NETAJI SUBHAS UNIVERSITY, JAMSHEDPUR

Estd. Under Jharkhand State Private University Act, 2018
Approved by AICTE, PCI, BCI, NCTE, INC & JNRC

EVALUATION SCHEME & SYLLABUS

FOR

MASTER OF TECHNOLOGY

IN

MECHANICAL ENGINEERING
(M.Tech-ME)

On

Choice Based Credit System

(Effective from the Session: 2025-26)

Netaji Subhas University

Pokhari, Near Bhilai Pahadi, Jamshedpur, Jharkhand, INDIA

VISION

To impart quality education in Mechanical Engineering and constantly pursuing excellence by upgrading knowledge skills and attitude useful to Industry, Academic and Society.

MISSION

1. To produce graduates having professional excellence in Basic Sciences and Mechanical Engineering with concern towards society
2. To provide a scientific environment, to help meet the desires and needs of students andfaculty for enhancing research efforts and technological innovations.
3. To provide technical support to higher education, industry and R&D units.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

The Mechanical Engineering program at NSU prepares graduates who can:

PEO1: Obtain good and high positions in public or private institutions as engineers and researchers.

PEO2: Follow higher education in prestigious universities and have a successful academic career.

PEO3: Demonstrate advancement in their chosen career by upgrading their skills continuously.

PEO4: Exhibit high ethical standards and responsibilities towards their profession and society.

PEO5: Exhibit high ethical standards and responsibilities towards their profession and society.

PROGRAM OUTCOMES (POs)

PO1:	**Engineering Knowledge:** Knowledge of mathematics, science, and engineering fundamentals and ability to apply them to solve complex mechanical phenomena.
PO2:	**Problem Analysis:** Identification and analysis of process - structure – property – performance correlation of metals and materials with the knowledge of science and engineering principles.
PO3:	**Design/Development of solutions:** Ability to design material systems, components, process to meet the desired needs within the realistic constraints of economic, public safety, environmental, manufacturability, and sustainability.
PO4:	**Conduct Investigations of Complex problems:** Design, conduct, analyze, and interpret the results of tests and researches in the field of mechanical engineering and propose appropriate measures for efficient capacity utilization of systems; components and equipment etc. with minimum energy and rejects.

PO5:	**Modern Tool Usage:** Select and apply appropriate methods for analysis and characterization of materials to check the quality and performance and usage of modern tools to address the specific needs of mechanical industries.
PO6:	Conduct independent research, analyze technical literature, and apply modern tools to investigate and solve complex production engineering problems.
PO7:	Demonstrate knowledge of engineering and management principles to lead and manage projects in multidisciplinary environments.
PO8:	Function effectively in teams and communicate technical information clearly and concisely in both oral and written forms.
PO9:	Recognize the need for and engage in independent, lifelong learning to keep pace with rapid technological changes in production engineering.
PO10:	Apply ethical principles and commit to professional ethics and responsibilities in manufacturing practices and research.
PO11:	Understand the impact of manufacturing processes on society and the environment, and design sustainable and eco-friendly systems.
PO12:	An ability to handle techno-scientific challenges of the society.

M. Tech in Mechanical Engineering (ME)

COURSE STRUCTURE

I-Semester

Code No.	Name of the Subjects	Periods			Credits	Marks		
		L	T	P	IA	IA	TE	TM
MTME101	Computational Methods in Engineering	3	1	-	4	30	70	100
MTME102	Advanced Mechanics of Solids	3	1	-	4	30	70	100
MTME103	Applied Dynamics & Vibrations	3	1	-	4	30	70	100
MTME104	Advanced Engineering Materials	3	1	-	4	30	70	100
MTME105	Applied Tribology	3	1	-	4	30	70	100
	Open Elective-I	2	1		3	30	70	100
MTME107	Seminar-1	-	-	-	2	-	50	50
MTME108-L	Advanced Solid Mechanics and Vibration Lab	-	-	4	2	15	35	50
MTME109-L	Computational Methods Laboratory	-	-	4	2	15	35	50
	Total	**17**	**6**	**8**	**25**	**210**	**540**	**750**

Name of the Subject		
Open Elective - I	**MTME106-OE-I**	Surface Engineering
	MTME107-OE-I	Industrial Robotics
	MTME108-OE-I	Fracture Mechanics
	MTME109-OE-I	Theory of Elasticity
	MTME110-OE-I	Materials Modelling and Simulation

II-Semester

Code No.	Name of the Subjects	Periods			Credits	Marks		
		L	T	P	IA	IA	TE	TM
MTME201	Robotic Manipulator Design	3	1	-	4	30	70	100
MTME202	Automatic Control	3	1	-	4	30	70	100
MTME203	Optimization Techniques	3	1	-	4	30	70	100
MTME204	Mechanics of Composite Materials	3	1	-	4	30	70	100
MTME205	Finite Element Analysis	3	1	-	4	30	70	100
	Open Elective-II	2	1		3	30	70	100
MTME207	Minor Project with Seminar-II	-	-	-	2	-	50	50
MTME208-L	Robotics Laboratory	-	-	4	2	15	35	50
MTME209-L	CAD LAB	-	-	4	2	15	35	50
	Total	**17**	**6**	**8**	**25**	**210**	**540**	**750**

Name of the Subject		
Open Elective - II	**MTME206-OE-II**	Vibration of Continuous System
	MTME207-OE-II	Secondary Steel Making
	MTME208-OE-II	Advances in Production of Non-Ferrous Metals.
	MTME209-OE-II	Design Methodology
	MTME210-OE-II	Renewable Energy

III-Semester

Code No.	Name of the Subjects	Periods			Credits
		L	T	P	
MTME301	Thesis-I	-	-	-	16
MTME302	Project Seminar-I	-	-	-	4
	Total	-	-	-	**20**

IV-Semester

Code No.	Name of the Subjects	Periods			Credits
		L	T	P	
MTME401	Thesis-II	-	-	-	16
MTME402	Project Seminar-II	-	-	-	4
	Total	-	-	-	**20**

COMPUTATIONAL METHODS IN ENGINEERING

Subject code:-	**MTME101**	**IA Marks**	**30**
Number of Lecture Hours/Week:-	**04**	**Term End Exam Marks**	**70**
Total Number of Lecture Hours: -	**40**	**CREDITS**	**04**

Course Objectives:-

This course enables the students to:

1. Learn different numerical techniques.
2. Learn linear algebra for solving problems.
3. Learn differential calculus to solve numerical problems
4. Learn integral calculus to solve numerical problems.
5. Apply numerical methods for solving engineering problems.

SYLLABUS

Topics Covered

Unit 1:

Numerical Methods in Linear Algebra: Direct and iterative solution techniques for simultaneous linear algebraic equations – Gauss elimination, Gauss – Jordan, LU and QR decomposition, Jacobi and Gauss-Seidel methods, Eigenvalues and Eigenvectors – Power and inverse power method, physical interpretation of eigenvalues and eigenvectors, householder transformation. (8L)

Unit 2:

Solution of nonlinear algebraic equations: Bisection method, fixed-point iteration method, Newton – Raphson, Secant method. Interpolation: Polynomial interpolation, Lagrange interpolating polynomial, Hermite interpolation, interpolation in two and three dimensions.

(8L)

Unit 3:

Numerical differentiation and Integration: Finite difference formula using Taylor series, Differentiation of Lagrange polynomials, Simpson's rule, Gauss – quadrature rule, Romberg method, multiple integrals. (8L)

Unit 4:

Numerical solutions of ordinary differential equations: Euler's method, Heun's method and stability criterion, second and fourth order Runge- Kutta methods, Adams – Bashforth – Moulton method, system of ODEs and nonlinear ODEs. (8L)

Unit 5:

Partial Differential Equations: Classifications of PDEs, Elliptic equations, parabolic equations, Hyperbolic equations (wave equation). (8L)

Course Outcomes:-

After the end of the course, a student should be able to:

CO No	Course Outcome Description	Bloom's Level
CO1.	Understand several numerical techniques used in linear algebra.	K2, K4
CO2.	Solve systems of linear and nonlinear algebraic equations encountered in engineering problems.	K4
CO3.	Evaluate differentiation and integration using different numerical techniques.	K4
CO4.	Solve ordinary and partial differential equations using numerical methods	K3, K4
CO5.	Create new ideas in engineering computations.	K2, K4

KL- Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1-Remember, K_2- Understand, K_3- Apply, K_4- Analyze, K_5- Evaluate, K_6- Create

CO-PO Mapping Matrix

PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	1	1	0	0	0	1	1	2
CO2	3	3	2	2	1	0	0	0	1	1	2
CO3	3	2	2	2	1	0	0	0	1	1	3
CO4	2	2	3	2	1	0	0	0	1	1	2
CO5	2	2	2	2	1	0	0	0	1	1	3
Average	2.6	2.2	2.2	1.8	1	0	0	0	1	1	2.4

Text Books

1. Joe D Hoffman, Numerical Methods for Engineer and Scientists, Marcel Dekker.
2. S. P. Venkateshan and P. Swaminathan, Computational Methods in Engineering, Ane books.

Reference Books

1. Gilbert Strang, Computational Science and Engineering, Wessley – Cambridge press.
2. Steven C. Chapra, Applied Numerical Methods with MATLAB for Engineers and Scientists, Tata McGrawhill.

ADVANCED MECHANICS OF SOLIDS

Subject code:-	**MTME102**	**IA Marks**	**30**
Number of Lecture Hours/Week:-	**04**	**Term End Exam Marks**	**70**
Total Number of Lecture Hours: -	**40**	**CREDITS**	**04**

Course Objectives

This course enables the students to:

1. Understand the advanced concept of stress-strain behavior of materials.
2. Understand the indicial notations.
3. Understand different elastic functions
4. Understand the mechanics of plates and shells.
5. Apply mathematical concepts in practical solid mechanics problems.

SYLLABUS

Unit 1: Mathematical Preliminaries

Introduction to tensor algebra: symmetric and skew-symmetric tensor, summation convention, eigenvalue and eigenvector of tensor, spectral theorem, polar decomposition theorem, product of tensor, principal invariants of tensor, coordinate transformation of tensor, Tensor calculus: gradient, divergence, curl, differentiation of scalar function of a tensor.

