hrs/wk	CE	MS	ES	CE	ES	
1	PCC	20MED507T	Experimental Methods	3	0	0	3	3	30	60	10	--	--	100
2	PCC	20MED508T	Theory and Analysis of Vibration	3	0	0	3	3	30	60	10	--	--	100
3	PCC	20MED509T	Product Design and Development	3	0	0	3	3	30	60	10	--	--	100
4	PCC	20MED510P	Design Lab-II	0	0	4	2	4	--	--	--	50	50	100
5	PCE		Elective III	3	0	0	3	3	30	60	10	--	--	100
6	PCE		Elective IV	3	0	0	3	3	30	60	10	--	--	100
Total				**15**	**0**	**4**	**17**	**19**						**600**

CE = Continuous Evaluation MS = Mid Semester Exam ES = End Semester Exam

20MED507T				Experimental Methods					
Teaching Scheme				Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	-	-	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To gain knowledge of strategy of conducting experimentation
- To gain an insight of the factors influencing the experiment
- To gain the knowledge of how to reduce the number of experiments through fractional factorial
- To appreciate the Taguchi's philosophy of quality loss function
- To use software (both open and commercial software) for statistical analysis

UNIT 1 Strategy of Experimentations **7 Hrs.**

Applications of experiment methods, basic principles, design guidelines, statistical design and problems Fundamentals of Statistics, Plots, Statistical Inference of Single Sample, Hypothesis Testing, Z- Test, t-Test, Statistical Inference of Two Samples, Confidence levels

UNIT 2 Comparative Experiments **8 Hrs.**

P-Values, variations, correlations, central limits, significance, confidence limits, distribution test, analysis of variance, goodness of fit, Inference of Variances of two Normal Distributions, Analysis of the fixed effects model, model adequacy checking, practical interpretation of results, the regression approach to the analysis of variance (ANOVA), Use of Commercial Software for statistical design

UNIT 3 Factorial Analysis **15 Hrs.**

Block design, Latin square design, Graeco-latin square design, 2^k and 3^k design with and without replicates, Fractional Factorial Designs, Regression Models, Residual Analysis, Introduction to Response Surface Methodology, Use of Open and Commercial software for statistical design

UNIT 4 Taguchi's Methodologies **10 Hrs.**

Introduction, Quality through product and process optimization, Taguchi's philosophy of loss function, Signal to Noise ratio, Taguchi Design of Experiments, ANOVA, Case Studies

Max. 40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Understand the experimentation philosophy through the fundamentals of statistics.
CO2 - Evaluate Hypothesis testing, significance and confidence limits, goodness of fit
CO3 - Evaluate ANOVA for experimental problems
CO4 - Analyze analysis of variance and blocking
CO5 - Develop statistical design using Factorial Design
CO6 - Formulate Taguchi's principle of quality and philosophy of experimentation

TEXT/REFERENCE BOOKS

1. D.C. Montgomery, Design and Analysis of Experiments, John Wiley, New York, 2001.
2. Ranjit K. Roy-Design of Experiments Using The Taguchi Approach 16 Steps to Product and Process Improvement-Wiley-Interscience (2001)

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 4 Questions (10 Marks each) 40 Marks
Part B/Question: 5 Questions (12 Marks each) 60 Marks

20MED508T					Theory and Analysis of Vibrations					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	--	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To learn theory of vibrations and characterize free and forced vibrations.
- To formulate the equation of motion for multi degree of freedom systems.
- To formulate initial and boundary conditions for continuous system and non linear equations.
- To design, analyze and interpret the significance of vibration sensors.

UNIT 1 Introduction **10 Hrs.**

Types of Vibrations, Simple Harmonic Motions, Fourier Series, Free vibration, Forced Vibration, Damping, Logarithmic decrement, Vibration isolation and transmissibility ratio.

UNIT 2 Multi Degree of Freedom System **12 Hrs.**

Introduction, principal modes and normal modes of vibration, co-ordinate coupling, generalized and principal co-ordinates, free vibration in terms of initial conditions. Geared systems. Dunkerley's equation. Holzer's method, Geared and branched systems, Rayleigh's method, Stodola method.

UNIT 3 Continuous Systems and Non Linear Vibrations **12 Hrs.**

Introduction, vibration of string, longitudinal vibration of rods, torsional vibration of rods, Euler's equation for beams, simple problems, MDOF systems, Non-linear vibration, Phase Plane, Conservative systems, Stability of equilibrium, Duffing Oscillator.

UNIT 4 Vibration Measurement **11 Hrs.**

Displacement, Velocity and Acceleration Sensors. Time domain and Frequency domain signal interpretation and analysis, Signal Sampling, Nyquist criteria. Interpretation of Statistical features such as RMS, kurtosis, skewness, standard deviation etc.

Max. 45 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: **Summarize** the basic concept of vibration and able to distinguish between free and forced vibrations.

CO2: **Select** suitable vibration parameters.

CO3: **Formulate** equation of motions for multi degree freedom system.

CO4: **Compare** various methods for determination of natural frequency and mode shapes.

CO5: **Construct** equations of motion for continuous system and non linear conditions.

CO6: **Identify** suitable sensor and signal interpretation.

TEXT/REFERENCE BOOKS

1. S.S. Rao, Mechanical Vibrations, Pearson Education, Sixth edition (2018)
2. W.T. Thomas, Theory of Vibration with Applications, Pearson, fifth edition (2008)
3. L. Meirovitch, Fundamentals of Vibrations, Waveland Pr, first edition (2010)
4. S.G. Kelly, Schaum's Outline of Mechanical Vibrations, McGraw-Hill, first edition (1996)

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100	**Exam Duration: 3 Hrs**
Part A : 2 Questions each carrying 5 Marks	10 Marks
Part B : 3 Questions each carrying 10 Marks	30 Marks
Part C : 4 Questions each carrying 15 Marks	60 Marks

20MED509T					Product Design and Development					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	-	-	6	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To develop an understanding on the modern product design and development process.
- Able to identify/solicit customer needs and perform functional decomposition.
- Analyse, evaluate and apply the methodologies and techniques of modern product design and development process for developing a new product.

UNIT 1 INTRODUCTION TO PRODUCT DESIGN AND DEVELOPMENT 10 Hrs.

Introduction to Product Design: Modern Product Development, Theories and Methodologies in Design. Product Development Process Tools: Team Compositions, strategies, Team Building and Evaluation. S-Curves and New Product Development, Mission and Vision statements.

UNIT 2 CUSTOMER NEEDS AND PRODUCT FUNCTION 10 Hrs.

Customer Needs: Voice of the customer, population, gathering needs, organizing and prioritizing the needs. Product function: Functional decomposition, Modelling process, FAST Method, Subtract and Operate method, Creating Function Structure. Product Tear Down Process, Different Methods, Post Tear down reporting.

UNIT 3 BENCHMARKING AND PRODUCT CONCEPT 10 Hrs.

Benchmarking and Establishing Engineering Specifications: Define benchmarking, steps for Benchmarking, Setting Product Specifications, Product Architecture. Generating Concepts: Information gathering and brainstorming, direct search method. Concept Selection: Factors that determine effective decision making, technical feasibility, selection process, Pugh concept selection charts.

UNIT 4 CONCEPT EMBODIMENT AND DESIGN FOR X 10 Hrs.

