M. Tech. in
DESIGN ENGINEERING

(Effective from 2022-23)

DEPARTMENT OF MECHANICAL ENGINEERING

MOTILAL NEHRU NATIONAL INSTITUTE OF TECHNOLOGY ALLAHABAD

Vision and Mission of the Institute

VISION

To attain a distinct identity for the Institute through innovation, knowledge creation and dissemination for the benefit of the society.

MISSION

- To nurture an eco-system for continuous enhancement of value-based teaching and learning process in the emerging areas of technology.
- To train quality human and knowledge resources in the service of society.
- To develop sustainable products and technologies.

Vision and Mission of the Department

VISION

To be a centre of excellence in Mechanical, Production and Industrial Engineering education and research for the benefits of society and humanity.

MISSION

- To educate and develop competent human resources for contemporary industry, academia and research.
- To promote interdisciplinary research and innovation skills in the graduates.
- To enhance the efforts to develop sustainable products, processes and technologies by developing competent entrepreneurs for the benefit of the society.

Department of Mechanical Engineering:

Brief about the Department:

The Department of Mechanical Engineering is one of the oldest departments of the institute and was established in the year 1961. We are the largest community of excellent, energetic, and dynamic faculty, staff and students in the institute. The department is having highly qualified and experienced faculty (36 faculty members) in all streams of Mechanical Engineering. The department is broadly divided into three academic streams in which students receive outstanding education with a wide choice of specializations, electives and research areas. These three academic streams are: Design Engineering, Production and Industrial Engineering and Thermal Engineering.

The department offers eight semester (i.e. 4 year) Bachelor of Technology (B. Tech.) programmes in Mechanical Engineering and Production and Industrial Engineering. Every year 223 students are admitted through JEE (mains) and 15% of this intake is through Direct Admission to Students Abroad (DASA) scheme for the above two B. Tech. programmes. Some students are also through ICCR and MEA (Govt. of India) Schemes.

The department also offers four semester (i.e. 2 year) Master of Technology (M. Tech.) programmes in Computer Aided Design and Manufacturing, Design Engineering, Product Design and Development, Production Engineering and Thermal Engineering. Every year 125 students (25 in each specialization) are admitted through GATE in the above five M. Tech. programmes.

The department also offers Doctor of Philosophy (Ph.D.) programme in various areas of Mechanical Engineering as well as Production and Industrial Engineering. The strength of the department lies in its Ph.D. programme with more than 100 PhDs already been awarded till March, 2022. About 80 research scholars are presently pursuing their PhDs. Every year the department admits Ph.D. students equal to half of the number of faculty holding Ph.D. degree. The department is also a QIP centre for PhD and M. Tech programmes.

Today, the world of Mechanical Engineering changes under the influence of advanced computational tools, improved simulation and analysis, and entirely different manufacturing protocols. This has opened up new vistas of research in the department.

List of Programmes offered by the Department:

Program	Title of the Program
B. Tech.	Mechanical Engineering
	Production & Industrial Engineering
M. Tech.	Computer Aided Design and Manufacturing
	Design Engineering
	Product Design and Development
	Production Engineering
	Thermal Engineering
Ph.D.	Mechanical Engineering

M. Tech. – Mechanical Engineering

Program Outcomes

PO1	Able to independently carry out research /investigation and development work to solve practical problems in Engineering.
PO2	Able to write and present a substantial technical report/document.
PO3	Able to demonstrate a degree of mastery over Design Engineering at a level higher than the requirements in the appropriate bachelor program.
PO4	Ability to successfully utilise different design, modelling, and analysis tools in solving design-engineering problems.

SCHEME OF INSTRUCTION

M. Tech. Design Engineering – Course Curriculum Structure

S. No.	Code	Course	Credit	L-T-P	Contact Hours
Semester-I					
1	ME21101	Advanced Mathematics and Optimization	4	4-0-0	
2	ME21102	Material Modeling for Design	4	4-0-0	
3		Elective I	4	4-0-0	
4		Elective II	4	4-0-0	
5		Elective III	4	4-0-0	
		Total	**20**		
Semester-II					
1	ME22103	Dynamic Design of Mechanical Systems	4	4-0-0	
2	ME22201	Design Engineering Lab	4	0-0-6	
3		Elective IV	4	4-0-0	
4		Elective V	4	4-0-0	
5		Elective VI	4	4-0-0	
		Total	**20**		
Semester-III					
1	ME23651	State of the art Seminar / Special Study / Term Project	4		
2	ME23601	Thesis	16		
		Total	**20**		

Semester-IV					
1	ME24601	Thesis	20		
		Total	**20**		

Note: The distribution of thesis evaluation marks will be as follows.

1. Supervisor (s) evaluation component: 50%
2. Oral Board evaluation component: 50%

List of Electives and Minors: M. Tech. (Design Engineering)

S. No.	Code	Name
1.	ME21131	Computer Aided Design
2.	ME21301	Finite Element Analysis for Mechanical Design
3.	ME21302	Ergonomics for Mechanical Design
4.	ME21303	Design of Pressure Vessels
5.	ME21304	Mechatronic Product Design
6.	ME21305	Tribological System Design
7.	ME21306	Design of Robotic System
8.	ME21307	Lubrication and Rotor Dynamics
9.	ME21308	Design of Electronically Controlled Automobiles
10.	ME21309	Design of Micro-Electro-Mechanical System
11.	ME22310	Design against Fatigue and Fracture
12.	ME22311	Design for Manufacturing and Assembly
13.	ME22312	Designing with Advanced Materials
14.	ME22313	Optimization Methods for Mechanical Design
15.	ME22314	Design of Turbo Pumps
16.	ME22315	Machinery Fault Diagnostics and Signal Processing
17.	ME22316	Rapid Product Development
18.	ME22317	Product Design and Development
19.	ME22318	Reverse Engineering

Course Code: ME 21101	Advanced Mathematics and Optimization	Credits: 4-0-0:4

Prerequisites: Engineering Mathematics (Undergraduate level)

Course Outcomes

S. No.	Outcomes	BT Level	BT Description
CO1	Students will understand the concept of linear algebra, numerical methods, optimization technique and differential equations.	2	Understand
CO2	Students will be able to develop the algorithm and code for solving linear algebraic equations and eigenvalues problems for engineering applications.	6	Create
CO3	Students will be able to apply numerical methods to solve problems for engineering applications.	3	Apply
CO4	Students will be able to develop differential equations for engineering problems and find their solution.	6	Create
CO5	Students will be able to apply optimization techniques and tools to solve engineering design problems.	3	Apply