(8L)

Unit 2: Analysis of Stress and Strain

Definition and notation of stress, Cauchy stress tensor, equations of equilibrium, principal stresses and stress invariants, stress deviator tensor, octahedral stress components, General deformations, small deformation theory, strain transformation, principal strains, spherical and deviatoric strains, Strain-displacement relations, strain compatibility, stress and strain in curvilinear, cylindrical, and spherical coordinates, fundamental equations of plasticity. (8L)

Unit 3: Problem formulation and solution strategies:

Field equations, boundary conditions, stress and displacement formulation, Beltrami-Michell compatibility equations, Lame-Navier's equations, principle of superposition, uniqueness theorem, Saint-Venant's principle, Brief descriptions about general solution strategies - direct, inverse, semi-inverse, analytical, approximate, and numerical methods. (8L)

Unit 4: Two-dimensional problems

Plane stress and plane strain problems, generalized plane stress, Antiplane strain, Airy stress function, polar coordinate formulation and solutions, Cartesian coordinate solutions using polynomials and Fourier series method. (8L)

Unit 5: Applications

Torsion of noncircular shafts: Warping and Prandtl stress function, Torsion analysis of circular, elliptical, and rectangular cylinder using Warping and Prandtl function, Membrane analogy, Photo elasticity, Plates and shells – Fundamental equations, Kirchhoff's theory, axisymmetric bending of circular plates, membrane theory of shells of revolutions.

(8L)

Course Outcomes

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

CO No	Course Outcome Description	Bloom's Level
CO1.	Understand the concept of a tensor.	K2, K4
CO2.	Analyze the advanced concepts of stress and strain in structural problems.	K4
CO3.	Apply the concept of different elastic functions to solve complex problems.	K4
CO4.	Evaluate the influence of various geometric and loading parameters in plane stress and plane strain problems.	K3, K4
CO5.	Implement the advanced concept of solid mechanics in torsion, plates and shells.	K2, K4

KL- Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1-Remember, K_2- Understand, K_3- Apply, K_4- Analyze, K_5- Evaluate, K_6- Create

CO-PO Mapping Matrix

PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	1	1	0	0	0	1	1	2
CO2	3	3	2	2	1	0	0	0	1	1	2
CO3	3	2	2	2	1	0	0	0	1	1	3
CO4	2	2	3	2	1	0	0	0	1	1	2
CO5	2	2	2	2	1	0	0	0	1	1	3
Average	2.6	2.2	2.2	1.8	1	0	0	0	1	1	2.4

Text Books

1. Elasticity, Theory, Applications, and Numerics by Martin H. Sadd
2. Theory of Elasticity by Stephen Timoshenko and , J. N. Goodier
3. Advanced Mechanics of Solids, Otto T. Bruhns, Springer publications.

Reference Books

1. Continuum Mechanics, A.J.M Spencer, Dover Publications, INC
2. Advanced Mechanics of Materials by H. Ford and J. M. Alexander
3. The Linearized Theory of Elasticity, W. S. Slaughter, Springer Science + Business Media, LLC

APPLIED DYNAMICS AND VIBRATION

Subject code:-	**MTME103**	**IA Marks**	**30**
Number of Lecture Hours/Week:-	**04**	**Term End Exam Marks**	**70**
Total Number of Lecture Hours: -	**40**	**CREDITS**	**04**

Course Objectives

This course enables the students to:

1. Understand advanced topics of rigid body kinematics and dynamics
2. Analyze free and forced vibration of single and multi-degree-of-freedom systems
3. Apply principles of classical mechanics to analyze dynamical systems.
4. Design dynamical systems.
5. Understand the working principles of the gyroscopic couple.

SYLLABUS

Unit 1: Rigid Body Kinematics

Vectors, Frame of reference, Coordinate systems, Coordinate transformation, Rotating frames, Rotation tensor, Axis angle relation, Euler angles, Angular velocity, Five term acceleration formula, Practical examples. (8L)

Unit 2: Rigid Body Kinetics

Linear momentum, Angular momentum, Moment of inertia and product of inertia, Laws of dynamics, Governing equations, Euler's equation, Steady state, Practical examples, Stability of bicycle, Gyroscope. (8L)

Unit 3: Classical Mechanics

Generalized coordinates, Constraints, Degrees of freedom, Principle of virtual work, Lagrange multiplier, Stability of conservative system, D'Alembert's principle, Lagrange's equation of motion, holonomic and nonholonomic systems, Conservative systems, Legendre transformation, Hamiltonian mechanics. (8L)

Unit 4: Introduction to Vibration

Basic elements of vibration, Free, damped and forced vibration, Logarithmic decrement, Half power band width, Base excitation, Transmissibility, Magnification factor, Response of general forcing, Torsional Vibration. (8L)

Unit 5: Vibration of Multi DOF System

Two DOF system, Normal modes, Forced vibration, Dynamic vibration absorber, Free and forced multi DOF system, Lagrange's equation of motion, Dunkerley's formula, Rayleigh method, Holzer's method, Jacobi's method. (8L)

Course Outcomes

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

CO No	Course Outcome Description	Bloom's Level
CO1.	Demonstrate various principles related to the kinematics and dynamics of rigid bodies in space.	K2, K4
CO2.	Apply a classical mechanical approach to construct equations of motion for dynamical systems	K4
CO3.	Evaluate the gyroscopic couple for systems with simultaneous spin and precession.	K4
CO4.	Design and analyze simple dynamical systems.	K3, K4
CO5.	Evaluate natural frequencies and mode shapes of single and multi-DOF vibrating systems.	K2, K4

KL- Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1-Remember, K_2- Understand, K_3- Apply, K_4- Analyze, K_5- Evaluate, K_6- Create

CO-PO Mapping Matrix

PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	1	1	0	0	0	1	1	2
CO2	3	3	2	2	1	0	0	0	1	1	2
CO3	3	2	2	2	1	0	0	0	1	1	3
CO4	2	2	3	2	1	0	0	0	1	1	2
CO5	2	2	2	2	1	0	0	0	1	1	3
Average	2.6	2.2	2.2	1.8	1	0	0	0	1	1	2.4

Text Books

1. J. L. Meriam and L. G. Kraige, Engineering Mechanics: Dynamics, John Wiley and Sons Inc., Seventh edition.
2. A. Chatterjee, Intermediate Dynamics, Indian Institute of Technology Kanpur, 2014.
3. D. T. Greenwood, Classical Dynamics, Dover Publications Inc.
4. L. Meirovitch, Elements of Vibration Analysis, McGraw Hill Education, Second edition.
5. S.S. Rao, Mechanical Vibrations, Pearson India Education Services Pvt Ltd. Fourth edition.

Reference Books

1. H. Goldsten , Classical Mechanics, Narosa Publishing House, Second edition.
2. W. T. Thomson, M. D. Dahleh, and C. Padmanabhan, Theory of Vibration with Applications, Pearson, Fifth edition.

ADVANCED ENGINEERING MATERIALS

Subject code:-	**MTME104**	**IA Marks**	**30**
Number of Lecture Hours/Week:-	**04**	**Term End Exam Marks**	**70**
Total Number of Lecture Hours: -	**40**	**CREDITS**	**04**

Course Objectives

This course enables the students to:

1. Identify the Discrepancy between the theoretical and observed yield stress of crystals
2. Determine the relation between dislocation movement and plastic flow.
3. Describe and explain the phenomenon of strain hardening in terms of dislocations and strain field interactions.
4. Discuss about natural fibres whose strength can be increased by different process technologies.
5. Discuss about recyclability/disposability issues related to metals, glass, plastic & rubber and composite materials.

SYLLABUS

Unit 1: Introduction, Remarks on material science in the context of engineering

Structure of perfect and imperfect solids, elastic deformation and stress distribution, theoretical strength of crystals, Discrepancy between theoretical and observed yield stress of crystals, Linear Defects, Interfacial defects, Bulk or Volume defects, Atomic Vibrations, Burgers vectors. (8L)

Unit 2: Dislocation and plastic deformation

Characteristics of dislocations, Slip planes and slip systems, Climb of edge dislocation, dislocation intersections, Stress field of an edge dislocation, Force on a dislocation, Strain energy of an edge and screw dislocation, relation between dislocation movement and plastic flow, dislocation generation, other modes of deformation in crystalline solids. (8L)

Unit 3: Strengthening Mechanism

Dislocation theory of yielding, yield point phenomenon, strengthening by grain size reduction, solid solution strengthening, Resolved Shear Stress and Stress-to-Initiate-Yielding, Computations, plastic deformation of polycrystalline materials, deformation by twinning, stain hardening and recovery mechanism of deformation at elevated temperature, Recrystallization, Grain growth, mechanism of fracture, ductile-brittle transition. (8L)

Unit 4: Mechanical behaviour of engineering materials

Under the fatigue, creeps and fracture design criteria for materials, Materials selection for a torsionally stressed shaft, environmental effects, thermal, electrical, magnetic and optical properties of materials, alloys for high temperature use, Data extrapolation methods (8L)

Unit 5: Economical, Environmental and Societal issues in material science and engineering

Component design materials, recycling issues in material science and engineering, materials of importance, bio-degradable and bio-renewable polymers, Case studies: on dual nature of flow stress, effect of alloying on the flow stress components. (8L)

Course Outcomes

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

CO No.	Course Outcome Description	Bloom's Level
CO1.	Describe the Discrepancy between the theoretical and observed yield stress of crystals.	K2, K4
CO2.	Determine the relation between dislocation movement and plastic flow.	K4
CO3.	Analyze the phenomenon of strain hardening in terms of dislocations and strain field interactions.	K4
CO4.	Evaluate the working stress of a material.	K3, K4
CO5.	Discuss about recyclability/disposability issues related to metals, glass, plastic & rubber and composite materials.	K2, K4

KL- Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1-Remember, K_2- Understand, K_3- Apply, K_4- Analyze, K_5- Evaluate, K_6- Create

CO-PO Mapping Matrix

PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	1	1	0	0	0	1	1	2
CO2	3	3	2	2	1	0	0	0	1	1	2
CO3	3	2	2	2	1	0	0	0	1	1	3
CO4	2	2	3	2	1	0	0	0	1	1	2
CO5	2	2	2	2	1	0	0	0	1	1	3
Average	2.6	2.2	2.2	1.8	1	0	0	0	1	1	2.4

Text Books

1. Materials Science and Engineering an introduction, W.D. Callister Jr.
2. Physical Metallurgy Principles, R.E. Reed, R. Abbaschian

Reference books

1. Fracture an Advanced Treatise, H. Liebowitz
2. Fundamentals of Fracture Mechanics, J.F. Knott.

APPLIED TRIBOLOGY

Subject code:-	**MTME105**	**IA Marks**	**30**
Number of Lecture Hours/Week:-	**04**	**Term End Exam Marks**	**70**
Total Number of Lecture Hours: -	**40**	**CREDITS**	**04**

Course Objectives

This course enables the students to:

1. Comprehend the concept of tribology for applying lubrication in bearings and other machine elements.
2. Design the tribological systems consisting bearings.
3. Apply modern technologies of surface texturing for performance improvements of bearings.
4. Derive governing equations of all types of bearings using knowledge of fluid mechanics.
5. Solve general Reynolds equation for lubrication problems using FDM.