Concept embodiment: Process embodiment, systems modeling, FMEA Method. Design for Manufacturing and Assembly, Design for Environment. Physical Prototyping, prototyping essentials, rapid prototyping techniques

Max. 40 Hrs.

COURSE OUTCOMES: On completion of the course, student will be able to

CO1 –**Apply** the concept of reverse engineering and redesign methodology in product design and development

CO2 – **Analyze** the analytical and numerical techniques used in product design and development engineering.

CO3 – **Generate, evaluate and compare** the product concepts as per voice of customers.

CO4 -**Apply** benchmarking technique and establish engineering specification in product design and development.

CO5 - **Develop** products by considering the aspects of manufacturing, assembly and environmental concern.

CO6 – **Appraise** the characteristics of a successful product design and development process.

TEXT/REFERENCE BOOKS

1. Otto, K. and Wood K., 2001.Product Design: Techniques in Reverse Engineering and New Product Development. Pearson Education.

2. Ulrich K. T. and Eppinger S. D., 2003. Product Design and Development. Tata McGraw-Hill.

3. Ullman D. G.,1992. The Mechanical Design Process. McGraw-Hill.

4. Roozenburg N. J. M., Eekels J. and Roozenburg N. F. M.,1995. Product Design: Fundamentals and Methods. John Wiley and Sons.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

5 questions of 2 marks each - No choice 10 Marks

4 questions of 5 marks each - No choice 20 Marks

20MED510T					Design Lab - II					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
--	--	4	2	4	--	--	--	50	50	100

5 questions of 10 marks each and one question of 20 Marks - No choice 70 Marks

COURSE OBJECTIVES

- To learn dynamic analysis using FEA.
- To determine natural frequencies and vibration parameters.
- To design, analyze and implement reverse engineering and rapid prototyping techniques.

PART A : Finite Element Analysis

1. Introduction to Finite Element Analysis: User Interface and Environment.
2. CAD Modelling, Geometry cleanup and Mesh refinement.
3. Static FE Analysis of 2D and 3D problems.
4. Introduction and Types of Dynamics Analysis.
5. Determination of Natural Frequency using Modal Analysis.
6. Determination of Harmonic Response under given conditions.
7. To Investigate Random Vibration Response of an Assembly.

PART B : Vibration Practicals

8. To study Undamped free vibrations (longitudinal) of a spring mass system.
9. To study Undamped free vibrations (torsional) of a single rotor system.
10. To determine the natural frequency of a two rotor system.
11. To find the damping coefficient of a system undergoing torsional oscillations.
12. To plot the characteristics of Forced Damped Vibrations for the given system
13. Introduction to sensors and signal processing instruments.
14. Introduction to machinery fault simulators.

PART C : Product Design and Rapid Product Development (Extended hours)

15. Reverse engineering using advanced CAD modeling techniques.
16. Reconstruction of CAD models and prototyping using 3D Printer.
17. Design of water tight models, STL preparation techniques (use of open ended software, study and editing of G-Codes).
18. Part manufacturing for optimized parameters.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: **Recall** and classify the types of FEA techniques.
CO2: **Summarize** and explain various types of dynamic analysis.
CO3: **Formulate** and compare the theoretical and experimental natural frequencies.
CO4: **Compare** free and forced vibration methods to determine natural frequency.
CO5: **Select** and compare suitability of sensors for vibration applications.
CO6: **Design** and develop suitable CAD modelling techniques for part manufacture.

REFERENCE MATERIALS

1. M. Tech Design Lab II manual and Tutorials conducted in lab.
2. Experimental facilities in DOM / PG research labs.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 50 **Exam Duration: 2 Hrs**

Part A : Lab examination – Experiments/FEA 25 Marks

Part B : Viva 25 Marks

COURSE STRUCTURE FOR M.TECH. DESIGN SECOND YEAR

SEMESTER III (Subjects)				M.TECH. SECOND YEAR (Mechanical Engineering)										
Sr. No.	Category code	Course Code	Course Name	Teaching Scheme					Exam Scheme					
				L	T	P	C	Hrs/wk	Theory			Practical		Total Marks
									CE	MS	ES	CE	ES	
1	PCC	20MT611	**Seminar**				4		--	50	50	--	--	100
2	PCC	20MT612	**Project**				14		--	50	50	--	--	100
3	PCC	20MT613	**Industrial Internship**						--	--	--	--	--	PP/NP
Total							**18**							**200**

CE = Continuous Evaluation MS = Mid Semester Exam ES = End Semester Exam

20MT611					Seminar		
Teaching Scheme					Examination Scheme		
L	T	P	C	Hrs/Week	Practical		Total Marks
					Mid Sem Presentation	End Semester Presentation	
--	--	--	4	--	50	50	100

COURSE OBJECTIVES

- To gathers and presents information or data about seminar topic.
- To present findings about recent trends in the area of seminar topic.
- To explore the recent areas of research.
- To analyse the topic of seminar with scope of work

Content:

Each Student shall present a state of the art presentation of 20-30 min duration on the topic of interest and to deliver a report of seminar as per proper format.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: To **Identify** the problem and Review the existing literature in the design domain.
CO2: To **classify** the suitable design problem based in literature survey.
CO3: To **analyze** the chosen design problem based on various analysis performed.
CO3: To **Demonstrate** the technical and communication skills while presenting real life problem.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 50 **Exam Duration: 30 mins**

Part A : Presentation based on Seminar 50 Marks

20MT612					Project		
Teaching Scheme					Examination Scheme		
L	T	P	C	Hrs/Week	Practical		Total Marks
					Mid Sem Presentation	End Semester Presentation	
--	--	--	14	--	50	50	100

COURSE OBJECTIVES

- To gathers and presents information or data about project topic.
- To present findings about recent trends in the area of project topic.
- To explore the recent areas of research.

Content:

Each Student shall present a project related to his/her thesis work for 30-40 min duration and to deliver a report of project as per proper format.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: To **Identify** and formulate a problem of research interest in the design domain.
CO2: To **summarize** the existing literature in the design domain.
CO3: To **prepare** the methodology in order to **solve** the defined problem.
CO3: To **analyze** based on various studies and analysis that can be perform on defined problem.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 50 **Exam Duration: 45 mins**

Part A : Presentation based on Project 50 Marks

COURSE STRUCTURE FOR M.TECH. DESIGN SECOND YEAR

SEMESTER IV (Subjects)				M.TECH. SECOND YEAR (Mechanical Engineering)											
Sr. No.	Category code	Course Code	Course Name	Teaching Scheme					Exam Scheme					
				L	T	P	C	Hrs/wk	Theory			Practical		Total Marks
									CE	MS	ES	CE	ES	
1	PCC	20MT621	**Seminar**				4		--	50	50	--	--	100
2	PCC	20MT622	**Project**				24		--	50	50	--	--	100
Total							**28**							**200**

CE = Continuous Evaluation MS = Mid Semester Exam ES = End Semester Exam

20MT621					Seminar		
Teaching Scheme					Examination Scheme		
L	T	P	C	Hrs/Week	Practical		Total Marks
					Mid Sem Presentation	End Semester Presentation	
--	--	--	4	--	50	50	100

COURSE OBJECTIVES

- To gathers and presents information or data about seminar topic.
- To present findings about recent trends in the area of seminar topic.
- To analyse the topic of seminar with scope of work

Content:

Each Student shall present a state of the art presentation of 20-30 min duration on the topic of interest and to deliver a report of seminar as per proper format.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: **Read** and understand recent trends and technologies in area of Mechanical Design.