Course Articulation Matrix

	PO1	PO2	PO3	PO4
CO1	1	-	2	3
CO2	3	1	3	3
CO3	2	-	3	1
CO4	2	-	3	1
CO5	2	1	3	3

Unit	Details	Lectures	CO mapping
1	Linear Algebra: Vector space and its basis, Matrices as coordinate-dependent linear transformation, null and range spaces, Solution of linear algebraic equations: Gauss elimination and Gauss-Jordon methods, LU Decomposition and Cholesky method, Gauss-Seidel/ Jacobi iterative methods, Condition number, Minimum norm and least square error solutions	8	CO1, CO2
2	Eigenvalues and eigenvectors of matrices and their properties, Similarity transformation, Jordon canonical form and orthogonal diagonalization, Mises power method for finding eigenvalues/eigenvectors of symmetric matrices.	8	CO1, CO2
3	Numerical Methods: Solution of a non-linear algebraic equation and system of equations, Interpolation methods, Regression, Numerical Integration.	6	CO1, CO3
4	Ordinary Differential Equations (ODEs): Techniques of the separation of variable and the integrating factor for 1st order ODEs, Solutions of linear, 2nd order ODEs with constant	8	CO1, CO4

	coefficients and Euler-Cauchy ODEs, System of 1st order ODEs, Numerical methods for solving ODEs, Homogeneous, linear, 2nd order ODEs with variable coefficients: power series and Frobenius methods, Sturm-Louville problem, Laplace transform method for non-homogeneous, linear, 2nd order ODEs: discontinuous right-hand sides		
5	Optimization: Introduction to Optimal Design: feasibility and boundedness, topography of search space, classification of methods. Single/Multi variable optimization problems, Gradient and Direct search based methods. Constrained and unconstrained problems, problems with non-linear constraints.	10	CO1, CO5

Text Books:

1	Advanced Engineering Mathematics	Erwin Kreyszig	Wiley Publication
2	Optimization for engineering design: algorithms and examples	Kalyanmoy Deb	Prentice-Hall of India Private Limited Publications

References:

1	Applied Mathematical Methods	Bhaskar Dasgupta	Pearson Education Publications
2	Advanced Engineering Mathematics	Peter V. O'Neil	Cengage Learning
3	Engineering Optimization: Theory and Practice	S S Rao	New Age International (P) Limited Publishers
4	OPTIMIZATION: Algorithms and Applications	Rajesh Kumar Arora	CRC Press

Course Code: ME21102	Material Modeling for Design	Credits: 4-0-0:4

Prerequisites: Mechanics of Materials, Material Science and Engineering

Course Outcomes

S. No.	Outcomes	BT Level	BT Description
CO1	Students will be able to understand the basic notion of tensor algebra and tensor calculus used in mathematical modelling of material.	2	Understand
CO2	Students will be able to evaluate the different measures of stress, strain, and kinematics of continuous medium	5	Evaluate
CO3	Students will be able to analyse various theoretical elements of the continuum mechanics in materials.	4	Analyse
CO4	Students will be able to apply the concepts of elasticity, plasticity, viscoelasticity and balance principles for a variety of materials.	3	Apply
CO5	Students will be able to create mathematical models of materials.	6	Create

Course Articulation Matrix

	PO1	PO2	PO3	PO4
CO1	1	1	1	3
CO2	2	2	3	3
CO3	3	3	3	3
CO4	3	3	3	3
CO5	3	3	3	3

Unit	Details	Lectures	CO mapping
1	**Mathematical Preliminaries:** Definition of scalar, vector and tensor, index notation, kroneckar delta and permutation symbol, dyadic product, transformation of tensors, tensor algebra, calculus of cartesian tensor, orthogonal curvilinear coordinates	5	CO1
2	**Analysis of strain:** Introduction, engineering strain and true strain, kinematics of continuous medium, material derivative, deformation gradient tensor, spin tensor, finite strain, and deformation, lagrangian and eulerian formulations, geometric measures of strain, relative deformation gradient, rotation and stretch tensor	9	CO2

3	**Analysis of stress:** Body forces and surface forces, traction or stress vector, stress components, stress transformation principal stresses, stress invariants, spherical and deviatoric stress tensors	4	CO2
4	**General principles:** Integral transformation, flux, conservation of mass, continuity equation, momentum principle, equation of motion and equilibrium, couple stresses, energy balance, first law of thermodynamics, energy equation, principle of virtual displacement, entropy and the second law of thermodynamics, the Clausius duhem Inequality, thermodynamic tensions, thermodynamic potentials, dissipation function.	9	CO3
5	**Constitutive equations:** Isotropy, hyperelasticty, the strain energy function, Material symmetry, Stress and Strain Transformations, Stiffness and Compliance Transformations **Plane problems:** Plane stress and strain, antiplane strain, Airy stress function, Polar coordinate formulation, Solution of two-dimensional plane problems	7	CO4
6	**Plasticity:** Plastic behaviour of metals, theories neglecting work hardening: Levy-Mises perfectly plastic, Prandtle-Reuss Elastic perfectly plastic, Yield condition, Plastic Potential Theory, hardening assumptions, deformation theory. **Viscoelasticity:** Linear viscoelastic response: glass transition temperature, creep, stress relaxation and periodic response, constitutive equation based on analogies to spring and dashpot models. **Advance topics (Self-study):** Dislocation modeling, singular stress states, elasticity theory with voids, Homogenization.	8	CO4, CO5

Text Books:

1	Continuum Mechanics Modeling for Materials Behavior	Martin H. Sadd,	Academic Press, Elsevier

References:

1	Elasticity: Theory, Applications, and Numerics,	Martin H. Sadd,	Elsevier
2	Introduction to the Mechanics of a Continuous Medium	Lawence Malvern	Prentice-Hall Inc.
3	Micromechanics of defects in solids	Mura T, Martinus Nijhoff	The Hague
4	Micromechanics: Overall Properties of Heterogeneous Materials	Nemat-Nasser S. and Hori M	Elsevier, Oxford.

Course Code: ME-17308	Dynamic Design of Mechanical Systems	Credits: 3-1-0:4

Prerequisites: Engineering Mechanics, Strength of materials (AM13104)

COURSE OUTCOME

Sl. No.	Outcomes
CO1	To learn basic concepts of vibration
CO2	To identify system components and model the system for vibration study and analysis
CO3	To solve the single and multi-degree freedom vibration model using analytical and numerical methods.
CO4	To evaluate/interpret and analyse the results to justify the dynamic design

CO-PO Mapping

	PO1	PO2	PO3	PO4
CO1	**2**	**3**	**3**	**1**
CO2	**3**	**3**	**2**	**1**
CO5	**2**	**3**	**3**	**2**
CO6	**3**	**2**	**2**	**1**

Unit	Content	Lectures
1	Introduction to modal testing-Overview of dynamic design and modal analysis. Use of MATLAB for solving vibration engineering problems. Basics of modal analysis and presentation and properties of FRF data for SDOF system, undamped multi-degrees-of-freedom systems(MDOF), proportional damping, hysteretic damping, viscous damping, characteristics and presentation of MDOF FRF data	8
2	**Mobility measurement techniques**-Basic measurement system, structure preparation, excitation of the structure, transducers and amplifiers, analyzers, digital signal processing, use of different excitation types, calibration, mass cancellation.	8
3	**Modal parameter extraction methods-**System identification techniques (SDOF and MDOF), Preliminary checks of FRF data, SDOF modal analysis – Peak amplitude, circle-fit method, inverse method, residuals, introduction to MDOF curve-fitting procedure – extension of SDOF method.	8
4	**Derivation of Mathematical models**: Modal models, display of modal model, response models, spatial models, mobility skeletons and system models.	8
5	**Application**: Comparison of experiment and predication, correction or adjustment of	8

models. Structural modifications and its optimization. Response predication and force determination. Application of modal analysis to real structures. Case studies.