SYLLABUS

Unit 1:

Friction, Wear, and Lubrication, Tribology principles, Principles for selection of bearing types, Lubricants and Lubrication, Mineral oils, Synthetic oils, Viscosity, Density and compressibility, Thermal Properties, Oil life, Greases, Solid lubricants, Lubricant supply methods. (8L)

Unit 2:

Surface Texture and Interactions, Geometric characterization of surfaces, Surface parameters, Measurement of surface texture, Measurement of surface flatness, Statistical descriptions, Contact between surfaces, Lubrication regime relation to surface roughness, Bearing Materials, Distinctive selection factors, Oil-film bearing materials, Dry and semi-lubricated bearing materials, Air bearing materials, High-temperature materials, Rolling bearing materials. (8L)

Unit 3:

Fundamentals of Viscous Flow, Conservation of mass, momentum, and energy, non-dimensionalisation, Reynolds Equation and Applications, Performance parameters, Thrust Bearings, Thrust bearing types, Design factors, Performance analysis, Design procedure**.** (8L)

Unit 4:

Journal Bearings, Full-arc plain journal bearing with infinitely long approximation, Boundary conditions, Definition of the Sommerfeld number, Cavitation phenomena, Bearing performance parameters, Finite journal bearing design and analysis, Bearing Stiffness, Rotor Vibration, and Oil-Whirl Instability, General design guides, Squeeze-Film Bearings, Governing equations, Planar squeeze film, Nonplanar squeeze film, Squeeze film of finite surfaces, Piston rings. (8L)

Unit 5:

Hydrostatic Bearings, Types and configurations, Circular step thrust bearings, Capillary- compensated hydrostatic bearings, Orifice-compensated bearings, Design procedure for compensated bearings, Hydraulic lift, Rolling Element Bearings, Ball bearing types, Roller bearing types, Thrust bearing types, Load–life relations, Adjusted rating life, Static load capacity. (8L)

Course Outcomes

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

CO No.	Course Outcome Description	Bloom's Level
CO1.	Understand the basic concepts of friction, wear, and lubrication.	K2, K4
CO2.	Apply the knowledge of surface texture parameters for selection of bearing materials.	K4
CO3.	Write Reynold's equation for various bearing problems and design thrust bearings.	K4
CO4.	Design journal bearings and squeeze-film bearings.	K3, K4
CO5.	Design hydrostatic and rolling element bearings.	K2, K4

KL- Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1-Remember, K_2- Understand, K_3- Apply, K_4- Analyze, K_5- Evaluate, K_6- Create

CO-PO Mapping Matrix

PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	1	1	0	0	0	1	1	2
CO2	3	3	2	2	1	0	0	0	1	1	2
CO3	3	2	2	2	1	0	0	0	1	1	3
CO4	2	2	3	2	1	0	0	0	1	1	2
CO5	2	2	2	2	1	0	0	0	1	1	3
Average	2.6	2.2	2.2	1.8	1	0	0	0	1	1	2.4

Text Books

1. M. M. Khonsari and E. R. Booser. Applied Tribology: Bearing Design and Lubrication, Second Edition. John Wiley & Sons, Ltd, 2008.

Reference Books

1. B. J. Hamrock, S. R. Schmid, B. O. Jacobson. Fundamental of Fluid Film Lubrication. Second Edition. Marcel Dekker, Inc., 2004.
2. G. W. Stachowiak, A. W. Batchelor. Engineering tribology. Butterworth-Heinemann, 2001.

ADVANCED SOLID MECHANICS AND VIBRATION LAB

Subject code:-	**MTME108-L**	**IA Marks**	**30**
Number of Lecture Hours/Week:-	**04**	**Term End Exam Marks**	**70**
Total Number of Lecture Hours: -	**40**	**CREDITS**	**02**

Course Objectives

This course enables the students to:

1. Determine material properties.
2. Understand fatigue and creep phenomena.
3. Understand vibration characteristics..

List of Experiments

Experiment 1: To determine surface hardness of mechanical components using micro hardness testing machine.
Experiment 2: To determine creep properties of materials (Lead, polymer materials) in room temperature
Experiment 3: To determine change of rate of deformation of a sample (Lead, polymer materials) at different temperature.
Experiment 4: To determine fatigue strength of material under tensile load (Rumul Fatigue Testing Machine)
Experiment 5: To determine fatigue strength of material under compressive load (Rumul Fatigue Testing Machine)
Experiment 6: To determine fatigue strength of material under flexural load (Rumul Fatigue Testing Machine)
Experiment 7: To determine the properties of materials under tensile load in Instron
Experiment 8: To determine the properties of materials under compressive load in Instron.
Experiment 9: To determine the properties of materials under flexural load in Instron.
Experiment 10: To determine secondary mass and spring stiffness for forced tuned vibration absorber

Course Outcomes

CO1.	Determine surface hardness of materials
CO2.	Determine creep strength of materials under different temperatures
CO3.	Evaluate fatigue strength of materials under different loading conditions
CO4.	Evaluate material properties under different loading conditions using Instron
CO5.	Analyse dynamic characteristics of wheel balancing, tuned vibration absorber, and weakly coupled pendulum.

COMPUTATIONAL METHODS LABORATORY

Subject code:-	**MTME109-L**	**IA Marks**	**30**
Number of Lecture Hours/Week:-	**04**	**Term End Exam Marks**	**70**
Total Number of Lecture Hours: -	**40**	**CREDITS**	**02**

Course Objectives

This course enables the students to:

1. Compute the mathematical problems using MATLAB
2. Analyse engineering problems using finite element packages ANSYS and COMSOL

List of Experiments

Experiment 1: Solving system of linear algebraic equations with MATLAB: Gauss elimination, Gauss – Jordan, and Gauss-Seidel method.

Experiment 2: Solving nonlinear algebraic equations and Polynomial interpolation with MATLAB: Newton – Raphson method and Lagrange interpolating polynomial.

Experiment 3: Numerical differentiation and integration with MATLAB: Finite difference, Simpson’s, and Gauss – quadrature rule.

Experiment 4: Solving ordinary differential equations with MATLAB: Euler’s and Heun’s method.

Experiment 5: Analysis of a Plane stress problem using ANSYS.

Experiment 6: Analysis of a Plane strain problem using ANSYS.

Experiment 7: Analysis of an Antiplane strain problem using ANSYS.

Experiment 8: Analysis of Torsion of circular shafts using ANSYS.

Experiment 9: Analysis of Plane stress and Plane strain problems using COMSOL.

Experiment 10: Analysis of Torsion of noncircular shafts using COMSOL.

Experiment 11: Analysis of axisymmetric bending of circular plates using COMSOL.

Experiment 12: An Equation based modelling in COMSOL.

Course Outcomes

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

CO1.	Solve system of linear and algebraic equations using MATLAB
CO2.	Evaluate numerical differentiation and integration using MATLAB
CO3.	Solve system of ordinary differential equations using MATLAB
CO4.	Analyse Plane stress, Plane strain, and torsion problems using finite element package ANSYS
CO5.	Analyse plate and shell problems, and equation-based modelling using finite element package COMSOL Multiphysics.

ROBOTIC MANIPULATOR DESIGN

Subject code:-	**MTME201**	**IA Marks**	**30**
Number of Lecture Hours/Week:-	**04**	**Term End Exam Marks**	**70**
Total Number of Lecture Hours: -	**40**	**CREDITS**	**02**

Course Objectives

This course enables the students to:

1.	Understand the kinematic design and dynamic formulation of a typical industrial robot.
2.	Foresee the possibilities in design uncertainties in kinematic model of a robot and make necessary changes in the modelling to make the controller perform precisely.
3.	Estimate the possible errors in dynamic forces/torques that may come on the Actuators due to unmolded parameters.
4.	Understand the parallel robot kinematic design and solve its inverse and forward Kinematics.
5.	Attain the expertise necessary to evaluate a robot performance based on standard Parameters.

SYLLABUS

Unit 1:

Introduction to serial and parallel robot structure, standard kinematic notations, transformation matrices, link and joint parameters, forward and inverse kinematics, calculation of kinematic Jacobian, Euler angles, Singularity and Redundant robots. (8L)

Unit 2:

Calibration of geometric parameters: Geometric parameters, parameters of robot location, parameters of end-effector, Generalized differential model of the robot, General form of calibration model, Identification of geometric parameters, Autonomous calibration methods. (8L)

Unit 3:

Dynamic modelling of a serial robot, concept of moment of inertia, general form of dynamic equation of motion, calculation of energy, Lagrange-Euler formulation, Properties of dynamic model, effect of friction, actuator's rotor inertia, environmental forces. Identification of dynamic parameters, choice of identification trajectories, Evaluation of joint coordinates and torques, Practical considerations. (8L)

Unit 4:

Modelling of parallel robots: Parallel robot characteristics, advantages, disadvantages, structure and applications. Planar 3 Degrees of Freedom (DoF) manipulator, Spatial 6 DoF manipulators, Inverse geometric model and inverse kinematics, Singularities and statics, Manoeuvrability and condition number, Direct geometric model. (8L)

Unit 5:

Performance analysis of Robots: Accessibility, Workspace of a robot manipulator: primary and secondary spaces, Orientation workspace, Concept of aspects and connectivity, Local performances: Manipulability, Repeatability, Isotropy, Lowest singular value. ISO Standards.