CO2: **Identify** the problem after doing research literature survey using various resources in the design domain.

CO3: **Prepare** concise report that include understanding, literature review, and conclusion of selective topic.

CO4: **Classify** the applicability of modern software tools, methods and technology suitable to selective problems.

CO5: **Summarize** the results analysed in the literature.

CO6: **Appraise** the findings presented in literature through technical report and oral presentation.

END SEMESTER EXAMINATION PATTERN

Max. Marks: 50 **Exam Duration: 30 mins**

Part A : Presentation based on Project 50 Marks

20MT622					Project		
Teaching Scheme					Examination Scheme		
L	T	P	C	Hrs/Week	Practical		Total Marks
					Mid Sem Presentation	End Semester Presentation	
--	--	--	14	--	50	50	100

COURSE OBJECTIVES

- To gathers and presents information or data about project topic.
- To present findings about recent trends in the area of project topic.
- To explore the recent areas of research.

Content:

Each Student shall present a project related to his/her thesis work for 30-40 min duration and to deliver a report of project as per proper format.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: **Recognise** the relevant domain of research and read a literature review of the relevant field.
CO2: **Identify** and formulate a problem of research interest in the design domain.
CO3: **Explain** the methodology by designing an appropriate research strategy and research methodology to carry out research.
CO4: **Analyse** the results obtained by solving selective problem.
CO5: **Appraise** the findings of research through technical report and oral presentation.
CO6: **Formulate** the problem and provide new solution in the design domain.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 50 **Exam Duration: 45 mins**

Part A : Presentation based on Project 50 Marks

20MED505T					MECHANICAL DESIGN OPTIMIZATION					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	--	--	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To understand the theory of optimization methods and algorithms developed for solving various types of optimization problems
- To develop and promote research interest in applying optimization techniques in problems of Engineering and Technology
- To apply the mathematical results and numerical techniques of optimization theory to concrete Engineering problems.

UNIT 1 Introduction **10 Hrs.**

Single variable optimization algorithms: Classical method, Region elimination methods, Gradient – based methods, MATLAB solution of one dimensional method; Multivariable optimization algorithms: Direct search methods and Gradient – based methods. Application to mechanical design problems

UNIT 2 Constrained optimization algorithms **10 Hrs.**

Random search methods, complex search methods, feasible direction method, gradient projection method, penalty function method, MATLAB solution of constrained optimization algorithms. Application to mechanical design problems

UNIT 3 Specialized optimization algorithms. **10 Hrs.**

Geometric programming, Dynamic programming, Integer programming, multi-objective optimization, Optimization of fuzzy systems, and Neural-Network based optimization. Application to mechanical design problems

UNIT 4 Advanced optimization methods **09 Hrs.**

Genetic algorithm, Simulated annealing, Particle Swarm optimization, Ant Colony optimization, and MATLAB solution. Application to mechanical design problems

Max. 39 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - **Formulate** the mathematical model of Mechanical Problems.

CO2 - **Solve** Non Linear single and multi-variable unconstrained problem through different algorithms.

CO3 - To **Analyze** and understand the different constraints handling techniques.

CO4 - S**olve** Non Linear single and multi-variable constrained problem through different algorithms.

CO5 - **Simulate** engineering and managerial problems.

CO6 - **Solve** optimization problems using evolutionary computing methods

TEXT/REFERENCE BOOKS

1. S. S. Rao, Engineering optimization: Theory and Practice, New Age publication.
2. K Deb Optimization for Engineering Design: Algorithms and Examples by, PHI Learning Private Limited.
3. A. Ravindran, K. Ragsdell and G. Reklaitis, Engineering optimization: Methods and Applications; Wiley and Sons.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

5 Questions of 3 marks each –no choice	15 Marks
4 Questions of 10 marks each –no choice	40 Marks
3 Questions of 15 marks each –no choice	45 Marks

20MED511T					Robotics					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
2	1	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To understand the constructional features of an Industrial Robot.
- To analyse the kinematic and dynamic aspect of Robotic Manipulation.
- To identify the allied technologies and their function in Robotic Manipulation.
- To comprehend the modern and futuristic technologies in the domain of Robotics.

UNIT 1 **08 Hrs.**

Introduction: Robots in human lives, Industrial Robots, Robot Anatomy, Robot Components

Robot Sensors: Sensor categories, Desirable Features, Binary Sensors, Analog versus Digital Sensors, Proximity and Tactile Sensors, Range Sensors, Force Sensors, Gyroscope, Accelerometer, Inclinometer

Robot Actuators: Purpose, DC Motors, Stepper Motors, Servo Motors, Hydraulic and Pneumatic Actuators

UNIT 2 **18 Hrs.**

Kinematics: Review of Spatial Descriptions and Transformations, Manipulator Kinematics, Description of Links and Joints, Convention for assigning frames to links, Manipulator Transformation Matrix, Inverse Kinematics, Solvability of Inverse Kinematic Model, Solution Techniques, Tutorials relating to Forward and Inverse Kinematic Analysis of Industrial Robots

Differential Kinematics: Linear and angular velocity of a Rigid Body, Mapping Velocity Vector, Velocity propagation along links, Manipulator Jacobian, Jacobian Inverse, Jacobian Singularities, Static Analysis, Tutorials for Differential Kinematic Analysis, Singularities and Static Analysis

Dynamic Modeling: Lagrangian Mechanics, Lagrange-Euler Formulation, Newton-Euler Formulation

Trajectory Generation: Trajectory, Terminology, Steps in Trajectory Planning, Joint Space Techniques, Cartesian Space Techniques, Tutorials for Various methods of Trajectory Generation

UNIT 3 **11 Hrs.**

Robot Control: Open and Close Loop Control, Manipulator Control Problem, Linear Control Scheme, Second order Linear Systems, PID Control Scheme, Torque Control, Force Control of Robotic Manipulators

Robot Vision: Applications of Robot Vision systems, Process of Imaging, Vision Systems, Image Acquisition, Image Representation, Image Processing

UNIT 4 **08 Hrs.**

Robot Programming: Introduction, Techniques of Robot Programming, Robot Programming Languages, Language Structures.

Artificial Intelligence: Introduction, AI Research Goals, AI techniques, Search Techniques, Search Techniques, Problem Solving.

Industry 4.0 (Live Content*): Technologies involved, Implementation and Potential, Relevance to Industry.

Non-industrial robots (Live Content*): Domestic Robots, Humanoids, Exploration and the concurrent robots.

* Concurrent content (to be referred online).

Max. 45 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – Explain the working and function of a Robotic Manipulator in an industrial arena.

CO2 – Analyse a manipulator for Kinematic and Dynamic aspects desired Robotic Manipulation.

CO3 – Develop mathematical model of trajectories for desired Robotic Manipulation.

CO4 – Evaluate the various fundamentals necessary to develop and control a Robot for Industrial applications.

CO5 – Identify the technologies allied with an Industrial Robotic Manipulator.

CO6 – Summarize futuristic Robotic Technologies for Industrial as well as Non-Industrial applications.