Text/Reference Books:

1	Modal Analysis	Jimin He and Zhi-Fang Fu	Butterworth-Heinemann
2	Modal testing; Theory, Practice and application,	D J Ewins, research studies Press Ltd.	research studies Press Ltd.
3	Fundamental of mechanical Vibration	S grahm Kelly	McGraw-Hill Intl. Editions
4	Mechanical Vibration	S S Rao	Addition-Wesley publishing company

Course Code: ME22201	Design Engineering Lab	Credits: 0-0-3:3

Prerequisites: NIL

Course Outcome

S.N.	Outcomes
CO1	Able to determine different material properties
CO2	Able to apply concepts of design and Finite Element Method in modelling and analysis of machine components
CO3	Able to determine damage and response of machine components

Course Articulation Matrix:

	PO1	PO2	PO3	PO4
CO1	1	1	3	2
CO2	3	1	3	3
CO3	2	1	2	2

Module	Content	Lab
1.	To determine Young's Modulus and Poisson's ratio of a composite material by FE analysis.	**1**
2.	To determine stress intensity factor and J-integral of a specimen by FE analysis.	**2**
3.	To design a mechanical crankshaft, CAD modelling, FE analysis and its validations.	**3**
4.	To design a mechanical piston, CAD modelling, FE analysis and validations.	**4**
5.	To draw S-N diagram of a material by rotating beam experiment and determine the fatigue strength.	**5**
6.	To determine fracture toughness of a material.	**6**
7.	To determine fatigue crack growth rate and material constants of the Paris Equation.	**7**
8.	To determine wear rate of a material under dry & lubricated conditions by Pin on Disc Friction and Wear Test Apparatus.	**8**
9.	To determine erosion wear rate of a material at room and elevated temperature by Air Jet Erosion Test Set-up.	**9**
10.	To study the control of flow, temperature, pressure & level and determine process control parameters.	**10**
11.	To measure the vibration of rotor-bearing system using DAQ [Data acquisition system].	**11**
12.	To find the frequency response function of a cantilever beam.	**12**
13.	To study the fault signatures of rotor bearing system.	**13**
14.	Design, Modelling and 3-D printing of a machine component.	**14**
15.	To determine damage in a component/structure by using EMI technique.	**15**
16.	To design and manufacture a composite material and determine	**16**

	mechanical properties.	
17.	Industrial Visit	**17**
18.	Design Project	**18**

Note: Any 12 Practical from the list given above:

Text and Reference Books:

1. Mechanical Vibrations, Singiresu S. Rao, Prentice Hall; 5th Edition (2011)
2. MATLAB Vibration Analysis online help: https://in.mathworks.com/help/signal/vibration-analysis.html
3. NPTEL Course: Machinery Fault Diagnosis and Signal Processing: https://onlinecourses.nptel.ac.in/noc22_me60/preview
4. Principles of Tribology (Chapter 15, Tribological Experiments), Shizhu Wen, Ping Huang; Wiley
5. http://www.digimat.in/nptel/courses/video/112102014/L01.html
6. Prashant Kumar, Elements of Fracture Mechanics, McGraw Hill
7. Fracture Toughness Testing (NPTEL): http://www.youtube.com/watch?v=ygGX09hCHj4

PO1	Able to independently carry out research /investigation and development work to solve practical problems in Engineering.
PO2	Able to write and present a substantial technical report/document.
PO3	Able to demonstrate a degree of mastery over Design Engineering at a level higher than the requirements in the appropriate bachelor program.
PO4	Ability to successfully utilise different design, modelling, and analysis tools in solving design-engineering problems.

Course Code: ME21131	Computer Aided Design	Credits: 4-0-0:4

Prerequisites: None

Course Outcomes

CO1	Students will be able to model the objects geometrically with curves, surfaces and solids by their mathematical representations.
CO2	Students will be able to apply geometrical transformations to an available geometric model.
CO3	Students will be able to create different projections of an available geometric model.
CO4	Students will be able to analyse the applications of solid modelling in product development.

Course Articulation Matrix

	PO1	PO2	PO3	PO4
CO1	2	1	2	3
CO2	2	1	2	3
CO3	2	1	2	3
CO4	3	1	3	3

Unit	Details	Lectures
1.	Introduction: Historical Development, Explicit and Implicit Equations, Intrinsic Equations, Parametric Equations, Coordinate Systems.	2
2.	Design of Curves: Fundamental of Curve Design, Parametric Space of a Curve, Reparametrization, Parametric cubic curve, Blending functions, Truncation, extension, and subdivision, composite curve: continuity requirements, Spline Curves, Bezier Curve, B-Spline Curve, Rational Polynomials, Rational curves, NURBS.	10
3.	Geometric Transformations: Translation, Rotation, Scaling Symmetry and Reflection, Homogeneous Transformations. Orthographic Projections, Axonometric Projections, Oblique Projections, Perspective Transformation.	6
4.	Design of Surfaces: Fundamental of Surface Design, Parametric Space of a Surface, Reparametrization of a Surface patch, Sixteen point form, Four Curve Form, Plane, Cylindrical and Ruled Surfaces, Surfaces of Revolutions, Bezier Surface, B-Spline and NURBS Surfaces.	8
5.	Design of Solids: Parametric Solid, Tricubic Solid, Curves and surfaces embedded in a Solid, Generalized notion scheme and higher dimension elements. Instances and parametric shapes, Sweep Solids, Controlled Deformable solids. Complex model construction: Topology of Models: Euler's formula, connectivity number, genus, Euler-Poincare formula, topological atlas, Orientation, non-orientable surface, topology of closed curved surfaces, Gauss-Bonnet theorem, Euler operators, Euler object, topological disc, nets. Graph based models, Boolean algebra, Boolean model construction, Constructive Solid Geometry, Boundary Models, Data transfer in a collaborative environment.	8
6.	Geometric Properties: Local and global properties of a curve, Local and global properties of a surface, Global properties of complex solids, Relational properties, intersections. Applications in Product Development	6

and other areas.

Reference Books:

1	Geometric Modeling	M E Mortenson	McGraw Hill Education
2	Mathematical Elements of Computer Graphics	Rogers and Adams	McGraw Hill Education
3	CAD/CAM: Theory and Practice	Ibrahim Zeid	McGraw Hill Education
4	Computer-Aided Engineering Design	B Sahay and A Saxena	Springer
5	Rapid Prototyping: Principles and Applications	C K Chua, K F Leong and C S Lim	Cambridge University Press

Course Code: ME-21301	Finite Element Analysis for Mechanical Design	Credits: 4-0-0:4

Prerequisites: None

Course Outcomes

CO1	Students will be able to understand the fundamental aspects of finite element method.
CO2	Students will be able to formulate the 1d engineering problems and solve them by hand calculations and FE software.
CO3	Students will be able to formulate the 2d engineering problems and solve them by hand calculations and FE software.
CO4	Students will be able to formulate the 3d engineering problems and solve them by programming and FE software.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4
CO1	2	1	2	1
CO2	2	1	2	3
CO3	2	1	2	3
CO4	2	1	2	3

Unit	Details	Lectures
1	**Introduction:** Basic concept, Historical background, and General applications of finite element method.	1
2	**Approaches of FEM:** Discrete, Variational and Weighted Residual.	5
3	**Direct Problems:** 1-D Rod and Heat conduction, Truss Systems, Solution and its post processing by hand calculations and FE software	6
4	1**-D Thermal and Beam Bending Problems:** Formulation using Galerkin and Rayleigh-Ritz approaches, Derivation of elemental equations and their assembly, Solution and its post processing by hand calculations and FE software.	6
5	**2-D Thermal and Plane stress, Plane strain and Axi-symmetric Problems-** Formulation using Galerkin and Rayleigh-Ritz approaches, Derivation of elemental equations and their assembly, Solution and its post processing by hand calculations, and FE software.	8