(8L)

Course Outcomes

CO No	Course Outcome Description	Bloom's Level
CO1.	Outline the structure of a typical robotic system, understand its link and joint parameters, and perform robot kinematics.	K2, K4
CO2.	Identify the geometric parameters of a serial robot by applying the knowledge of serial robot kinematics and generalized differential model of the robot.	K4
CO3.	Identify the dynamic parameters of a serial robot by applying the knowledge of general form of dynamic equation of motion.	K4
CO4.	Analyse planar and spatial parallel robots in context to its forward and inverse kinematics, and evaluate its singularity, condition number and maneuverability.	K3, K4
CO5.	Design a robotic manipulator and evaluate its primary and secondary workspace. Evaluate the performance of an industrial robot based on ISO standards.	K2, K4

CO-PO Mapping Matrix

PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	1	1	0	0	0	1	1	2
CO2	3	3	2	2	1	0	0	0	1	1	2
CO3	3	2	2	2	1	0	0	0	1	1	3
CO4	2	2	3	2	1	0	0	0	1	1	2
CO5	2	2	2	2	1	0	0	0	1	1	3
Average	2.6	2.2	2.2	1.8	1	0	0	0	1	1	2.4

KL- Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1-Remember, K_2- Understand, K_3- Apply, K_4- Analyze, K_5- Evaluate, K_6- Create

CO-PO Mapping Matrix

Text Books

1. Etienne Dombre and Wisama Khalil, Robot Manipulators: Modeling, Performance Analysis and Control, ISTE, 2007.
2. S. K. Saha, Introduction to Robotics, McGraw Hill Education, 2008.
3. J. P. Marlett, Parallel Robots, Springer, 2006.

Reference Books

1. Bruno Siciliano and Oussama Khatib, Handbook of Robotics, Springer, 2016.
2. KS Fu, C. S. G Lee, R. Gonzalez, Robotics: Control, Sensing, Vision and Intelligence, McGraw-Hill Education, 1987.

3. ISO 9283:1998 Manipulating industrial robots -- Performance criteria and related test methods, ISO, 1998.

AUTOMATIC CONTROL

Subject code:-	**MTME202**	**IA Marks**	**30**
Number of Lecture Hours/Week:-	**04**	**Term End Exam Marks**	**70**
Total Number of Lecture Hours: -	**40**	**CREDITS**	**04**

Course Objectives

This course enables the students to:

1.	Express dynamic systems in form of differential equations, state space models, transient responses, transfer functions and frequency responses.
2.	Analyse the stability, steady state properties, controllability and observability, and fastness and damping of a linear system.
3.	Evaluate closed loop systems with respect to stability, as well as robustness against and sensitivity for model errors and disturbances
4.	Interpret and apply graphical methods and tools like block diagrams, root locus, Bode and Nyquist diagram to design simple controllers.
5.	Understand the function of simple controllers (PID controllers, lead-lag filters, state feedback) and controller structures (feedforward and cascade control)

SYLLABUS

Unit 1:

Introduction to control system, open-loop and closed loop systems, Laplace transforms, Inverse Laplace transforms, Solving linear time-invariant differential equations. Mathematical modelling of dynamic systems: Transfer function and Impulse response, Block diagrams, Modelling in state space, Mechanical, Electrical and Thermal systems, Linearization. (8L)

Unit 2:

Transient Analysis: First and Second order systems and its analysis, Basic Control systems: Proportional, Integral and Derivative (PID) Control, Routh's stability criterion, Pneumatic, Hydraulic and Electronic controllers. (8L)

Unit 3:

Root Locus Analysis in Control system, Rules for constructing a root locus, Control system design by root locus method: Lead and lag compensation. (8L)

Unit 4:

Frequency response analysis: Bode plots, Nyquist stability criterion, Stability analysis, Closed loop frequency response, control system design by frequency response: Lead and lag compensation. (8L)

Unit 5:

Analysis of Control system in State space, State-space representation for transfer functions, Controllability and Observability, Solving the time invariant state equation. Design of control systems in State-space, Pole placement, State observers, Design of servo systems. Tuning of PID controllers, Applications of Automatic Control and PLC. (8L)

Course Outcomes

CO No	Course Outcome Description	Bloom's Level
CO1.	Outline the working of a typical open-loop and closed loop control systems and can mathematically define and solve any dynamic system expressed as linear time invariant differential equations.	K2, K4
CO2.	Apply the knowledge of proportional, derivative and integral controllers to design a controller and analyse its stability.	K4
CO3.	Analyse a control system using root-locus and apply root locus method to design a control system.	K4
CO4.	Analyse a control system using frequency response (bode-plots) and evaluate the stability of a controller using Nyquist criterion.	K3, K4
CO5.	Design a servo-system based on state-space representation and define its controllability and observability.	K2, K4

CO-PO Mapping Matrix

PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	1	1	0	0	0	1	1	2
CO2	3	3	2	2	1	0	0	0	1	1	2
CO3	3	2	2	2	1	0	0	0	1	1	3
CO4	2	2	3	2	1	0	0	0	1	1	2
CO5	2	2	2	2	1	0	0	0	1	1	3
Average	2.6	2.2	2.2	1.8	1	0	0	0	1	1	2.4

KL- Bloom's Knowledge Level (K1, K2, K3, K4, K5, K6)

K1-Remember, K2- Understand, K3- Apply, K4- Analyze, K5- Evaluate, K_6- Create

Text Books

1. Katsuhiko Ogata, Modern Control Engineering, Prentice Hall of India, 2013.
2. N. S. Nise, Control Systems Engineering, Willey, 2008.
3. Madan Gopal, Control System Engineering, New Age Int. Publication, 2007.

Reference Books

1. Benjamin Kuo, Automatic Control System, Prentice Hall of India, 1995
2. Raven, F.H., Automatic Control Theory, McGraw Hill, 1995.
3. B. C. Nakra, Theory and Applications of Automatic Controls, New Age Int. Publication, 2017.

OPTIMIZATION TECHNIQUES

Subject code:-	**MTME203**	**IA Marks**	**30**
Number of Lecture Hours/Week:-	**04**	**Term End Exam Marks**	**70**
Total Number of Lecture Hours: -	**40**	**CREDITS**	**04**

Course Objectives

This course enables the students to:

1.	Formulate the different engineering optimization problems using the concept of optimization technique.
2.	Develop basic concept of algorithm to solve the different engineering optimization problems.
3.	Analyse and appreciate different algorithm methods in the field of optimization technique.

SYLLABUS

Unit 1: Introduction

Introduction to optimization, optimal problem formulation: design variables, constraints, objective function, variable bounds, engineering optimization problems, optimization algorithms. (8L)

Unit 2: Single variable optimization algorithms

Optimality criteria, bracketing methods, regional –elimination method, point estimation method, gradient based method, root finding using optimization techniques. (8L)

Unit 3: Multi variable optimization algorithms

Optimality criteria, Unidirectional search, direct search method: evolutionary optimization method, Simplex search method. (8L)

Unit 4: Constrained Optimization algorithms

Transformation methods, sensitivity analysis, direct search for constrained minimization, linearized search technique. (8L)

Unit 5: Specialized algorithms

Integer Programming: penalty function, branch and bound method, geometric programming, Bathtub curve, Genetic algorithm (GA): working principle, Differences and similarity between GAs and traditional methods, GAs for constrained optimization, real coded GAs, Advanced Gas. (8L)

Course Outcomes

After the end of the course, a student should be able to:

CO No	Course Outcome Description	Bloom's Level
CO1.	Understand and formulation of various optimization problem.	K2, K4
CO2.	Analyse the single variable optimization algorithm.	K4
CO3.	Analyse the multi variable optimization algorithm.	K4
CO4.	Analyse the constrained optimization algorithm.	K3, K4
CO5.	Design and modelling of specialized algorithm.	K2, K4

CO-PO Mapping Matrix

PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	1	1	0	0	0	1	1	2
CO2	3	3	2	2	1	0	0	0	1	1	2
CO3	3	2	2	2	1	0	0	0	1	1	3
CO4	2	2	3	2	1	0	0	0	1	1	2
CO5	2	2	2	2	1	0	0	0	1	1	3
Average	2.6	2.2	2.2	1.8	1	0	0	0	1	1	2.4

KL- Bloom's Knowledge Level (K1, K2, K3, K4, K5, K6)

K1-Remember, K2- Understand, K3- Apply, K4- Analyze, K5- Evaluate, K6- Create

Text Books

1. Kalyanmoy Deb, "Optimization for Engineering Design", First Edition, Prentice-Hall India Publishers, 2009.
2. Singiresu S. Rao, "Engineering Optimization theory and practice", Third Edition, New Age Publishers, 2018.

Reference Books

1. Jasbir Arora, "Optimal Design", Mc Graw Hill (International) Publishers.
2. D. E. Goldberg, "Genetic Algorithms in Search, Optimization and Machine Learning", First Edition, John Wiley Publishers, 2009.
3. Kalyanmoy Deb, "Multi Objective Optimization using Evolutionary Algorithms", Wiley Student Edition.

MECHANICS OF COMPOSITE MATERIALS

Subject code:-	**MTME204**	**IA Marks**	**30**
Number of Lecture Hours/Week:-	**04**	**Term End Exam Marks**	**70**
Total Number of Lecture Hours: -	**40**	**CREDITS**	**04**

Course Objectives

This course enables the students to:

1.	Present a comprehensive exposure to different composite materials
2.	Do various types and kinds of fabrication of composite materials
3.	Develop an intuitive understanding of Polymer, ceramic, metal based Composite materials.