TEXT/REFERENCE BOOKS

1. Introduction to Robotics-Mechanics and Control, 3E, John. J. Craig, Pearson
2. Robotics and Control, R. K. Mittal, I. J. Nagrath, Tata McGraw-Hill
3. Introduction to Industrial Robotics, Ramachandran Nagarajan, Pearson
4. Robotics, Appin Knowledge Solutions, Infinity Science Press LLC
5. Robotics and Automation Handbook, Thomas R. Kurfess (edited), CRC Press
6. Embedded Robotics-Mobile Robot Design and Application with Embedded Systems, Thomas Braunl, Springer

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

4 questions 10 marks each 40 Marks

4 questions 15 marks each 60 Marks

20MED512T					Automotive Design					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To develop an understanding about the considerations in Automotive design.
- To analyse and propose design solution for various sub-systems of an Automobile.
- To identify the importance of various allied systems in function of an Automobile.

UNIT 1 **08 Hrs.**

Automotive Engineering: Introduction, World Scenario, Vehicles and its sub-systems, Vehicle Design
Modern Materials in Vehicle Design: Introduction, Structure and manufacturing technology of automotive materials, Mechanical and physical properties of automotive materials, Materials selection for Automotive Materials

UNIT 2 **16 Hrs.**

Body Design (Styling): Studios, Working environment and structure, Product Planning, Concept Sketching, Clay modeling
Body Design (Aerodynamics): Aerodynamic Forces, Drag and its reduction, Stability, Noise, Ventilation, Wind Tunnel Testing
Chassis Design and Analysis: Chassis types, loads, Structural analysis by simple structural method, computational methods
Crashworthiness: Accident and injury analysis, dynamics of vehicle impact, crash characteristics of impacts, structural collapse and its influence upon safety

UNIT 3 **13 Hrs.**

Suspension system design: Role of suspension system, factors affecting design, Suspension types, Kinematic analysis, Roll Center analysis, Force Analysis, Vehicle Ride Analysis
Transmission: Purpose, Manual Transmission, Automatic Transmission, Continuously variable transmission, Application issues. Other elements of Power-Train
Electrical and electronic system: Key Systems and their purpose, Working, Design features and considerations

UNIT 4 **08 Hrs.**

Ergonomics in Automotive Industry: Ergonomics methods to promote occupant accommodation, Strategies for improving occupant accommodation and comfort
Future trends in Automobile Design: Introduction, Mechanical possibilities, electrical and electronic possibilities, State-of-the-art technologies

Max. 45 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to
CO1 – Explain the key aspects involved during the design of various components of an Automobile.
CO2 – Compare materials being employed for a particular job in an Automobile.
CO3 – Propose design for the body and chassis of an Automobile.
CO4 – Analyze the design parameters for suspension of an Automobile.
CO5 – Explain the key features of transmission and other systems in an Automobile.
CO6 – Explain the allied discipline of Ergonomics and its importance in an Automobile.

TEXT/REFERENCE BOOKS

1. An Introduction to Modern Vehicle Design, Julian Happian-Smith (edited), Butterworth Heinemann
2. Handbook of Automotive Design Analysis, John Fenton (edited), Newnes Butterworths
3. Vehicle Design-Aesthetic Principles in Transportation Design, Jordan Meadows, Routledge
4. Ergonomics in the Automotive Design Process, Vivek D. Bhise, CRC Press

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

20MED513T					Design of Material Handling Equipment					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	--	--	3	3	25	50	25	--	--	100

Max. Marks: 100 **Exam Duration: 3 Hrs**
10 questions 10 marks each 100 Marks

COURSE OBJECTIVES

- To develop competency for system visualization and design.
- To enable student to design material handling systems.
- To Ability to apply the statistical considerations in design and analyze the defects and failure modes in material handling systems.

UNIT 1 Introduction to material handling system **08 Hrs.**

Principles and features of material handling system, importance, terminology, objectives and benefits of better material handling, Criteria for selection of Material Handling Equipment's.

UNIT 2 Conveyor Design **10 Hrs.**

Design of Belt conveyor- Belt selection procedure and calculation of drop energy, Idler design. Design of Screw conveyors and vibratory conveyors.

UNIT 3 Hoists Design **10 Hrs.**

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

UNIT 4 Design of cranes and Elevators **11 Hrs.**

Hand-propelled and travelling mechanisms of cantilever and monorail cranes, design considerations for structures of rotary cranes with fixed radius, fixed post and overhead traveling cranes, electric overhead travelling crane - essential parts, design parameters, structural considerations, end carriages, long and cross travel mechanisms, brakes, motor selection, safety arrangements, electrical control system, design of Bucket elevators, Cage elevators - shaft way, guides, counter weights, hoisting machine.

Max. 39 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - **Identify** the appropriate material handling systems to suit the said requirement.
CO2 - **Design** material handling systems for a variety of scenarios pertaining to manufacturing and service industry.
CO3 - **Design** conveyors that are used for handling the various materials in manufacturing and service industry.
CO4 - **Design** hoists that are used for handling the various materials in manufacturing and service industry.
CO5 - **Design** cranes that are used for handling the various materials in manufacturing and service industry.
CO6 - **Apply** the statistical considerations in **design** and **analyze** the defects and failure modes in material handling systems.

TEXT/REFERENCE BOOKS

1. Rudenko, N., Materials handling equipment, ELnvee Publishers.
2. Spivakovsy, A.O. and Dyachkov, V.K., L Conveying Machines, Volumes I and II,MIR Publishers.
3. Alexandrov, M., Materials Handling Equipments, MIR Publishers.
4. Boltzharol, A., Materials Handling Handbook, the Ronald Press Company.
5. Tech. P.S.G., "Design Data Book", Kalaikathir Achchagam, Coimbatore, 2008.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**
5 Questions of 3 marks each –no choice 15 Marks
4 Questions of 10 marks each –no choice 40 Marks
3 Questions of 15 marks each –no choice 45 Marks

20MED514T					Fault Diagnosis and Condition Monitoring of Systems (Elective V)					
Teaching Scheme					**Examination Scheme**					
L	**T**	**P**	**C**	**Hrs/Week**	**Theory**			**Practical**		**Total Marks**
					MS	**ES**	**IA**	**LW**	**LE/Viva**	
3	**0**	**--**	**3**	**3**	**25**	**50**	**25**	**--**	**--**	**100**

COURSE OBJECTIVES

- To understand various kinds of maintenance methods applied in industry.
- To study various types of signatures generated from the machinery components.
- To identify, interpret and apply vibration based condition monitoring techniques.
- To systematically analyze the machine learning algorithms for mechanical applications.

UNIT 1 Introduction **10 Hrs.**

Introduction, Types of Maintenance preventive, breakdown etc., Maintenance Strategies, Failure Modes and Effects Criticality Analysis (FMECA),Types of condition monitoring techniques, advantages and disadvantages, Case studies and analysis

UNIT 2 Signal Processing Techniques **12 Hrs.**

Introduction, Machinery signatures, Selection of Transducers and signal conditioning. Analysis Techniques such as time, frequency, combined time frequency methods, FFT, Wavelet etc. Machine failure modes, Measurement location, Case studies.