6	**3-D Thermal and Stress Problems-** Formulation using Galerkin and Rayleigh-Ritz approaches, Derivation of elemental equations and their assembly, Solution and its post processing by programming and FE software.	6

Textbooks:

1	A first course in the finite elementmethod	Daryl L. Logan	Cengage Learning India Pvt. Ltd
2	Textbook of Finite Element Analysis	P Seshu	PHI

References:

1	Introduction to Finite Elements in Engineering	TirupathChandrupatla, AshokBelegundu	Pearson
2	The Finite Element Method for Engineers	Kenneth H. Huebner, Donald L. Dewhirst, Doughlas E. Smith	Wiley India Pvt.Ltd
3	Fundamentals of Finite Element Analysis	David V. Hutton	Tata McGraw Hill Education
4	The Finite Element Method in Engineering	S. S. Rao	Butterworth-Heinemann
5	Finite Element Procedure	K. J. Bathe	PHI
6	Concept and Applications of Finite Element Analysis	Robert D. Cook, David S. Malkus, Michael E. Plesha, Robert J. Witt	John Wiley

Course Code: ME21302	Ergonomics for Mechanical Design	Credits: 3-1-0:4

Prerequisites: Product Design and Development

Course Outcomes

CO1	Students will be able to apply the physical ergonomics concepts for the product improvement.
CO2	Students will be able to apply ergonomics concepts for the design of work space and work environments.
CO3	Students will be able to understand the human information processing and apply these principles for the product interface design.
CO4	Students will be able to apply human factors in product design for enhanced safety.

Course Articulation Matrix

	PO1	PO2	PO3	PO4
CO1	2	1	3	3
CO2	2	2	3	3
CO3	3	2	3	3
CO4	3	2	3	3

Unit	Details	Hours
1	Introduction to ergonomics and relevance to design, Anthropometric measures and use of anthropometric data.	4
2	Physiology, Biomechanics, Kinesiology, Work-related musculoskeletal disorders.	7
3	Workspace Design: Postural triangle, design for standing operator, design for sitting operator, design for hand use, design for foot operation.	8
4	Manual material handling, Hand tool design.	6
5	Human information processing, Design of controls and displays, Graphic-user interface, Tactile interface.	6
6	Human Error, Accidents, and Safety, Human Factors in Systems Design.	4

Text Books:

1	Human Factors in Engineering and Design	S M Sanders and E J McCormick	McGraw Hill Publication
2	Introduction to Ergonomics	R S Bridger	McGraw Hill Publication
3	Ergonomics - How to design for ease and efficiency	K Kroemer, H Kroemer, and K E Kroemer-Elbert	Prentice Hall

References

1	Human – Computer Interaction	A Dix, J Finlay, G D	Pearson Education

		Abowd and R Beale	
2	Ergonomics and safety in hand tool design	C A Cacha	Lewis Publishers
3	The Design of Everyday Things	D Norman	Basic Books
4	Ergonomics for beginners: Industrial design perspective	https://nptel.ac.in/courses /107103004	
5	Applied Ergonomics	https://nptel.ac.in/courses /112104222	

Course Code: ME21306	Design of Robotic System	Credits: 3-1-0:4

Prerequisites: Basic knowledge of Kinematics, Automation and Control Systems.

Course Outcomes

CO1	Students will be able to understand the concepts of robotics and automation systems. Basic components robot manipulator and their working principles.
CO2	Students will be able to Identify and Classify the types of industrial robots based on kinematic structure, DOF, control system and actuation.
CO3	Students will be able to Analyse and evaluate the motion analysis such as Robot kinematics, Motion dynamics, trajectory planning & Robot work envelopes etc. Identify and Classify the types of sensors and actuators.
CO4	Students will be able to Apply and analyse the acquired knowledge for designing the robot, Robot Programming methods for motion planning, gripper force analysis for specific applications. To get familiar with the latest improvements in robotics technology.

Course Articulation Matrix

	PO1	PO2	PO3	PO4
CO1	1	1	2	3
CO2	2	2	3	3
CO3	3	3	3	3
CO4	3	3	3	3
CO5	3	3	3	3

Unit	Details	Lectures
1	**Introduction:** Past, Present & Future; Robot Terminology; Applications, Components and Subsystems; Classification of Robot, End Effectors, Different types of grippers and design concepts.	6
2	**Motion Analysis:** Homogeneous transformations as applicable to rotation and translation – problems.	6
3	**Robot Kinematics:** Specifications of matrices, D-H notation joint coordinates and world coordinates Forward and inverse kinematics – problems. Differential transformation and manipulators, Jacobians – problems.	6
4	**Dynamics:** Lagrange – Euler and Newton – Euler formations – Problems.	6
5	**Trajectory planning and avoidance of obstacles:** path planning, Skew motion, joint integrated motion, straight line motion – Robot programming, languages and software packages. Robot actuators and Feedback components: Actuators: Pneumatic, Hydraulic actuators, electric & stepper motors. Feedback components: position sensors – potentiometers, resolvers, encoders	8

Text Books:

1	Robotics	Fu K S	McGraw Hill

References:

1	An Introduction to Robot Technology	Coiffet and Chaironze	Kogam Page Ltd. London
2	Robotic Engineering	Richard D. Klafter	Prentice Hall
3	Robot Analysis and Intelligence	Asada and Slow time	Wiley Inter-Science
4	Introduction to Robotics	John J Craig	Pearson Edu
5	Robot Dynamics & Control	Mark W. Spong and M. Vidyasagar	John Wiley & Sons

Course Code: ME 22310	Design Against Fatigue and Fracture	Credits: 4-0-0:4

Prerequisites: Material Modeling for Design/Introduction to Solid Mechanics

Course Outcomes

S. No.	Outcomes	BT Level	BT Description
CO1	Apply approaches of fracture mechanics in the design of products and systems.	3	Apply
CO2	Formulate the effect of cracks, flaws on mechanical behavior of components.	6	create
CO3	Analyze and determine the effect of inherent/nucleated cracks and flaws under monotonic and fluctuating load conditions both analytically and experimentally.	4	Analyze
CO4	Evaluate the life of components under fluctuating load.	5	Evaluate

Course Articulation Matrix

	PO1	PO2	PO3	PO4
CO1	2	-	3	1
CO2	2	-	3	1
CO3	2	2	3	3
CO4	2	-	3	1

Unit	Details	Lectures	CO mapping
1	Stress concentration effect of flaws, Cracks as stress raisers; The Griffith energy balance, The energy release rate, Crack growth instability analysis and R-curve.	6	CO2
2	Stress analysis of cracks: Generalised In-plane Loading (Williams approach), Westergaard stress function, Behaviour at Crack Tips in Real Materials; Effects of Cracks on Strength; Effect of Cracks on Brittle versus Ductile Behaviors, The stress Intensity factor K, Effect of size, Principle of superposition, Weight functions, Crack tip plasticity, Fracture toughness, K as a failure criterion, Trends of K_{IC} with material; Effects of Temperature and loading rate; Microstructural Influences on K_{IC}; Mixed mode fracture.	8	CO1, CO2
3	Crack tip opening displacement (CTOD), The J-contour integral, J as a nonlinear energy release rate, The HRR singularity, J as a Path-Independent Line Integral, J as a Stress Intensity Parameter, The large strain zone, Laboratory measurement of J, Relationship between J and CTOD.	7	CO1, CO2 CO3
4	Micro-mechanism of fatigue, Introduction, Fatigue Design Criteria : Infinite life design, safe life design, fail-safe design, Damage Tolerant Design, Fatigue Tests and the stress-life (S-N) Approach.	6	CO1, CO4