SYLLABUS

Unit 1:

Introduction to Composite Materials Applications: Definition, classification and characteristics of composite Materials – fibrous composites, laminated composites, particulate composites. Applications: Automobile, Aircrafts, missiles, Space hardware, Electrical and electronics, Marine, recreational and sports equipment, future potential of composites. (7L)

Unit 2:

Fiber Reinforced Plastic Composite Materials Processing: Lay-up and curing, fabricating process, open and closed mould process, hand lay-up techniques; structural laminate bag molding, production procedures for bag molding; filament winding, pultrusion, pulforming, thermo-forming, injection molding, blow molding. (8L)

Unit 3:

Macro Mechanics of a Lamina: Two - dimensional relationship of compliance and stiffness matrix, Engineering constants, Stress-Strain relations for lamina of arbitrary orientation, Maximum stress theory, Maximum strain theory, Tsai-Hill theory, Tsai-Wu tensor theory, Numerical problems. (9L)

Unit 4:

Micro Mechanical Analysis of a Lamina: Introduction, Evaluation of the four elastic moduli by Rule of mixture, Hooke's law for different types of materials, Number of elastic constants, Numerical problems. (8L)

Unit 5:

Metal Matrix Composites: Reinforcement materials, types, characteristics and selection base metals selection. Need for production MMC's and its application. Fabrication Process for MMC's: Powder metallurgy technique, liquid metallurgy technique and secondary processing, special fabrication techniques. (8L)

Course Outcomes

After the end of the course, a student should be able to:

CO No	Course Outcome Description	Bloom's Level
CO1.	Correlate requirement of composite materials.	K2, K4
CO2.	Understand applicability and mechanics of composite materials under various conditions.	K4
CO3.	Characterize necessity of choice of various components of composite materials and their forms like filler, fibre, nano etc. with relative properties.	K4
CO4.	Apply various techniques for suitable composite material with required enhanced properties.	K3, K4
CO5.	Evaluate the performance composite materials for engineering applications.	K2, K4

CO-PO Mapping Matrix

PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	1	1	0	0	0	1	1	2
CO2	3	3	2	2	1	0	0	0	1	1	2
CO3	3	2	2	2	1	0	0	0	1	1	3
CO4	2	2	3	2	1	0	0	0	1	1	2
CO5	2	2	2	2	1	0	0	0	1	1	3
Average	2.6	2.2	2.2	1.8	1	0	0	0	1	1	2.4

KL- Bloom's Knowledge Level (K1, K2, K3, K4, K5, K6)

K1-Remember, K2- Understand, K3- Apply, K4- Analyze, K5- Evaluate, K6- Create

Text Books

1. R.M. Jones, Mechanics of Composites, 2nd ed., Taylor & Francis, 1999.
2. T. G. Gutowski, (Ed.) Advanced Composites Manufacturing, John Wiley & Sons, New York 1997.
3. P.M. Ajayan, L. Schadler, P.V. Braun Nano Composite Science and Technology, Wiley VCH, 2003.

Reference Books

1. E. Fitzer, L.M. Manocha, Carbon Reinforcement and Carbon/Carbon Composites, SpringerVerlag, Heidelberg, New York, 1998.
2. N. Chawla, K.K. Chawla, Metal Matrix Composites, Springer-Verlag, 2006.
3. J.C. Seferis, L. Nicolais, (Eds.) The Role of the Polymeric Matrix in the Processing and Structural Properties of Composite Materials, Plenum Press, New York 1983

FINITE ELEMENT ANALYSIS

Subject code:-	**MTME205**	**IA Marks**	**30**
Number of Lecture Hours/Week:-	**04**	**Term End Exam Marks**	**70**
Total Number of Lecture Hours: -	**40**	**CREDITS**	**04**

Course Objectives

This course enables the students to:

1.	Understand the basic concepts and procedures in finite element analysis.
2.	Analyze different types of mechanics problems in engineering using the finite element method.
3.	Apply hands-on experience on conducting various mechanics analyses by using a state-of-the-art finite element software.

SYLLABUS

Unit 1: Overview of engineering systems

Continuous and discrete systems (discussion on differential equations, matrix algebra), steady state, propagation and eigenvalue problems. (8L)

Unit 2: Energy methods

Variational principles and weighted residual techniques (least square method, collocation, sub-domain collocation, Galerkin method) for one-dimensional equation, Rayleigh-Ritz Formulation, development of bar and beam element, application to truss and frames. (8L)

Unit 3: Finite elements for two-dimensions

Equivalence between energy formulation and Galerkin approach, discretization concepts, choice of elements, derivation of element shape functions (Lagrangian and Hermite) in physical coordinates. (8L)

Unit 4: Iso-parametric mapping

Iso-parametric mapping, numerical integration, Assembly procedure, solution techniques, Jacobian matrix. Numerical integration – 2- and 3-point Gauss Quadrature, full and reduced integration. Sub-modeling, sub-structuring, introduction to finite element programming. (8L)

Unit 5: Case study

Torsion of prismatic bars, modal analysis; direct integration methods for dynamic analysis; contact analysis, applications to problems in engineering: plane elasticity, heat conduction, potential flow and Transient problems. Computer implementation (8L)

Course Outcomes

After the end of the course, a student should be able to:

CO No	Course Outcome Description	Bloom's Level
CO1.	Understand the basics of Finite Element Analysis, viz. Continuous and discrete systems.	K2, K4
CO2.	Evaluate structural problems using energy methods.	K4
CO3.	Analyze different approaches and theorems to structural problems in finite elements for two dimensions.	K4
CO4.	Implement the concept of Iso-parametric mapping in sub-modeling, sub structuring using finite element programming.	K3, K4
CO5.	Apply the concept of Finite Element Methods in different practical engineering analysis.	K2, K4

CO-PO Mapping Matrix

PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	1	1	0	0	0	1	1	2
CO2	3	3	2	2	1	0	0	0	1	1	2
CO3	3	2	2	2	1	0	0	0	1	1	3
CO4	2	2	3	2	1	0	0	0	1	1	2
CO5	2	2	2	2	1	0	0	0	1	1	3
Average	2.6	2.2	2.2	1.8	1	0	0	0	1	1	2.4

KL- Bloom's Knowledge Level (K1, K2, K3, K4, K5, K6)

K1-Remember, K2- Understand, K3- Apply, K4- Analyze, K5- Evaluate, K6- Create

Text Books

1. Chandrupatla T . R., and Belegundu, A. D., Introduction to Finite Elements in Engineering, Prentice Hall, 2003.
2. Reddy, J. N., An Introduction to the Finite Element Method, 3rd Edition, McGraw- Hill Science/Engineering/Math, 2005.
3. Bhatti, M.A., Fundamental Finite Element Analysis and Applications: with Mathematica and Matlab Computations, Wiley, 2005.

Reference Books

1. Bathe, K-J., Finite Element Procedures, Prentice Hall, 1996.
2. Logan D. L., A First Course in the Finite Element Method, Thomson- Engineering, 3rd edition, 2001.
3. Zienkiewicz, O.C. and Taylor, R.L., The Finite Element Method, 6th Ed., Vol. 1, Elsevier, 2005.

ROBOTICS LABORATORY

Subject code:-	**MTME208-L**	**IA Marks**	**30**
Number of Lecture Hours/Week:-	**04**	**Term End Exam Marks**	**70**
Total Number of Lecture Hours: -	**40**	**CREDITS**	**02**

Course Objectives

This course enables the students to:

1.	Learn about industrial robots and systems and its safe handling.
2.	Create a kinematic and dynamic robot simulation of robot using scientific visualization tools like V-Rep or MATLAB/Sim Mechanics.
3.	Be acquainted with standard industrial robot, its sub-systems and prepare application programs for standard industrial tasks.
4.	Gain a hands-on experience in a rigging an industrial pneumatics and electro-pneumatics circuit and integrate with a PLC.
5.	Identify the kinematic parameters and troubleshoot a given robotic system.

List of Experiments

Experiment 1: Introduction to Industrial Robot (KUKA KR5 Arc): Frames, Safety, Teach Pendant, etc.

Experiment 2: End-effector tool and base calibration and manual/CAD verification.

Experiment 3: Program industrial robot for a standard pelletizing operation.

Experiment 4: Identification of DH Parameters of a 3R Spatial robot through experiment and verification using robot simulation tool like, Robo Analyzer.

Experiment 5: Electro-pneumatic circuit design for automated single cylinder reciprocating action.

Experiment 6: Sequential double cylinder reciprocating action using electro-pneumatic circuit.

Experiment 7: PLC: Introduction to Ladder Logic Programming.

Experiment 8: Interfacing electro-pneumatic circuit for single cylinder using PLC.

Experiment 9: Troubleshooting of electro-pneumatic circuit for an unknown fault.

Experiment 10: Using MATLAB/Sim Mechanics for perform mechanical simulation.

Experiment 11: Create and simulate a 3R robot in MATLAB/Sim Mechanics and verify its forward kinematics.

Experiment 12: Extend the MATLAB/Sim Mechanics model to verify analytical inverse kinematics solution.

Experiment 13: Use MATLAB/Sim Mechanics to perform inverse and forward dynamics of a 2R planar robot.

Course Outcomes

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

CO No	Course Outcome Description	Bloom's Level
CO1.	Be acquainted with standard industrial robot, safe handling, its sub-systems and prepare application programs for standard industrial tasks.	K2, K4
CO2.	Apply the knowledge of robot kinematics to identify the kinematic parameters of standard industrial robot	K4
CO3.	Analyse a given robot system using virtual simulation tools and interpret the results of kinematics, forward and inverse dynamics.	K4
CO4.	Design and create pneumatic and electro-pneumatic circuits using PLC.	K3, K4
CO5.	Build up an aptitude to troubleshoot any unknown problem in a standard electro-pneumatic circuit.	K2, K4

CAD LAB

Subject code:-	**MTME209-L**	**IA Marks**	**30**
Number of Lecture Hours/Week:-	**04**	**Term End Exam Marks**	**70**
Total Number of Lecture Hours: -	**40**	**CREDITS**	**02**

Course Objectives

This course enables the students to:

1. Do Solid Modeling using CAD Software.
2. Generate CAD curves.
3. Interface CAD and FE packages

List of Experiments

Experiment 1: Review of 2-Dimensional drawing.

Experiment 2: 3-Dimensional modelling and assembly of Foot step bearing using CREO.

Experiment 3: 3-Dimensional modelling and assembly of Cotter joint bearing using CREO.

Experiment 4: Writing program for 2-D and 3-D transformation for Translation, Scaling, and Rotation.

Experiment 5: Writing program for 2-D and 3-D transformation for Shearing and Reflection.

Experiment 6: Generation of Bezier curve.

Experiment 7: Generation of Hermite and B-Spline curve.

Experiment 8: Development of programs for design, drawing and plotting of machine element: Shaft.

Experiment 9: Development of programs for design, drawing and plotting of machine element: Gears.

Experiment 10: Development of programs for design, drawing and plotting of machine element: Connecting rod.

Course Outcomes

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

CO No	Course Outcome Description	Bloom's Level
CO1.	Perform solid modeling of mechanical parts.	K2, K4
CO2.	Model assemblies of mechanical equipments.	K4
CO3.	Generate Drawing / Orthographic View.	K4
CO4.	Develop program for 2-D and 3-D transformation.	K3, K4
CO5.	Develop programs for design, drawing and plotting of machine element.	K2, K4

SURFACE ENGINEERING

Course Objectives

This course enables the students to:

1.	To understand the basic principle of material science and engineering, including material properties, microstructure, and surface behaviour.
2.	To learn about various surface engineering techniques, including surface treatment methods (like hardening and alloying), coating processes (like thermal spraying, PVD, and CVD), and their respective advantages and disadvantages.
3.	To understand the surface engineering affects the behaviour and performance of materials, including aspects like wear resistance, corrosion resistance, friction.
4.	To understand how surface engineering is used in various application, such as tribology, corrosion protection, and tool manufacturing.
5.	To analyze specific material requirements and select appropriate surface engineering methods to achieve desired outcomes.