UNIT 3 Vibration based condition monitoring **11 Hrs.**

Real-Time Image Feature Extraction and Defect/Fault Classification, The Virtual Sensor, Fusion or Integration Technologies, Usage-Pattern Tracking, Vibration severity criteria, Case studies

UNIT 4 Application of Artificial Intelligence Techniques **12 Hrs.**

Introduction, Machine Learning: Supervised, Unsupervised learning and semi supervised learning, advantages and disadvantages, Feature vectors and classification, Linear and Nonlinear classifiers, Feature selection and dimensionality reduction. Case Studies and Analysis using Experimental Data.

Max. 45 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: **Compare** and **classify** various maintenance strategies.

CO2: Interpret and **Analyze** machinery component signatures.

CO3: **Comprehend** various types of signal processing techniques.

CO4: Identify and **Analyze** suitable condition monitoring technique.

CO5: **Distinguish** and apply various machine learning methods.

CO6: **Understand** the applications of Artificial Intelligence Techniques in mechanical engineering.

TEXT/REFERENCE BOOKS

1. A. R. Mohanty, Machinery Condition Monitoring: Principles and Practices, CRC Press, first edition (2014)
2. R. Isermann, Fault-Diagnosis Applications Model-Based Condition Monitoring: Actuators, Drives, Machinery, Plants, Sensors, and Fault-tolerant Systems, Springer (2011)
3. J. S. Rao, Vibratory Condition Monitoring of Machines, Narosa, first edition (2000)

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100	**Exam Duration: 3 Hrs**
Part A : 4 Questions each carrying 10 Marks	40 Marks
Part B : 4 Questions each carrying 15 Marks	60 Mark

20MED515T					Mechanics of Smart Materials (Elective)					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	--	3	3	**25**	**50**	**25**	**--**	**--**	**100**

COURSE OBJECTIVES

- To understand the different types and importance of smart materials.
- To perform the mathematical modelling of smart structures.
- To learn the important applications of smart materials.

UNIT 1 Introduction to smart materials **08 Hrs.**

Introduction to Smart Materials, Smart and traditional materials, Classification of smart materials, Nature inspired materials. Application, Processing and characteristics of Piezoelectric materials, Shape memory alloys, Magnetostrictive materials, Electrostrictive Materials, Rheological fluids and Electro active Polymers.

UNIT 2 Mechanics of structures **14 Hrs.**

Beams and Plates- Introduction, Displacement field theories, Constitutive relations, Variational Principle, Stiffness Matrices, Governing Equations. Closed form solution-Navier's solution, static and dynamic analysis.

UNIT 3 Modelling of Smart Materials **14 Hrs.**

Piezoelectric Materials: Piezoelectric coefficients, Influence of mechanical stress and electric field, Electro-mechanical constitutive relations, mathematical modelling. Shape Memory Alloys: Pseudo elasticity and shape memory effect, One-way and Two-way effect, constitutive models, mathematical modelling.

UNIT 4 Application and Implementation **13 Hrs**

Introduction, Piezoelectric: Piezoelectric Accelerometers, Cantilever Piezoelectric actuator mode, Vibration based Energy Harvesting, Modeling of Piezoelectric Energy Harvesters. Shape Memory Alloys Wires: Tuning of composite Beams, Free Vibration analysis of composite beams with SMA Wires. Introduction to Programming, Modelling of smart structure using MatLab.

Max. 49 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - **Recall** the concept of mechanics and properties of materials.

CO2 - **Classify** and understand various characteristics and features of the smart materials.

CO3 - **Prepare** the governing differential equation for beam and plates.

CO4 - **Select** and **Compare** the constitutive modelling for different types of smart applications.

CO5 - **Evaluate** the deflection, stresses and free vibration response of smart structures.

CO6 - **Develop** a program using MatLab to model a smart structure.

TEXT/REFERENCE BOOKS

1. Paolo Gaudenzi, Smart Structures, 1st Edition, Wiley publishers, 2009.
2. M. S. Vijaya, Piezoelectric Materials and Devices, CRC Press, 2013.
3. Inderjit Chopra & Jayant Sirohi, Smart Structures Theory, Cambridge University Press, 2013.
4. V. L. Jr., V. S. Jr. and M. A. Savi, Dynamics of Smart Systems and Structures, Springer, 2016.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100	**Exam Duration: 3 Hrs**
Part A-6 Questions: 5 Marks each	30 Marks
Part B-4 Questions: 10 Marks each	40 Marks
Part C-2 Questions: 15 Marks each	30 Marks

20MED516T					Rapid Product Development					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	-	-	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To gain knowledge of Product Development
- To gain an insight Rapid Prototyping technologies
- To gain the knowledge of pre and post processing techniques during rapid product development
- To gain the knowledge of Rapid Tooling, use of Reverse Engineering for product development

UNIT 1 Introduction: 11 Hrs.

CAD-CAM and its integration, Development of CAD CAM, Importance of being Rapid, Rapid Prototyping (RP) Defined, Product development and its relationship. Process chain for Rapid Prototyping, Reverse Engineering and CAD model, Digitizing Techniques: Mechanical Contact, Optical Non-contact, Data interface STL interface, data generation, Manipulation, Open files, Repair of STL files, Alternative RP interfaces.

UNIT 2 Part orientation and support generation: 12 Hrs.

Factors affecting part orientation, support structure design, Automatic support structure generation. Model Slicing and Contour Data organization: Model slicing and skin contour determination, Identification of external and internal contours, Contour data organization, Direct and adaptive slicing: Identification of peak features, Adaptive layer thickness determination, Skin contour computation. Tool path generation

UNIT 3 Part Building and Post Processing 11 Hrs.

Recoating, parameters affecting part building time, part quality. Part removal, finishing, curing. Other issues: Shrinkage, Swelling, Curl and distortion, Surface Deviation and accuracy, Build Style Decisions

UNIT 4 Rapid Prototyping machines and materials 11 Hrs.

Classification, Description of SLA, SLS, FDM, 3D Printing, LOM, SDM, Contour Crafting, 3D Welding, etc., CNC-machines and hybrid systems. Rapid Tooling and Manufacturing: Classification of RT Routes, RP of Patterns, Indirect RT: Indirect method for Soft and Bridge Tooling, Indirect method for Production Tooling, Direct RT: Direct RT method for Soft and Bridge Tooling, Direct method for Production Tooling

Max. 45 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Comprehend various types of rapid prototyping/3D printing techniques
CO2 - Solve the problems in RP process chain such as error in STL files, tessellation algorithms
CO3 - Examine the important factors affecting the final product accuracy and precision
CO4 - Comprehend the product development cycle, RT processes and reverse engineering solutions
CO5 - Evaluate the efficacy of the data processing techniques for 3D model reconstruction
CO6 - Understand the working principles of various 3D printing machines

TEXT/REFERENCE BOOKS

1. Jacobs, PF (Ed), Rapid Prototyping and Manufacturing, Society of Manuf. Engrs.
2. Chua C. K. and L. K. Fai, Rapid Prototyping: Principles and Applications in Manufacturing.
3. Gibson, I. (Ed.), Software Solutions for Rapid Prototyping, Professional Engineering Publications, UK

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 5 Questions (8 Marks each) 40 Marks
Part B/Question: 5 Questions (12 Marks each) 60 Marks

20MED517T					Elective IV: Theory of Elasticity and Plasticity					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	-	-	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To learn the theory and characteristics of Elasticity and Plasticity.
- To Solve Two dimensional Problems in Rectangular Coordinates using Complex functions.
- To learn and solve problems Elastoplastic Bending and Torsion.