5	Cyclic deformation and the strain-life (ε-N) approach, Fundamentals of LEFM and application to fatigue crack growth LEFM concepts, Cyclic plastic zone size, fatigue crack growth, mean stress effect, Experimental measurement of fatigue crack growth.	6	CO1, CO4
6	Fatigue from variable amplitude loading: Spectrum loading, Cumulative damage theories, Load interaction and sequence effects, cyclic counting method, crack growth and life estimation methods.	7	CO1, CO4

Text Books

1	Fracture Mechanics	Michael Janssen, Jan Zuidema and Russell Wanhill	Spon Press (Taylor & Francis Group)
2	Metal Fatigue in Engineering	R.I. Stephens , A.Fatemi, R.R. Stephens and H.O. Fuchs	John Wiley

Reference:

1	Fracture Mechanics: Fundamentals and Applications	T.L.Anderson	CRC Press
2	Fundamentals of Fracture Mechanics	J.F.Knott	Butterworths
3	Fatigue Damage, Crack Growth and Life Prediction	F.Ellyin	Chapman & Hall
4	Elementary Engineering Fracture Mechanics	D. Broek	Kluwer Academic
5	Fracture Mechanics with an introduction to micromechanics	Gross and Seelig	Springer
6	Elements of Fracture Mechanics	Prashant Kumar	Tata McGraw Hill
7	Deformation and Fracture Mechanics of Engineering, Materials	R.W. Hertzberg	John Wiley

Course Code: ME-22313	Optimization Methods for Mechanical Design	Credits: 3-0-0:3

Prerequisites: Operational Research & Mathematics

Course Outcomes

S. No.	Outcomes	BT Level	BT description
CO1	Student will be able to understand the formulation of optimization problems	2	Understand
CO2	Student will be able to solve the single and multi-variable optimization problems	3	Apply
CO3	Student will be able to solve the constrained and specialized optimization problems	3	Apply
CO4	Student will be able to solve the non-traditional optimization problems.	3	Apply

Course Articulation Matrix

	PO1	PO2	PO3	PO4
CO1	3	2	2	2
CO2	3	2	2	1
CO3	3	3	3	3
CO4	3	3	3	2

Unit	Details	Lectures
1	**Introduction**- Terminology, Design Variables, Constraints, Objective Function, Variable Bounds, Problem Formulation, Engineering Optimization Problems, Calculus Method, Linear Programming-Simplex Method, Concept of Dualit. .	6
2	**Single Variable Optimization Problems:** Optimality Criterion, Bracketing Methods: Exhaustive Search Method, Bounding Phase Method, Region Elimination Methods: Interval Halving Method, Fibonacci Search Method, Golden Section Method, Successive Quadratic Estimation Method. Gradient Based Methods: Newton-Raphson Method, Bisection Method, Secant Method, Application to Root finding	5
3	**Multivariable Optimization Algorithms:** Optimality Criteria, Unidirectional Search, Direct Search Methods: Box Method, Hooke-Jeeves Pattern Search Method/ Powell's Conjugate Direction Method. Gradient Based Methods: Any two of the following: Cauchy's Steepest Descent Method, Newton's method, Marquardt's Method, Powell's Conjugate Gradient Method, Variable-metric (DFP) Method .	6
4	**Constrained Optimization Algorithms:** Kuhn Tucker Conditions, Transformation Methods: Penalty Function Method, Method of Multipliers (MOM), Sensitivity Analysis.	6

5	**Specialized Algorithms:** Integer Programming: Penalty Function Method, Branch and Bound Method, Geometric Programming, Applications.	6
6	**Non-Traditional Optimization Algorithms:** Genetic Algorithms: Basic Theory, Operators, Working, Differences between GAs and Traditional Methods, GAs for Constrained Optimization, Simulated Annealing, Elementary Idea of Neural Networks and Fuzzy Logic, Ant Colony Optimization, Particle Swarm Optimization.	4

Text Books:

1	Optimization for engineering design: algorithms and examples	Kalyanmoy Deb	Prentice-Hall of India Private Limited, New Delhi
2	Engineering optimization: theory and practice	Singiresu S Rao	Fourth Edition, New Age International (P) Limited Publishers, New Delhi

References:

1.	Engineering optimization - methods and applications.	A. M. Natarajan, P. Balasubramani, A. Tamilarasi	Pearson Education, 2013.
2.	Optimization in Operations research	Rardin, Ronald L.	Pearson Education
3.	Operations Research	Sulabha K. Kulkarni	Springer
4.	Operations Research Theory and Applications	J K Sharma,	MacMillan India Ltd.

5. https://www.youtube.com/watch?v=aJKuM4U-eYg

6. http://www.digimat.in/nptel/courses/video/111105039/L31.html

Course Code: ME-22318	Reverse Engineering	Credits: 4-0-0:4

Pre-requisites: PH-1101 Physics-I and MA-1101 Mathematics-I

COURSE OUTCOME

S.N.	Outcomes
CO1	Understand the various techniques for acquiring 3D coordinates of the points lying on the physical object and pre-process it
CO2	Construct the first order approximation surface with data point (triangular mesh modelling) for the computation of various topological and geometrical properties
CO3	Segment the data points for exact fitting of surfaces
CO4	Construct Surface model so as to be used for various engineering applications like analysis, modification, manufacturing etc.

CO-PO Mapping

	PO1	PO2	PO3	PO4
CO1	2	-	-	3
CO2	2	-	2	3
CO3	2	-	1	3
CO4	2	-	1	3

Unit	Details	Lectures
1	**Introduction:** Need of Reverse Engineering, definition, application	2
2	**Data acquisition technique:** Contact method, coordinate measurement machine and robotic arms Non-contact methods, triangulation , Structured Light etc.	8
3	**Pre - processing technique:** Need of pre-processing, import of the point cloud data, registration , data reduction and filtering	5
4	**Triangular mesh modelling:** Need of triangular mesh model and its definition , topological characteristics, Euler formula for triangular mesh model, various methods of construction of triangular mesh model	8
5	**Segmentation**: Definition and need of segmentation, various methods used for segmentation like edge based and face based method of segmentation	8
6	**Curve and Surface modelling**: Parametric form of curves and a surfaces, Hermite curve and surface, Bezier curve and Surface, B-spline curve and Surface, Introduction of NURBS	8
7	**B-Rep model creation:** Need of consistent and contiguous model, Blending curves and surfaces	3

Text/Reference Books:

1	Reverse Engineering and Industrial Prospective	Raja, Vinesh, Fernandes, Kiran J.	Springer Series in advanced Manufacturing

2	Reverse Engineering- Recent Advances and Applications	Alexander C Telea	Intech Janeza trotline
3	Smart Product Engineering	Michael Abramovici, Rainer Stark	Springer Berlin Heidelberg

Course Code: ME21303	Design of Pressure Vessels	Credits: X-0-0:X

Cylindrical Shell and Various Closures: Membrane theory for thin shells, stresses in cylindrical, spherical and conical shells, dilation of above shells, general theory of membrane stresses in vessel under internal pressure and its application to ellipsoidal and torispherical end closures. bending of circular plates and determination of stresses in simply supported and clamped circular plate. Introduction to ASME code and formulae.