SYLLABUS

Unit- 1
Introduction of conventional casting: Introduction of surface engineering, Philosophy of surface, general applications and requirements. Engineering components, surface dependent properties and failures, importance and scope of surface engineering. [8L]

Unit- 2
Surface Degradation: Basic principles of electrochemistry and aqueous corrosion processes; Oxidation and related concept; Mechanical Friction and Wear like abrasive, erosive and sliding wear etc.; Interaction between wear and corrosion. Surface engineering processes and their types (only basic idea, Conventional surface heat treatment processes. Surface engineering by material removal: Cleaning, pickling, etching, grinding, polishing, buffing / puffing (techniques employed, its principle). Role and estimate of surface roughness, material addition: From liquid bath - hot dipping (principle and its application with examples). [12L]

Unit- 3
Surface engineering Process: General classification, scope and principles, types and intensity/energy deposition profile; Laser assisted microstructural modification – surface melting, hardening, shocking and similar processes; Laser assisted compositional modification – surface alloying of steel and non-ferrous metals and alloys; surface cladding, composite surfacing and similar techniques; Electron beam assisted modification and joining; Ion beam assisted microstructure and compositional modification.

[12L]

Unit- 4: Advanced Process
Physical vapour-deposition, PEPVD, Chemical vapour-deposition, Electrodeposition, Anodizing, Galvanizing, Thermal Spraying (all types), Plasma based techniques like plasma nitriding, plasma carburizing, PSII, LSH, LSA, LSM etc. Weld-surfacing, friction surfacing, explosive cladding. [12L]

Unit- 5
Characterization of engineered surface: XRD, XPS, surface-mechanical characterization, corrosion study

etc. (Apart from common techniques) [5L]

Course Outcomes

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

1.	To understand the basic principle for surface degradation of materials	K2, K4
2.	To learn surface morphology of different kind of materials and their response in working conditions	K4
3.	To understand principles, theory, mechanism and key variables of different advanced surface modification techniques.	K4
4.	Appreciate cutting edge research in the area of surface engineering and coatings.	K3, K4
5.	Use surface engineering methods and coating technologies to investigate new and emerging technologies.	K2, K4

CO-PO Mapping Matrix

PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	1	1	0	0	0	1	1	2
CO2	3	3	2	2	1	0	0	0	1	1	2
CO3	3	2	2	2	1	0	0	0	1	1	3
CO4	2	2	3	2	1	0	0	0	1	1	2
CO5	2	2	2	2	1	0	0	0	1	1	3
Average	2.6	2.2	2.2	1.8	1	0	0	0	1	1	2.4

KL- Bloom's Knowledge Level (K1, K2, K3, K4, K5, K6)
K1-Remember, K2- Understand, K3- Apply, K4- Analyze, K5- Evaluate, K6- Create

Text Books:

1. T Burakowski and T. Wierzchon, Surface engineering of metals, CRC Press.
2. W. Batchelor, L. N. Lam and M. Chandrasekaran, Materials degradation and its control by surface engineering, Imperial college press.
3. S Grainger and J. Blunt, Engineering coatings, William Andrew Publishing.

Reference Books:

1. K.G. Budinski, Surface Engineering for Wear Resistances, Prentice Hall, Englewood Cliffs, 1988.
2. Laser Surface Engineering Processes and Applications, J. R. Lawrence, C. Dowding, D. Waugh and J. B. Griffiths, A volume in Woodhead Publishing, 2015.

INDUSTRIAL ROBOTICS

Subject code:-	**MTME107-1OE-I**	**IA Marks**	**30**
Number of Lecture Hours/Week:-	**04**	**Term End Exam Marks**	**70**
Total Number of Lecture Hours: -	**40**	**CREDITS**	**04**

Course Objectives

This course enables the students to:

1. Understand the kinematic design and dynamic formulation of a typical industrial robot.
2. Foresee the possibilities in design uncertainties in kinematic model of a robot and make necessary changes in the modelling to make the controller perform precisely.
3. Estimate the possible errors in dynamic forces/torques that may come on the actuators due to un-modelled parameters.
4. Understand the parallel robot kinematic design and solve its inverse and forward kinematics.
5. Evaluate a robot performance based on standard parameters.

SYLLABUS

Unit 1:

Robotic systems - Its role in automated manufacturing; robot anatomy; classifications and specifications, Serial robot kinematics: forward and inverse, homogeneous transformations. (8L)

Unit 2:

Robot sensors, different types of contact and non-contact sensors; Robot vision and their interfaces. (8L)

Unit 3:

Robot actuators and control; Pneumatic, hydraulic and electrical drives, controls used in robots. Robot end-effectors: mechanical, magnetic and vacuum grippers, gripping forces RCC and design features of grippers. (8L)

Unit 4:

Robot languages and programming techniques. Performance analysis of Robots: Accessibility, Workspace of a robot manipulator: primary and secondary spaces, Orientation workspace, Local performances: Manipulability, Repeatability, Isotropy and Dexterity. (8L)

Unit 5:

Applications of robots in materials handling, machine loading/unloading, inspection, welding, spray painting and finish coating, and assembly, etc. Robot installation and planning. (8L)

Course Outcomes

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

CO No	Course Outcome Description	Bloom's Level
CO1.	Outline the structure of a typical robotic system, understand its link and joint parameters, and perform robot kinematics.	K2, K4
CO2.	Identify the geometric parameters of a serial robot by applying the knowledge of serial robot kinematics and generalized differential model of the robot.	K4
CO3.	Identify the dynamic parameters of a serial robot by applying the knowledge of general form of dynamic equation of motion.	K4
CO4.	Analyze planar and spatial parallel robots in context to its forward and inverse kinematics, and evaluate its singularity, condition number and maneuverability.	K3, K4
CO5.	Design a robotic manipulator and evaluate its primary and secondary workspace. Evaluate the performance of an industrial robot based on ISO standards.	K2, K4

CO-PO Mapping Matrix

PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	1	1	0	0	0	1	1	2
CO2	3	3	2	2	1	0	0	0	1	1	2
CO3	3	2	2	2	1	0	0	0	1	1	3
CO4	2	2	3	2	1	0	0	0	1	1	2
CO5	2	2	2	2	1	0	0	0	1	1	3
Average	2.6	2.2	2.2	1.8	1	0	0	0	1	1	2.4

KL- Bloom's Knowledge Level (K1, K2, K3, K4, K5, K6)
K1-Remember, K2- Understand, K3- Apply, K4- Analyze, K5- Evaluate, K6- Create

Text Books

1. Industrial Robotic Technology - Programming and Application by M. P. Groover et. al., McGraw Hill
2. KS Fu, C. S. G Lee, R. Gonzalez, Robotics: Control, Sensing, Vision and Intelligence, McGraw-Hill Education, 1987.
3. S. K. Saha, Introduction to Robotics, McGraw Hill Education, 2008.

Reference Books

1. Bruno Siciliano and Oussama Khatib, Handbook of Robotics, Springer, 2016.
2. ISO 9283:1998 Manipulating industrial robots -- Performance criteria and related test methods, ISO, 1998.

FRACTURE MECHANICS

Subject code:-	**MTME108OE-I**	**IA Marks**	**30**
Number of Lecture Hours/Week:-	**04**	**Term End Exam Marks**	**70**
Total Number of Lecture Hours: -	**40**	**CREDITS**	**04**

Course Objectives

This course enables the students to:

1. Review basics of Solid Mechanics and Fracture Mechanics
2. Analyse crack propagation in linear elastic regime.
3. Develop Finite Element Model for linear and nonlinear elastic materials.
4. Analyse fracture in viscoelastic materials
5. Develop Mathematical Models for crack growth

SYLLABUS

Unit 1: Introduction and Overview

Current Fracture Mechanics and its application. Elements of Solid Mechanics: Stress analysis, Equilibrium Equation, Strain analysis Compatibility Equation, Strain energy Density, Elastic Boundary Value Problem, Rubber Elasticity, Principle of Virtual work. Viscoelasticity: Linear Viscoelastic Materials, Thermorheologically Simple Materials. Elastoplasticity: Yield Criteria, Incremental Plasticity, Deformation Plasticity. (6L)

Unit 2: Linear Elastic Fracture Mechanics

Linear Elastic Crack Tip Field, The Stress Intensity Factor (close form solution and Numerical Method). Energetics of Cracked Bodies: The Energy Release Rate, The J-Integral. The Plastic Zone and Fracture Toughness. Dynamic Fracture Mechanics: Dynamic Crack Propagation and Arrest Concepts, Mathematical Basis of Dynamic Fracture Mechanics, Application of Dynamic Fracture Mechanics.(8L)

Unit 3: Fracture Mechanics Model for Fiber Reinforced Composites

Classifications and Terminology for Composites, Basic Mechanical Behaviour of Composite structures, Anisotropic Fracture Mechanics, Micromechanical Failure process. Nonlinear Fracture Mechanics analysis: Continuum Models, Hybrid Models, Finite Element Modes. (6L)

Unit 4: Stationary Crack-Tip Fields

Elastic Secondary Creep, Elastic Primary Creep, Primary Secondary Creep, Plastic-Primary Creep, Elastic-Exponential Law Creep, The ΔTk Integral. Creep Crack Growth: Elastic- Secondary Creep Crack Field, Steady State Crack Growth, Transient Crack Growth, Elastic- Primary Creep Crack Fields, Creep Crack Growth Correlations. (8L)

Unit 5: Basic considerations in prediction of Fatigue Crack Propagation

Constant Amplitude Fatigue Crack Growth Relations, Load Interaction Effects, The Crack Closure Concept. Theoretical Models for Fatigue Crack Propagation: The Model of Budiansky and Hutchinson, The inclined Strip Yield Model, The Short Crack Problem in Fatigue, Fatigue Crack Growth in Welds. (12L)

Course Outcomes

After the end of the course, a student should be able to:

CO No	Course Outcome Description	Bloom's Level
CO1.	Demonstrate basics of Fracture Mechanics	K2, K4
CO2.	Apply linear elastic approach to analyze crack propagation	K4
CO3.	Apply numerical technique to analyze fracture in composite materials	K4
CO4.	Analyze deformation and fracture in viscoelastic materials	K3, K4
CO5.	Develop Mathematical Models to predict and arrest crack	K2, K4

CO-PO Mapping Matrix

PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	1	1	0	0	0	1	1	2
CO2	3	3	2	2	1	0	0	0	1	1	2
CO3	3	2	2	2	1	0	0	0	1	1	3
CO4	2	2	3	2	1	0	0	0	1	1	2
CO5	2	2	2	2	1	0	0	0	1	1	3
Average	2.6	2.2	2.2	1.8	1	0	0	0	1	1	2.4

KL- Bloom's Knowledge Level (K1, K2, K3, K4, K5, K6)

K1-Remember, K2- Understand, K3- Apply, K4- Analyze, K5- Evaluate, K6- Create

Text Books

1. Advanced Fracture Mechanics, M. F. Kanninen and C. H. Popelar

Reference Books

1. Fracture Mechanics Fundamentals and Applications, T. L. Anderson
2. Elementary Engineering Fracture Mechanics, David Broek
3. Fracture Mechanics for Modern Engineering Design, K. R. Y. Simha

THEORY OF ELASTICITY

Subject code:-	**MTME109OE-I**	**IA Marks**	**30**
Number of Lecture Hours/Week:-	**04**	**Term End Exam Marks**	**70**
Total Number of Lecture Hours: -	**40**	**CREDITS**	**04**

Course Objectives

This course enables the students to:

1. Present the mathematical and physical principles in understanding the continuum behaviour of solids.
2. Understand advanced topics of elasticity.

SYLLABUS

Unit 1: Analysis of Finite Deformations

Material and spatial description of a continuous body, Deformation gradient tensor, Cauchy- Green deformation tensor, Deformation of line and surface element, Polar decomposition of deformations, Principal stretches and principal axes of deformation, Strain invariants, Alternative stress measures – first and second Piola- Kirchhoff stress tensor. (10L)

Unit 2: Constitutive Equations

Linear constitutive equations, Generalized Hooke's Law, Material Symmetry, Monoclinic Materials, Orthotropic Materials, Transversely Isotropic Materials, Isotropic Materials, Nonlinear constitutive equations, theory of finite elastic deformations. (5L)

Unit 3: Three – dimensional problems

Field theory - Poisson's Equation, Three-Dimensional Dirac Delta Function, Helmholtz's Representation Theorem, Green's Theorem, Potentials in Elasticity -Displacement Potentials, Papkovich Representation, Kelvin's Problem, Mindlin's Problem, Boussinesq's problem. (8L)

Unit 4: Variational Methods

Calculus of Variations - Process of "Taking Variations", Lagrange Multipliers, Energy Theorems in Elasticity - Principle of Virtual Work, Principle of Minimum Potential Energy, Complementary Strain Energy Density, Principle of Minimum Complementary Energy, Approximate Solutions - Rayleigh-Ritz Method. (8L)

Unit 5: Complex Variable Methods

Review of complex variable theory, Formulation of plane elasticity problems, Resultant boundary conditions, General structure of complex potentials, Circular domain problems, Plane and half-plane problems, Applications using method of conformal mapping. (9L)

Course Outcomes

After the end of the course, a student should be able to:

CO No	Course Outcome Description	Bloom's Level
CO1.	Analyze finite and nonlinear elastic deformation behaviour of solid material.	K2, K4
CO2.	Implement the idea of linear and nonlinear constitutive equations in the field of elasticity of materials.	K4
CO3.	Apply mathematical principles (Poisson's equation, Green's theorem, etc.) to solve three-dimensional problems.	K4
CO4.	Understand variational and complex variable method for solving elasticity problems.	K3, K4
CO5.	Create new ideas in the area of theory of elasticity.	K2, K4

CO-PO Mapping Matrix

PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	1	1	0	0	0	1	1	2
CO2	3	3	2	2	1	0	0	0	1	1	2
CO3	3	2	2	2	1	0	0	0	1	1	3
CO4	2	2	3	2	1	0	0	0	1	1	2
CO5	2	2	2	2	1	0	0	0	1	1	3
Average	2.6	2.2	2.2	1.8	1	0	0	0	1	1	2.4

KL- Bloom's Knowledge Level (K1, K2, K3, K4, K5, K6)

K1-Remember, K2- Understand, K3- Apply, K4- Analyze, K5- Evaluate, K6- Create

Text Books

1. Continuum Mechanics, A.J.M Spencer, Dover Publications, INC
2. Elasticity, Theory, Applications, and Numerics by Martin H. Sadd
3. Theory of Elasticity by Stephen Timoshenko and, J. N. Goodier

Reference Books

1. An Introduction to Continuum Mechanics, J. N. Reddy, Cambridge University Press.
2. The Linearized Theory of Elasticity, W. S. Slaughter, Springer Science+Business Media, LLC

MATERIALS MODELLING AND SIMULATION

Subject code:-	**MTME110-OE-I**	**IA Marks**	**30**
Number of Lecture Hours/Week:-	**04**	**Term End Exam Marks**	**70**
Total Number of Lecture Hours: -	**40**	**CREDITS**	**04**

Unit-1

Introduction to materials modelling and simulation; concept of multiscale materials modelling; different approaches used in **materials** modelling and their benefits and drawbacks. General overview of atomistic modelling techniques - molecular dynamics (MD) and montecarlo (MC) technique applied to engineering materials; DFT calculations; Ab-initio molecular dynamics; kinetic montecarlo simulation.

[5L]

Unit-2

Molecular dynamics modelling and simulation - general steps; ensembles; interatomic potential; initial and boundary conditions; force calculation; phase space evolution; integration algorithms; thermostatting and barostatting; MD data analysis and property calculations. [5L]

Unit-3

General overview of continuum modelling techniques - finite element method (FEM) modelling and simulation - advantages and drawbacks of the method; types and applications of the method.

[5L]

Unit-4

FEM modelling - general steps; different approaches for deriving element properties: direct approach, variational approach, and Galerkin's method; types of elements and interpolation functions; condensation and substructuring; continuity requirements; mesh refining; Gauss quadrature; FEM modelling for structural and thermal problems. [5L]

Unit-5

Coding and use of software for materials modelling using MD and FEM technique. Demonstration of a multiscale model developed by coupled MD - FEM simulation. [5L]

Course Outcomes

After the end of the course, a student should be able to:

CO No	Course Outcome Description	Bloom's Level
CO1.	To understand the concept of materials modelling and simulation for structure and properties of materials.	K2, K4
CO2.	To understand molecular dynamics simulation.	K4
CO3.	To understand FEM simulation.	K4
CO4.	To apply materials modelling methodologies for extracting behaviour of materials in real applications.	K3, K4

CO-PO Mapping Matrix

PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	1	1	0	0	0	1	1	2
CO2	3	3	2	2	1	0	0	0	1	1	2
CO3	3	2	2	2	1	0	0	0	1	1	3
CO4	2	2	3	2	1	0	0	0	1	1	2
CO5	2	2	2	2	1	0	0	0	1	1	3
Average	2.6	2.2	2.2	1.8	1	0	0	0	1	1	2.4

KL- Bloom's Knowledge Level (K1, K2, K3, K4, K5, K6)

K1-Remember, K2- Understand, K3- Apply, K4- Analyze, K5- Evaluate, K6- Create

Text Books:

1. Understanding Molecular Simulation*: D. Frenkel and B. Smit*, Academic Press, 2002.
2. The Finite Element Method for Engineers, 4th Edition: *Kenneth H. Huebner, Donald L. Dewhirst, Douglas E. Smith, Ted G. Byrom, Wiley, 2001*

Reference Books:

1. The Art of Molecular Dynamics Simulation: *D.C. Rapaport*, Cambridge University Press, 2004.
2. Statistical mechanics: *Donald A. Mcquarrie*, Harper Row, 1976.
3. An Introduction to the Finite Element Method (Mcgraw Hill Series in Mechanical Engineering)3rd Edition: *J. N. Reddy*.

VIBRATION OF CONTINUOUS SYSTEMS

Subject code:-	**MTME206-OE-II**	**IA Marks**	**30**
Number of Lecture Hours/Week:-	**04**	**Term End Exam Marks**	**70**
Total Number of Lecture Hours: -	**40**	**CREDITS**	**04**

Course Objectives

This course enables the students to:

1. Set-up initial-boundary value problems for some important and fundamental structural members viz. bars, strings, membrane and plates.
2. Find analytical and approximate solutions to above mentioned problems for various loading and boundary conditions.

SYLLABUS

Unit 1: Vibrations of strings and bars

Dynamics of strings and bars: the Newtonian formulation, Dynamics of strings and bars: the variational formulation, Free vibration problem: Bernoulli's solution, Modal analysis, The initial value problem: solution using Laplace transform, Forced vibration analysis, approximate methods for continuous systems, Continuous systems with damping, Non- homogeneous boundary conditions. (9L)

Unit 2: One-dimensional wave equation: D'Alembert's solution

D'Alembert's solution of the wave equation- The initial value problem, The initial value problem: solution using Fourier transform, Harmonic waves and wave impedance, Energetics of wave motion, Scattering of waves, Applications of the wave solution. (7L)

Unit 3: Vibrations of beams

Equation of motion, Free & Forced vibration problem analysis, Non-homogeneous boundary conditions, The Timoshenko beam, Damped vibration of beams, Special problems in vibrations of beams- Influence of axial force on dynamic stability, Beam with eccentric mass distribution, Problems involving the motion of material points of a vibrating beam. (7L)

Unit 4: Vibrations of membranes

Dynamics of a membrane, Modal analysis-The rectangular membrane, the circular membrane, Forced vibration analysis, Waves in membranes- Waves in Cartesian coordinates, Waves in polar coordinates, Energetics of membrane waves, Initial value problem for infinite membrane. (8L)

Unit 5: Vibrations of plates

Dynamics of plates, Vibrations of rectangular plates- Free vibrations, Orthogonality of plate Eigen functions, Forced vibrations, Vibrations of circular plates - Free vibrations, Forced vibrations, Waves in plates, Plates with varying thickness. (8L)

Course Outcomes

After the end of the course, a student should be able to:

CO No	Course Outcome Description	Bloom's Level
CO1.	Define various continuous systems viz. strings, bars, beams, plates	K2, K4
CO2.	Formulate those continuous systems-using various techniques	K4
CO3.	Solve the continuous systems under free and forced vibration conditions.	K4
CO4.	Calculate the response of the systems.	K3, K4
CO5.	Analyze the response of the systems of various practical applications.	K2, K4

CO-PO Mapping Matrix

PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	1	1	0	0	0	1	1	2
CO2	3	3	2	2	1	0	0	0	1	1	2
CO3	3	2	2	2	1	0	0	0	1	1	3
CO4	2	2	3	2	1	0	0	0	1	1	2
CO5	2	2	2	2	1	0	0	0	1	1	3
Average	2.6	2.2	2.2	1.8	1	0	0	0	1	1	2.4

KL- Bloom's Knowledge Level (K1, K2, K3, K4, K5, K6)

K1-Remember, K2- Understand, K3- Apply, K4- Analyze, K5- Evaluate, K6- Create

Text Books

1. P. Hagedorm & A. Dasgupta, Vibrations & waves in continuous mechanical systems, John Wiley & Sons Ltd.
2. S S Rao, Vibration of Continuous System, John Wiley & Sons Ltd, 2007.