UNIT 1 Introduction to Elasticity **08 Hrs.**

Introduction to Elasticity, Stress, Components, Hook's Law, Plane stress and Strain, Stress at a point, Strain at a point, Differential Equation of Equilibrium, Boundary Conditions, Compatibility Conditions, Stress Functions

UNIT 2 Two dimensional Problems in Rectangular Coordinates **12 Hrs.**

Solutions of Two dimensional Problems in Rectangular Coordinates: Saint Vanant's Principle, Bending of Beams by loaded at the end and uniform load, Solution by Fourier Series, Solutions of Two dimensional Problems in Curvilinear Coordinates: Functions of Complex Variable, Analytical solution through Laplace transform, Displacement and Stresses in terms of Complex Functions, Elliptical Hole loaded in uniformly stressed plate, Method of Muskhelishvili.

UNIT 3 Introduction to Plasticity **8 Hrs.**

Introduction to Plasticity, the stress strain behavior, Mohr's circle, Analysis and Concept of Strain Rate, The Criteria of yielding, Strain Hardening, The rule of Plastic Flow, Strain- Strain Relations, Total Strain Theory

UNIT 4 Elastoplastic Bending and Torsion **11 Hrs.**

Elastoplastic Bending and Torsion: Plane Strain Compression and Bending, Cylindrical bars under torsion and Tension, Pure bending of beams, Torsion of Bars, Combine bending and twisting of bars

Max. 39 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: **Recall** the fundamentals of Stress and Strain, Stress and Strain Components, Hook's Law.

CO2: **Explain** the Differential Equation of Equilibrium, Compatibility Conditions, stress functions in-terms of complex functions.

CO3: **Explain** the fundamentals concepts of Plasticity, stress-strain diagrams and relations

CO4: **Apply** the concepts of Stress Functions towards solving Elasticity Problems in Rectangular and Curvilinear Coordinates

CO5: **Apply** the concept of Plasticity to solve Elastoplastic Bending and Torsion problems

CO6: **Formulate** the elasticity and plasticity problems exist in Mechanical

TEXT/REFERENCE BOOKS

1. Timoshenko, S.P and J. N. Goodier, Theory of Elasticity, McGRAW-Hill, 1951.
2. Timoshenko, S.P. Winowsky. S., and Kreger, Theory of Plates and Shells, McGraw-Hill Book Co. 1990.
3. Kachanov. L.M., Fundamentals of the Theory of Plasticity, Dover Publication, 2004.
4. Dixit, P. M. and Dixit, U. S., Plasticity: Fundamentals and applications, CRC press, 2015.
5. Chakrabarty, J., Theory Of Plasticity, Elsevier.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100	**Exam Duration: 3 Hrs**
5 Questions of 2 marks each-No choice	10 Marks
4 Questions of 5 marks each-No choice	20 Marks
5 Questions of 10 marks each-one choice and 1 question of 20 marks	70 Marks

20MED518T					Vehicle Dynamics					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To understand the modelling approach for multibody systems like vehicles.
- To analyse the dynamic behaviour of a vehicle in different real-world scenarios.
- To understand the influence of sub-systems of a vehicle on its performance.
- To enable development of better technologies for superior vehicle performance.

UNIT 1 **12 Hrs.**

Multibody Systems: System definition and modeling, elements of multibody systems, equations of motion for multibody systems, fundamental approach to modeling.

One dimensional Dynamics of Vehicles: Various vehicle scenarios- Parked Car on a Level Road, Parked Car on an Inclined Road, Accelerating Car on a Level Road, Accelerating Car on an Inclined Road, Parked Car on a Banked Road, Vehicles on a Crest and Dip

UNIT 2 **13 Hrs.**

Road Loads: Aerodynamic Loads and its mitigation. Rolling resistance and their mechanisms.

Acceleration Performance: Power limited acceleration and traction limited acceleration.

Braking Performance of a vehicle: Basic equation for deceleration, braking forces, brakes and Anti-lock Braking System

Steering dynamics: Kinematics of steering, steering mechanisms, four-wheel steering, steering mechanism optimization, roll dynamics and rollover prevention: one DOF, four DOF roll dynamics, rollover dynamics, rollover index, Steady state cornering.

UNIT 3 **12 Hrs.**

Suspensions: Solid axles, Independent suspensions, anti-squat and anti – pitch suspension geometry, design and analysis of passive suspension, full half and quarter car models, model decoupling, verification of models, Active automotive suspensions, Active control, Active system asymptotes, trade - offs, Semi active suspensions, model analysis and optimal semi active suspension, suspension optimization.

UNIT 4 **08 Hrs.**

Tires: Tire stiffness, tire forces, rolling resistance, tire vibrations, Basic tire modeling considerations, semi – empirical type models, single contact point transient tire models, Longitudinal vehicle dynamics.

Max. 45 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – Demonstrate the modelling approach for multi-body systems.

CO2 – Build models for one-dimensional dynamics of vehicles.

CO3 – Examine various road loads along with the acceleration and braking performance of a vehicle.

CO4 – Analyse the steering dynamics of a vehicle.

CO5 – Analyse the effect of suspension systems on the performance of a vehicle.

CO6 – Determine the effect of tire characteristics on the performance of a vehicle.

TEXT/REFERENCE BOOKS

1. Fundamentals of Vehicle Dynamics by Thomas Gillespie, Society of Automotive Engineers.
2. Vehicle Dynamics and Control by Rajesh Rajamani, Springer publication.
3. Tire and Vehicle Dynamics by Hans B Pacejka, SAE International.
4. Ground Vehicle Dynamics by Karl Popp and Werner Schiehlen, Springer publication.
5. Vehicle Dynamics: Theory and Applications by Raza Jazor, Springer Publication

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

4 questions 10 marks each 40 Marks

4 questions 15 marks each 60 Marks

20MED506T					Machine Learning Applications in Design and Manufacturing					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	--	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To learn the advantages and architecture of machine learning algorithms.
- To design and formulate the algorithms from scratch.
- To select suitable algorithm for practical implementations.
- To systematically analyze the algorithms for design and manufacturing applications.

UNIT 1 Introduction **11 Hrs.**

History of Artificial Intelligence, Development, Architecture, Hardware and Software, Advantages and Disadvantages, Data Mining, Data Analysis, Machine Learning Case Study

UNIT 2 Machine Learning Techniques **12 Hrs.**

Introduction, Supervised, Unsupervised learning and semi supervised learning, advantages and disadvantages, regression analysis, forecasting techniques, cluster analysis, feature vector and its application for classification and regression analysis.

UNIT 3 Classification and Regression Analysis of Mechanical components **11 Hrs.**

Linear vs Non Linear Classifier, Linear regression, Logistic regression, Support vector Machine , Case study for rotating components such as bearing, gears, pumps etc.

UNIT 4 Classification and Regression Analysis in Manufacturing **11 Hrs.**

Historic development of Artificial Intelligence and Machine learning for manufacturing applications, Artificial neural network, Architecture, types of Artificial neural network ,Trees for classification and regression. Case study for tool wear rate classification and prediction, Texture analysis of machined components, future directions.

Max. 45 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: **Understand** the basics of machine learning and artificial intelligence.

CO2: **Analyze** and **Prepare** suitable architecture of machine learning framework.