Junction Stresses, Opening and Reinforcements: Discontinuity stresses. stress concentration in plate having circular hole due to bi-axial loading. theory of reinforced opening and reinforcement limits.

Support Design: Supports for vertical & horizontal vessels. design of base plate and support lugs. types of anchor bolt, its material and allowable stresses. design of saddle supports. Buckling in Vessels:

Buckling of vessels:- under external pressure. Elastic buckling of long cylinders, buckling modes, collapse under external pressure. design for stiffening rings. buckling under combined external pressure and axial loading. Piping stress analysis: Flow diagram, piping layout and piping stress analysis. flexibility factor and stress intensification factor.

References:

1	Pressure Vessel Design	Harvey J F	Cbs Publication
2	Process Equipment Design	Brownell. L. E & Young. E. D	Wiley Eastern Ltd., India
3	Pressure Vessel Design Hand Book	Henry H Bednar	Cbs Publishers And Distributors
4	Chemical Process Equipment, Selection And Design	Stanley M Wales	Butterworths, Series In Chemical Engineering, 1988

Course Code: ME21304	Mechatronic Product Design	Credits: X-0-0:X

Introduction to key elements of Mechatronic products; Principles of basic electronics - Digital logic, number system logic gates, Sequence logic flip flop systems; Sensors and Actuators, Signals and Systems, Computers and Logic Systems, Software and Data Acquisition; Mechatronic Design Approach, System Interfacing, Instrumentation and Control Systems; Microprocessor-Based Controllers and Microelectronics; Product functional block diagram; PCB Design, Product enclosure design, Microcontroller interfacing and programming, Interfacing with sensors and actuators, driver circuits and motion control, Stepper and servo motion control. Software and hardware tools to build mechatronic systems. Design and selection of mechatronic elements namely sensors like encoders and resolvers; stepper and servomotors, ball screws, solenoid like actuators, and controllers with applications to CNC systems, robotics, and consumer electronic products;

References:

1. Mechatronics by W. Bolton, published by Addison Worley Longman Pvt. Ltd.,
2. Mechatronics System Design by Devdas Shetty and Richard A. Kolk

Course Code: MEX21305	Tribological System Design	Credits: X-0-0:X

Lubrication, Friction and Wear aspects in Design; Tribological Surfaces – Measures of Roughness and associated mechanisms of Lubrication, Regimes of Lubrication; Boundary lubrication and lubricants. Friction and wear at different length scales. Viscosity - its representation and measurement, apparent viscosity. Selection of Bearings - Rubbing, Fluid Film, Rolling Element. Lubricants - Types and Selection, Bearing Design - Rubbing, Fluid Film Journal and Thrust, Dynamically Loaded, Rolling Element, Design of lubrication Systems. Introduction to maintenance of Bearings, Seals, Linear Bearing Design, Slideways. Material considerations for selected tribological applications.

References:

1. Friction, Wear, Lubrication: A Textbook in Tribology by Kenneth C Ludema, CRC press
2. History of Tribology by Dowson D, Longman London, 1979.
3. Experimental methods in Tribology by Stachowiak, Batchelor and Stachowick
4. Applied Tribology (Bearing Design and Lubrication) by Michael M Khonsari
5. Principles of Tribology by J Halling

Course Code: ME21307	Lubrication and Rotor Dynamics	Credits: X-0-0:X

Introduction: Tribology Needs for the 2000's. Performance Objective. Lubrication principles: types of bearings. The need of a rotor dynamic analysis. The fundamental equations of lubrication.

Classical Lubrication: Laminar Flow Fluid Film Bearings. The Reynolds Equation. Magnitude of fluid inertia effects. Boundary conditions and the notion of liquid cavitation.

1-Dimensional bearings: Evaluation of pressure field and forces for slider, Rayleigh-step bearings and simple dampers; Evaluation of pressure field and forces for ideal tilting pad bearings.

Kinematics of motion in cylindrical journal bearings: Reynolds equation for journal bearings. Fixed & rotating coordinates. Pure squeeze film vector. Impedance formulation.

Static load performance of plain journal bearings: Long and short JB models. Pressure and forces for short JBs. Equilibrium condition, attitude angle and Somerfield Number.

Dynamics of rigid rotor-fluid film bearing system: Eqns. of motion. The concept of force coefficients. Stability and synchronous response. Effect of cross-coupled stiffness.

Rotordynamics Basics: Objectives of rotordynamic analysis, spring-mass model, synchronous and nonsynchronous whirl, analysis of Jeffcott rotor, some damping definitions, effect of flexible supports, rotordynamic instability, the gravity critical, added complexities. Rotordynamic considerations in turbomachinery design: rotor design, bearing selection and support design, rotordynamic design evaluation, scaling of existing designs, torsional vibration considerations, synchronous electric motor drive trains, torsional stabilityconsiderations, the roles of analysis and testing.

Critical Speeds and Response to Imbalance: Methods of analysis and the equations of motion, the long rigid symmetric rotor, Forward/backward whirl, Finite Element modeling of rotor, free and forced lateral vibration response of rotor, Eigen value/critical speed analysis, Campbell diagram, balancing of rotor.

References:-

1. Modern Lubrication Theory by San Andres, L., Texax A&M University Digital Libraries.
2. Rotordynamics of Turbomachinery byVance, J. M., John Wiley & Sons, Inc. New Jersey.

3. Dynamics of Rotating Machines by Friswell, Penny, Garvey, and Lees, Cambridge University Press.
4. Rotating Machinery Vibration by Adams, M. L., Marcel Dekker, Inc.

Course Code: ME21308	Design of Electronically Controlled Automobiles	Credits: X-0-0:X

Introduction of automobile system: Current trends in automobiles with emphasis on increasing role of electronics and software, overview of generic automotive control ECU functioning, overview of typical automotive subsystems and components, AUTOSAR.

Engine management systems: Basic sensor arrangement, types of sensors such as oxygen sensors, crank angle position sensors, Fuel metering/ vehicle speed sensors, flow sensor, temperature, air mass flow sensors, throttle position sensor, solenoids etc., algorithms for engine control including open loop and closed loop control system, electronic ignition, EGR for exhaust emission control.

Vehicle power train and motion control: Electronic transmission control, adaptive power Steering, adaptive cruise control, safety and comfort systems, anti-lock braking, traction control and electronic stability, active suspension control.

Active and passive safety system: Body electronics including lighting control, remote keyless entry, immobilizers etc., electronic instrument clusters and dashboard electronics, aspects of hardware design for automotive including electro-magnetic interference suppression, electromagnetic compatibility etc., (ABS) antilock braking system, (ESP) electronic stability program, air bags.