CO3: **Identify** the suitable algorithm for implementations.

CO4: **Comprehend** various types of machine learning algorithms.

CO5: **Formulate** and **Organize** appropriate algorithm for rotary components.

CO6: **Design** and implement applications of classification and regression in manufacturing domain.

TEXT/REFERENCE BOOKS

1. D. Forsyth, Applied Machine Learning, Springer, first edition (2019)
2. E. Alpaydin, Introduction to Machine Learning, Pearson third edition (2015)
3. S.O. Hykin, Neural Networks and Learning Machines, Pearson ,third edition (2016)
4. C. Bishop, Pattern Recognition and Machine Learning, Springer, first edition (2006)

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100	**Exam Duration: 3 Hrs**
Part A : 2 Questions each carrying 5 Marks	10 Marks
Part B : 3 Questions each carrying 10 Marks	30 Marks
Part C : 4 Questions each carrying 15 Marks	60 Marks

20MED519T				Theory of Plates and Shells					
Teaching Scheme				Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	-	-	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To learn the theory and characteristics of plates and shells.
- To solve the problems of Symmetrical Bending of Circular Plates and Simply Supported Rectangular Plates.
- To learn and solve problems of shells for symmetric loading of cylindrical shells.

UNIT 1 Introduction **12 Hrs.**

Introduction to plates, History of plate theory development, general behavior of plates, Bending of Long Rectangular Plates: Differential equation for cylindrical bending of plates, Cylindrical bending of uniformly loaded rectangular plates with simply supported, Buit-in edges and Elastically buit-in edges, the effect of stresses and deflection of small displacement longitudinal edges in plane of plate, Pure Bending of Plates: Slope and Curvature of slightly bent plates, Relationship between bending moments and curvature, Strain Energy in Pure Bending

UNIT 2 Symmetrical Bending of Circular Plates **11 Hrs.**

Symmetrical Bending of Circular Plates: Differential Equation for symmetric bending, Uniformly loaded circular plates, Circular Plate with a Circular Hole at Centre, Circular Plate Concentrically Loaded, Circular Plate Loaded at the center, Small Deflections of laterally loaded plates: The Differential equation, Boundary Conditions, reduction of Problem from Plate to membrane

UNIT 3 Simply Supported Rectangular Plates **5 Hrs.**

Simply Supported Rectangular Plates: Plate Under Sinusoidal Load, Navier's solution and its applications, M. Lavy's Solution, Rectagular Plates with infinite length with simply supported edges.

UNIT 4 Shell Structures **12 Hrs.**

General remarks on shell structures, Theory of shell structures as a branch of structural mechanics, Generalised Hooke's law for an element of a shell, Mechanical properties of curved elements, Cylindrical shells under symmetric loading: The governing equation, Semi-infinite cylindrical shell, The ring and bend-loaded long cylindrical shell, the membrane hypothesis and Solution

Max. 39 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: **Recall** the the fundamentals of history and introduction to plates and shells.

CO2: **Explain** fundamentals of differential equation of cylindrical bending of circular plates and differential equation of Simply Supported Rectangular Plates

CO3: **Explain** fundamentals of shell structure and symmetrical loading of cylindrical shells.

CO4: **Apply** theory of plates to Simply Supported Rectangular Plates and to Symmetrical Bending of Circular Plates.

CO5: **Apply** the theory of shells to cylindrical shells under symmetric loading

CO6: **Formulate** 2D elasticity problems considering mechanical structure as a plate or shell.

TEXT/REFERENCE BOOKS

1. Timoshenko, S.P. Winowsky. S., and Kreger, Theory of Plates and Shells, McGraw-Hill Book Co. 1990.
2. Maan H. Jawad , Theory And Design Of Plate And Shell Structures, Springer, 1994.
3. Calladine C. R., Theory Of Shell Structures, Cambridge University Press, 1983
4. Ugural, A. C. Stresses in Plates and Shells. 2nd ed. New York, NY: McGraw-Hill, 1998

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100	**Exam Duration: 3 Hrs**
5 Questions of 2 marks each-No choice	10 Marks
4 Questions of 5 marks each-No choice	20 Marks
5 Questions of 10 marks each-one choice and 1 question of 20 marks	70 Marks

20MED520T					Design of Light Weight Structures					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	-	-	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To gain knowledge of different types of Light weight structures and its manufacturing techniques
- To gain an insight micro and macro mechanical design aspects of Composites
- To gain the knowledge of various mechanical testing of composites

UNIT 1 Introduction: **12 Hrs.**

Definition, Advantages of FRP, Applications, Types of Reinforcements, Fabrication, Structure and Properties, Matrix Materials: Types of Matrix Materials, Fabrication, Structure and Properties, Types of interfaces Processing, Structure Properties, PMC, MMC, CMC, CCC, Recycling: Chemical & Mechanical methods recovery.

UNIT 2 Micro Mechanical Behavior of a Lamina: **11 Hrs.**

Materials approach to stiffness, determination of elastic constants E1, E2, G12, υ12, Elasticity approach to stiffness, The Haplin Tsai equations, Mechanics of materials approach to strength, tensile and compressive strength in fiber direction.

UNIT 3 Macro-mechanics of a laminate **11 Hrs.**

Classical lamination theory, lamina stress strain behavior, stress strain variation in a lamina, resultant forces and moments in laminate, strength of laminates, strength analysis, thermal and mechanical stress analysis, strength of cross ply, angle ply laminates, inter laminar stresses, elasticity formulation, elasticity solution results.

UNIT 4 Mechanical Testing of Composites: **11 Hrs.**

Tensile, Compressive strengths, Fracture modes Bending, Buckling and Vibration of Laminated Plates: Governing equations, deflection, buckling, vibration of simply supported laminated plates

Max. 45 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Comprehend various types and manufacturing of Composites
CO2 - Design of Composites based on mechanics of materials approach
CO3 - Design of Composites based on various failure criteria
CO4 - Evaluate stress and strain based on classical laminate theory
CO5 - Evaluate various stresses using macro-mechanics of laminate theory
CO6 - Understand the mechanical testing methods of composites

TEXT/REFERENCE BOOKS

1. Krishan K. Chawla, “Composite Materials: Science and Engineering”, 2nd ed. Springer-Verlag, 2010
2. Robert M. Jones, “Mechanics of Composite Materials”, 2nd Ed. Taylor and Francis, New Delhi, 2010
3. Autar K. Kaw, “Mechanics of Composite Materials”, 1st Edition. Taylor and Francis, New Delhi, 2009.
4. B.D. Agrawal L.J. Broutman and K. Chandrashekhara “Analysis and Performance of Fiber Composites”, John Wiley & Sons Inc, 2006.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 5 Questions (8 Marks each) 40 Marks
Part B/Question: 5 Questions (12 Marks each) 60 Marks

20MED521T					Industrial Tribology and Lubrication					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	-	-	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- Understand the basic concept of friction, wear and lubrication.
- To apply the underlying concepts, methods and application of Industrial Tribology.
- To Familiarize with current research trends in field of tribology

UNIT 1 INTRODUCTION TO TRIBOLOGY **10 Hrs.**

History and significance of Tribology, Tribology principles, Stribeck curves and lubrication regimes, selection of different types of bearings, Types of Lubricants: viscosity index, SAE grade and API index, Solid surface characterization, Methods to measure surface roughness.