Automotive standards and protocols: Automotive standards like CAN protocol, Lin protocol, flex ray, OBD-II, CAN FD, automotive Ethernet etc. Automotive standards like MISRA, functional safety standards (ISO 26262). System design and energy management: BMS (battery management system), FCM (fuel control module), principles of system design, assembly process of automotive and instrumentation systems.

References:-

1. Understanding Automotive Electronics by W.B. Ribbens, Butterworth Heinemann Woburn
2. Sensors for Automotive Technology by Jiri Marek, Hans Peter Trah, Wiley
3. Automotive Control Systems by U. Kiencke, and L. Nielson, Springer Verlag Berlin
4. Automotive Electrical Equipment by Young A.P., Griffiths, ELBS & New Press
5. Automobile Electrical Equipment by Crouse W.H., McGraw Hill Co. Inc., New York,
6. Automotive Hand Book by Robert Boshe, Bentely Publishers, 5th ed. Germany

Course Code: ME21309	Design of Micro-Electro-Mechanical System	Credits: X-0-0:X

Overview of Micro Electro Mechanical systems (MEMS) and Microsystems: MEMS and Microsystem products: Microgears, Micromotors, Microturbines, Mirco-optical Components, Application of Microsystems in Automotive Industry, Application of Microsystems in other Industries: Health care, Aerospace, Industrial Products, Consumer Products, Telecommunications; Scaling Laws in Miniaturization.

Working Principles of Microsystems: Microsensors, Microactuation, MEMS with Microactuators, Microactuators with Mechanical Inertia, Microfluidics.

Engineering Science for Microsystems Design and Fabrication: Atomic structure of matter, Ions and Ionization, Molecular theory of matter and Intermolecular forces, Doping of semiconductor, Diffusion process, Plasma Physics, Electrochemistry.

Engineering Mechanics for Microsystems Design: Static bending of thin plates, Design theory of accelerometer, micro accelerometer, thin film mechanics: thermo mechanics, fracture mechanics.

Thermo-fluid Engineering and Microsystems Design: Fluid flow in micro conduits, Heat conduction in multilayered thin films and in solids at sub-micrometer scale.

Materials for MEMS and Microsystems: Substrates and Wafers, Active substrate materials, Silicon and its compounds, polymers, packaging materials.

Microsystems Fabrication and manufacturing Processes: Photolithography, Ion implantation, Diffusion, Oxidation, Chemical Vapour Deposition, Physical Vapour Deposition, Etching, Bulk micro manufacturing, Surface micro machining LIGA process.

Microsystems Design: Design Constraints: Selection of Materials, manufacturing processes, signal transduction, electromechanical system, packaging. Process Design: Photolithography, Thin film fabrications, Geometry shaping. Mechanical Design: Geometry of MEMS components, Thermo mechanical loading, stress analysis, dynamic analysis, interfacial fracture analysis. Mechanical Design using FEM: FEM formulation, Simulation of micro fabrication processes, Design of Silicon Die of a Micro pressure sensor, Design of micro fluidic network systems, Design of Micro gas turbine rotor, bearings.

References:

1. MEMS and Microsystems: Design, Manufacture, and Nanoscale Engineering by Hsu, T.R., John Wiley & Sons, Inc. New Jersey.
2. Fundamentals of Microfabrication by Madau, M. J., Taylor &Fransis CRC Press, Boca Ratan Handbook of MEMS: Introduction and Fundamentals by Gad-el-Hak, M., Taylor &Fransis CRC Press, Boca Ratan.

Course Code: ME22311	Design for Manufacturing and Assembly	Credits: X-0-0:X

Introduction to DFMA, Implementation of Concurrent Engineering, Issues involved in introducing DFMA, Current state of commercial DFMA packages, Requirements for a new generation of DFMA systems, Knowledge-based approaches to DFMA, Interfacing Design (CAD) and DFMA systems.

Tools for total Design: Quality Function Deployment, Failure Modes and Effects Analysis (FMEA),Axiomatic Design, DFM Guidelines, Design Science, Design for assembly, Robust Design, The Taguchi Method for Robust Design, Manufacturing Process Design Rules, Computer-Aided DFM, Value –Engineering.

Machining Process: Overview of various machining processes — general design rules for machining - Dimensional tolerance and surface roughness — Design for machining — Ease — Redesigning of components for machining ease with suitable examples. General design recommendations for machined parts.

Metal Casting: Appraisal of various casting processes, selection of casting process, general design considerations for casting — casting tolerances — use of solidification simulation in casting design — product design rules for sand casting.

Metal Joining: Appraisal of various welding processes, Factors in design of weld aments— general design guidelines — pre and post treatment of welds — effects of thermal stresses in weld joints — design of brazed joints.

Forging: Design factors for Forging — Closed die forging design — parting lines of die, drop forging die design — general design recommendations. Extrusion & Sheet Metal Work: Design guidelines for extruded sections - design principles for Punching, Blanking, Bending, Deep Drawing— Keeler Goodman Forming Line Diagram — Component Design for Blanking.

Assembly Advantages: Development of the assembly process, choice of assembly method, assembly advantages, social effects of automation. Automatic Assembly Transfer Systems: Continuous transfer, intermittent transfer, indexing mechanisms, and operator-paced free-transfer machine.

Design Of Manual Assembly: Design for assembly fits in the design process, general design guidelines for manual assembly, development of the systematic DFA methodology, assembly efficiency, classification system for manual handling, classification system for manual insertion and fastening, effect of part symmetry on handling time, effect of part thickness and size on handling time, effect of weight on handling time, parts requiring two hands for manipulation, effects of combinations of factors, effect of symmetry effect of chamfer design on insertion operations, estimation of insertion time.

References:

1. Geoffrey Boothroyd, Peter Dewhurst, Winston A. Knight, Product Design for Manufacture and Assembly, Third Edition, CRC Press
2. Geoffrey Boothroyd, Assembly Automation and Product Design, Book World Enterprises
3. Product Design and Development by Karl T. Ulrich, Steven D. Eppinger, TMHPublication.
4. Computer Integrated Design and Manufacturing by David D. Bedworth, Mark R. Henderson, Philip M. Wolfe, McGraw-Hill Publication.
5. James Bralla, Design for Manufacturability Handbook, McGraw-Hill Professional
6. O. Molloy, E. A. Warman, S. Tilley, Design for Manufacturing and Assembly: Concepts, architectures and implementation, Chapman & Hall, London

Course Code: ME22312	Designing with Advanced Materials	Credits: X-0-0:X

Introduction to polymers, composites and smart materials. Polymer microstructure and mechanical properties. Thermosets and thermoplastics. Viscoelastic creep and relaxation behavior, mechanical models, and polymer failure. Design considerations and practices for polymeric components with case studies. Composite materials and their applications. Micro and macro mechanics of lamina, failure criteria of lamina, classical laminate theory, strength of laminates. Design considerations and practices for composite structures with case studies. Structure, applications and design considerations of smart materials such as shape memory alloys and piezoelectric materials.

References:-

1. Introduction to Composite Materials Design by Ever J. Barbero, CRC Press.
2. Engineering Design with Polymers and Composites by Gerdeen and Rorrer, CRC Press.
3. Engineering Materials 2: An introduction to Microstructure and Processing by Jones and Ashby, Butterworth-Heinemann.
4. Polymer Engineering Science and Viscoelasticity by Brinson and Brinson, Springer
5. Mechanics of Composite Materials by Jones, CRC Press

Course Code: ME22314	Design of Turbo Pumps	Credits: X-0-0:X

Fundamental of impeller pump: Historical development of rotodynamics pumps and Fundamental definition, Classification of impeller pumps, Comparison of properties of impeller and displacement type pumps. Hydrodynamic equations, Conversion of energy in a flowing of liquid, Basics of theory of impeller pumps.

Basic quantities in the energy balance of pumps: Suction, delivery and total heads, Discharge, Power, Efficiencies, Calculation of the head and the power of the motive unit driving a pump.

Flow through impeller: The phenomenon of the flow through the impeller, Euler's fundamental equations, theoretical head, energy equation for relative flow through an impeller, theoretical head for infinite number of blades, impulse and reaction types of pumps and choice for outlet angle of blades.

Impeller shape: Geometrical velocity fields, evolution of impeller shapes, choice of number of impeller blades, Range of application of impeller pumps, Relationship between overall efficiency, hydraulic efficiency and the specific speed.

Impeller with blades of single curvature: General remarries on the design of impellers, Calculation of the dimensions of the impeller. Impeller with blades of double curvature: method of designing impeller, shaping of blade surface, Basic design procedure of impeller for centrifugal boiler feed pump.

Inlet and outlet elements: type of suction element and construction of volute suction chambers. Vane-less guide-ring. Annular-type recuperators of constants and volute type, vaned diffuser rings on return passages.

References:

1. Impeller Pumps by Stephen Lazariciewicz& Adam T. Troscolanski, Rersaman Press, Oxford London.
2. Turbopumps and Pumping Systems by Nourbakhsh, A., Jaumotte, A., Hirsch, C., Parizi, H.B, Springer.

Course Code: ME22315	Machinery Fault Diagnostics and Signal Processing	Credits: X-0-0:X

Principles of Maintenance: Reactive Maintenance, Preventive Maintenance, Predictive Maintenance, Enterprise Resource Planning, Bath Tub Curve, Failure Modes Effects and Criticality Analysis (FMECA).

Digital Signal Processing: Classification of Signals, Signal Analysis, Frequency Domain Signal Analysis, Fundamentals of Fast Fourier Transform, Computer-Aided Data Acquisition, Signal Conditioning, Signal Demodulation, Cepstrum Analysis.

Instrumentation: Measurement Standards, Measurement Errors, Calibration Principles, Static and Dynamic Measurements, Frequency Response, Dynamic Range, Basic Measuring Equipment, Vibration Force Measurements, Rotational Speed, Noise Measurements, Temperature Measurements, Laser-Based Measurements, Current Measurements, Chemical Composition Measurement, Ultrasonic Thickness Measurement, Data Recorders.

Vibration Monitoring: Principles of Vibration Monitoring, Misalignment Detection, Eccentricity Detection, Cracked Shaft, Bowed and Bent Shaft, Unbalanced Shaft, Looseness, Rub, Bearing Defects, Gear Fault, Faults in Fluid Machines.

Noise Monitoring: Acoustical Terminology, Noise Sources, Sound Fields, Anechoic Chamber, Reverberation Chamber, Noise Measurements, Noise Source Identification.

Electrical Machinery Faults: Construction of an Electric Motor, Faults in Electric Motor, Fault Detection in Electric Motors, MCSA for Fault Detection in Electrical Motors, Instrumentation for Motor Current Signature Analysis, Fault Detection in Mechanical Systems by MCSA, MCSA for Fault Detection in any Rotating Machine, Fault Detection in Power Supply Transformers, Fault Detection in Switchgear Devices.

Thermography: Thermal Imaging Devices, Use of IR Camera, Industrial Applications of Thermography, Applications of Thermography in Condition Monitoring.

Wear Debris Analysis: Mechanisms of Wear, Detection of Wear Particles, Common Wear Materials, Oil Sampling Technique, Oil Analysis, Limits of Oil Analysis.

Other Methods in Condition Monitoring: Eddy Current Testing, Ultrasonic Testing, Radiography, Acoustic Emission.

Machine Tool Condition Monitoring: Tool Wear, Sensor Fusion in Tool Condition Monitoring, Sensors for Tool Condition Monitoring, A Tool Condition Monitoring System.

References:-

1. Machinery Condition Monitoring: Principles and Practices by A.R. Mohanty, Taylor and Francis, CRC Press
2. Mechanical fault diagnosis and condition monitoring by R.A. Collacott, John Wiley, New York
3. Handbook of condition monitoring by A. Davis, Springer Science Business Media
4. Machinery malfunction diagnosis and correction by R.C. Eisenmann, Prentice Hall

Course Code: ME22316	Rapid Product Development	Credits: X-0-0:X

Overview of Rapid Product Development: Product Developing Cycle and Rapid Product Development, Virtual Prototyping and Rapid Manufacturing Technologies, Physical Prototyping & Rapid Manufacturing Technologies, Synergic Integration Technologies; Rapid Prototyping: Principal of Rapid Prototyping, Various RP technologies, Selection of a suitable RP process for a given application, Status of outstanding issue in RP- accuracy, speed, materials (strength, homogeneity and isotropy); Rapid Tooling: Introduction to Rapid Tooling, Indirect Rapid Tooling Processes, Direct Rapid Tooling Processes, Emerging Trends in Rapid Tooling; Reverse Engineering: Data Extraction and Data Processing; Applications and Case Studies: Engineering Applications, Medical Applications; Processing of Polyhedral Data: Polyhedral BRep modeling, Introduction to STL format, Defects and repair of STL files, Overview of the algorithms required for RP&T and Reverse Engineering.

References:-

1. John Vince, Virtual Reality Systems, Addison-Wesley. 1995
2. Linda Jacobson, Garage Virtual Reality, Sams Publishing, 1994.
3. Chua Chee Kai and Leong Kah Fai, Rapid Prototyping: Principles and Applications in Manufacturing, John Wiley & Sons, 1997
4. Paul F. Jacobs, Stereo-lithography and Other RP&M Technologies: from Rapid Prototyping to Rapid Tooling, SME/ASME, 1996.
5. Peter D. Hilton and Paul F. Jacobs (Editors), Rapid Tooling: Technologies and Industrial Applications, Marcel Dekker, 2000.

Course Code: ME22317	Product Design and Development	Credits: X-0-0:X

Introduction to Product Design: Characteristics of successful product Development.

Who designs & develops products- Industrial & Practical Examples.

Creative thinking- Invention- innovation & inventiveness in a society.

Development Process & Organization.

A Generic Development Process & Concept Development.

Identifying Customer Needs.

Concept Generation, Concept Selection.

Product Architecture, Industrial Design.

Human Factors & System Information Input- Text graphics, symbols and codes.

Work Place Design- case studies.

Human Factors Application – case studies.

Human Errors – accidents and safety. Techno legal issues

Intellectual Property Rights.

References:

1. Product Design & Development- Karl T. Ulrich, Steven D Eppinger, McGraw Hill Publishers.
2. The Mechanical Design Process – by David G. Ullman
3. Human Factors in Engineering Design- Mark S sanders & Ernst J. Mc Cornick McGraw Hill Publishers.
4. Product Design & Process Engineering – Benjamin W Nishel& Alan B Draker- McGraw Hill Publishers.
5. Any other reference discussed in class for specific topics.