UNIT 2 FRICTION AND WEAR **10 Hrs.**

Genesis of friction, laws of friction, Mechanism of sliding and rolling and friction, bearing materials, Definition of wear, Mechanism of wear, Measurement of friction and wear, factors affecting wear, Wear of metals and non-metals.

UNIT 3 LUBRICATION **10 Hrs.**

Fundamentals of fluid flow: mass and momentum conservation equation, Energy equation, laminar and turbulent flow in bearing, order of magnitude analysis. Different types of fluid film bearings: journal bearing, thrust bearing, hydrostatic bearing, squeeze film bearings, aerostatic bearing. Rolling Element Bearings types and selection, bearing life capacity and variable loads, Bearings Failures, Bearing vibration measurement

UNIT 4 RECENT TRENDS IN TRIBOLOGY **10 Hrs.**

Biomimetic surfaces and their application in tribology, Introduction to Micro and nano-tribology (MEMS/NEMS), Green Tribology: Green Lubricants, Smart Lubricants, Introduction to standard bearing test rig, Use of numerical programming to simulate fluid film bearings.

Max. 40 Hrs.

COURSE OUTCOMES: On completion of the course, student will be able to

CO1: Build an understanding on the fundamentals and principles of applied Tribology.
CO2: Analyze and apply the concept of friction, wear and lubrication in an industrial context.
CO3: Analyze the various parameter that influence the performance of tribo-system.
CO4: Develop an ability to mathematically model and evaluate the performance of a tribo-system.
CO5: Apply principles of applied Tribology in design of energy efficient and eco-friendly bearing system.
CO6: Understand the working principle of different tribo-testing apparatus used in industry.

TEXT/REFERENCE BOOKS

1. Khonsari, M.M. and Booser, E.R., 2017. Applied tribology: bearing design and lubrication. John Wiley & Sons.
2. Bhushan, B., 2013. Introduction to tribology. John Wiley & Sons.
3. Harnoy, A., 2002. Bearing design in machinery: engineering tribology and lubrication. CRC press.
4. Majumdar, B.C., 2008. Introduction to tribology of bearings. S. Chand Publishing.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

5 questions of 2 marks each - No choice	10 Marks
4 questions of 5 marks each - No choice	20 Marks
5 questions of 10 marks each and one question of 20 Marks - No choice	70 Marks

20MED522T					Fracture Mechanics					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To examine the concept of failure in components with pre-existing flaws.
- To be able to understand and solve the fracture mechanics problems
- To be able to understand the fatigue crack propagation
- To get familiar with the Finite Element Analysis of Cracks in Solids

UNIT I : Linear Elastic Fracture Mechanics **15 Hrs.**

Introduction of kinds of failure; Brittle and Ductile Fracture; Modes of fracture failure; Griffith's energy balance; Instability and R-curves; Stress analysis of Cracks; Relationship between K and G; Crack-Tip Plasticity; Stress intensity factors; Westergaard's Approach

UNIT II : Elastic Plastic Fracture Mechanics **10 Hrs.**

Crack tip opening displacement, J Integrals, Crack-Growth Resistance curves, Crack tip constraint under large-scale yielding, creep crack growth

UNIT III : Fatigue crack propagation **10 Hrs.**

Fatigue crack propagation: Fatigue crack growth theories, empirical fatigue crack growth equations, S-N Curve, Crack Initiation, Crack Propagation, effect of an overload, Crack Closure

UNIT IV : Finite Element Analysis of Cracks in Solids **10 Hrs.**

Finite element method, Direct methods to determine fracture parameters, Indirect methods to determine fracture parameters- J-Integral method, energy release rate method, stiffness derivate method, singular elemet method

Max. <45> Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: Identify the theories of fracture and fatigue to solve linear elastic fracture mechanics problems
CO2: Understand the basic techniques to predict and control fatigue.
CO3: Apply the physical and mathematical principles of fracture mechanics
CO4: Analyze the shape and size of the plastic zone subjected to plane stress and plane strain condition
CO5: Evaluate the relationship between Crack tip opening displacement, Stress intensity factor, energy release rate and J integral
CO6: Create the fundamental concepts related to the basic engineering problems

TEXT/REFERENCE BOOKS

- Prashant Kumar, Elements Of Fracture Mechanics 1st Edition, McGrawHill India
- T. L. Anderson, Fracture Mechanics Fundamentals and Applications, CRC Press, 1994
- D. Brock,Elementary Engineering Fracture Mechanics, MaritinusNijhoff Publishers, 1982
- S. T. Rolfe and J. M. Barson, Fracture and Fatigue Control in Structures, PHI, 1977

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 8 questions of 2 marks each 16 Marks
Part B/Question: 6 questions of 14 marks each 84 Marks

20MED523T					BICYCLE DESIGN AND FRAME BUILDING					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	--	--	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To understand the bicycle geometry and bicycle ergonomics.
- To apply the basic science principle in design of bicycles.
- To develop and promote research interest in design and fabrication of E Bicycle and modular bicycle.

UNIT 1 Introduction **09 Hrs.**

Introduction to bicycle, Ergonomics of bicycle, Fundamentals of bicycle dynamics, Stability of bicycle, Steering of bicycle, Motion over uneven surfaces, Bicycle gear

UNIT 2 Design of Bicycle Frame **10 Hrs.**

Frame construction: Material selection, Frame design, Free body diagram of frame
FEM analysis of Frame: Two dimensional arbitrarily oriented beam elements, Rigid plane frame examples, Frame elements and implementation of frame elements into bicycle frame design

UNIT 3 Design of Bicycle Components **10 Hrs.**

Wheels selection and design: Design of spoke, Spared of spokes, Design of Bicycle transmission system: Bearings, Chain and Chain Gearing, Brakes, Bicycle suspension Design, Structural analysis and optimization of bicycle components using CAE tools

UNIT 4 Fabrication of Bicycle **10 Hrs.**

Bicycle Manufacturing processes: Basic of Welding, Brazing, Machining, and Polishing
Design and fabricate the E-Bicycle and Modular Bicycle, Case studies on E-Bicycle

Max. 39 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to
CO1 - **Understand** the bicycle ergonomics
CO2 - **Demonstrate, apply, explain**, and **identify** basic engineering and mechanical principles to design the bicycle.
CO3 - **Apply** Structural analysis and optimization of bicycle components using CAE tools and manual calculation.
CO4 - **Demonstrate** and employ Fundamentals of bicycle dynamics to design a Bicycle.
CO5 - **Demonstrate** and employ drafting principles to convey concepts for Modular and E-Bicycle.
CO6 - **Create** an ability to design and fabricate the different bicycle frames.

TEXT/REFERENCE BOOKS

1. Marc-Andre R. Chimonas, Lugged Bicycle Frame Construction: Third Edition
2. Archibald Sharp, Bicycles & Tricycles: An Elementary Treatise On Their Design and Construction, with Examples and Tables.
3. David Gordon Wilson, Bicycling Science, MIT Press
4. Stephen S Cheung and Mikel-Zabala, Cycling Science, Human Kinetics

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100	**Exam Duration: 3 Hrs**
5 Questions of 6 marks each –no choice	30 Marks
4 Questions of 10 marks each –no choice	40 Marks
2 Questions of 15 marks each –no choice	30 Marks