Reference Books

1. L. Meirovitch, Elements of Vibration Analysis, McGraw Hill Education (India), 1986.
2. A W Leissa & M S Qata, Vibrations of Continuous System, McGraw Hill Education, 2011.

SECONDARY STEEL MAKING

Subject code:-	**MTME207-OE-II**	**IA Marks**	**30**
Number of Lecture Hours/Week:-	**04**	**Term End Exam Marks**	**70**
Total Number of Lecture Hours: -	**40**	**CREDITS**	**04**

Course Objectives

This course enables the students to:

1. The students will acquire knowledge of secondary steelmaking processes.
2. The students will be able to solve industry-related problems with the knowledge of thermodynamics and reaction kinetics.
3. The students will understand the role of different types of slags and powders for inclusion controls.
4. The students will be able to acquire the concept of ultra-low carbon, ultra-low sulfur, ultra-low phosphorus, and inclusion-free steel-making processes.
5. The students will understand the concept of clean steelmaking, the origin of non-metallic inclusion, and its modification techniques.

SYLLABUS

Unit-1

Introduction: Brief review of primary steel making processes, composition of the crude steel, need for secondary refining, objective of secondary steel making, secondary steel making equipment and processes, preheating and recycling of ladles. [4L]

Unit-2

Chemical equilibrium, Activity-Composition relationships: Concentrated solutions, Activity- Composition relationships: dilute solutions, interaction coefficient, chemical potential and equilibrium, physico-chemical principles of Secondary steel making, Slag basicity and capacities. [4L]

Unit-3

Fluid flow in steel melts in Gas-Stirred ladle. Mixing, Mass transfer and kinetics: Introduction, mixing in steel melts in Gas-stirred ladles, kinetics of reactions among phases, Mass transferrin a Gas-Stirred ladle, Mixing Vs. Mass transfer control. Powder injection refining: Introduction, Advantages and disadvantages, transitory and permanent contact reaction, bubbling-jetting phenomena. Core wire injection: Introduction, Advantages and application Deoxidation of liquid steel: Introduction, slag Carry-over: Impact on Ladle Metallurgy, Thermodynamics of deoxidation of molten steel, Kinetics of deoxidation of molten steel, deoxidation in industry. [6L]

Unit-4

Degassing and Decarburization in liquid steel: Introduction, thermodynamics of reactions in vacuum degassing, side reactions during degassing, fluid flow and mixing in vacuum degassing, rates of vacuum degassing and decarburization, decarburization for Ultra-low carbon (ULC) and stainless steel. [14L]

Unit-5

Desulfurization in secondary steelmaking: Introduction, thermodynamics aspects, desulfurization with only top slag, injection metallurgy for Desulfurization. Gas absorption during tapping and teeming from surrounding atmosphere, temperature changes of molten steel during secondary steelmaking, phosphorus control in secondary steelmaking, Nitrogen control in steel making. Inclusions and inclusion modification: Introduction, origin of nonmetallic inclusions, Types and properties of inclusions, Influence of inclusions on the mechanical properties of steel, Inclusion identification and cleanliness assessment, formation of inclusions during solidification, inclusion modification. [14L]

Course Outcomes

After the end of the course, a student should be able to:

CO No	Course Outcome Description	Bloom's Level
CO1.	Learn fundamentals of physico-chemical principles of Secondary steel making.	K2, K4
CO2.	Identify and solve reaction kinetics and mechanisms.	K4
CO3.	To learn the design & operational aspects of Vacuum technology.	K4
CO4.	Ability to analyze industrial processes to meet the current need.	K4

CO-PO Mapping Matrix

PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	1	1	0	0	0	1	1	2
CO2	3	3	2	2	1	0	0	0	1	1	2
CO3	3	2	2	2	1	0	0	0	1	1	3
CO4	2	2	3	2	1	0	0	0	1	1	2
CO5	2	2	2	2	1	0	0	0	1	1	3
Average	2.6	2.2	2.2	1.8	1	0	0	0	1	1	2.4

KL- Bloom's Knowledge Level (K1, K2, K3, K4, K5, K6)

K1-Remember, K2- Understand, K3- Apply, K4- Analyze, K5- Evaluate, K6- Create

Text Books:

1. A. Ghosh, and A. Chatterjee, , Principles and Practices in Iron and Steel making, Prentice Hall of India, New Delhi, 2008.
2. A. Ghosh, Secondary Steelmaking, CRC Press, Boca Raton, 2000.

Reference Books:

1. Making, Shaping and Treating of Steel (Steelmaking and Refining), 10th Edition, 1985, AISE, Pittsburgh.

ADVANCES IN PRODUCTION OF NON-FERROUS METALS

Subject code:-	**MTME208-OE-II**	**IA Marks**	**30**
Number of Lecture Hours/Week:-	**04**	**Term End Exam Marks**	**70**
Total Number of Lecture Hours: -	**40**	**CREDITS**	**04**

Course Objectives

This course enables the students to:

1. Understand the principles of various extraction and refining processes for non-ferrous metals, including pyrometallurgy, hydrometallurgy, and electrowinning.
2. Analyze the thermodynamic and kinetic factorsinfluencing the production of non-ferrous metls, enabling students to optimize process parameters.
3. Design and evaluate different non-ferrous metal production processes, considering factors such as cost, efficiency, and environmental impact.
4. Identify and implement advanced techniques for quality control and characterization of non-ferrous metal products.
5. Develop an understanding of the applications of various non-ferrous metals in different industries.

SYLLABUS

Unit-1

Aluminium: Bayer process, its chemistry and practice, Soda-Lime Sinter Process. Hall Heroult process: carbon anodes, theoretical principles, factors influencing the process, current and energy efficiencies. Alternane Al production like, Mitsubisi Kwara process. Modern development of Aluminium production like Inert anode drained cathode. [8L]

Unit-2

Copper: Advances in Concentration, Roasting, matte smelting, converting, fire-refining and electro-refining process. Slag-Matte characteristics. Recent development in concentration, roasting and smelting process. Outokumpu and INCO process, Ausmel/ Isasmelt process. [8L]

Unit-3

Zinc: Pyrometallurgy, sinter-roasting and Electrical and Blast furnace process. Hydrometallurgical extraction: roasting, leaching and electro- winning. Double leaching/ Jarosite process, Direct leaching process Lead: Direct smelting of lead (ISP), thermodynamic consideration, Modern practices Refining of lead bullion. [6L]

Unit-4

Titanium: Up-gradation of ilmenite and Hunter and Kroll process, Specific advantages a limitation. Uranium: Acid and alkali processes for digestion of uranium ores. Production o reactor grade uranium.

[6L]

Unit-5

Gold: Cyanidation process. Carbon-in pulp process. Nickel and Magnesium: Different production routes their advantages and limitation in Nickel and Magnesium production. Status of Non-ferrous metal production in India. Environmental aspects of Non-ferrous metal production. [8L]

Course Outcomes

After the end of the course, a student should be able to:

CO No	Course Outcome Description	Bloom's Level
CO1.	Ability to build up the concepts of non-ferrous metals production.	K2, K4
CO2.	Ability to learn the modern advance technologies for nonferrous metal extraction.	K4
CO3.	Ability to analyze and solve various industrial problems during production and operation in nonferrous metal industries.	K4

CO-PO Mapping Matrix

PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	1	1	0	0	0	1	1	2
CO2	3	3	2	2	1	0	0	0	1	1	2
CO3	3	2	2	2	1	0	0	0	1	1	3
CO4	2	2	3	2	1	0	0	0	1	1	2
CO5	2	2	2	2	1	0	0	0	1	1	3
Average	2.6	2.2	2.2	1.8	1	0	0	0	1	1	2.4

KL- Bloom's Knowledge Level (K1, K2, K3, K4, K5, K6)

K1-Remember, K2- Understand, K3- Apply, K4- Analyze, K5- Evaluate, K6- Create

Textbooks:

1. K. Grjortheim and B.J. Welch: Aluminium Smelter Technology, Aluminium-Verlag.
2. A. K. Biswas and W.G. Davenport: Extractive Metallurgy of Copper, Pergamon.
3. S.W.K Morgaon: Zinc and its Alloy, Mac Donald and Evans.
4. H.S.Ray, R. Sridhar and K.P. Abraham: Ex traction of Non-Ferrous Metals, Affiliated East–West.

Reference books:

1. A.R. Burkin (ed.): Production of Aluminium and Alumina Wiley.
2. A.R. Burkin (ed.): Extractive Metallurgy of Nickel, Wiley.
3. C. D. Harrington and AE. Reuhle: Uranium Production Technology, Van Naostrand.
4. N. Sevryukov, B.Kuzumin and Y. Chelishchev: General Metallurgy, Mir.
5. FathiHabashi; Principles of Extractive metallurgy, vol 1,2,3and4; Gordon and Breach.

DESIGN METHODOLOGY

Subject code:-	**MTME209-OE-II**	**IA Marks**	**30**
Number of Lecture Hours/Week:-	**04**	**Term End Exam Marks**	**70**
Total Number of Lecture Hours: -	**40**	**CREDITS**	**04**

Course Objectives

This course enables the students to:

1. Gain concepts of design research and methodology
2. Carry out research into design.
3. Understand design as a phenomenon.
4. Identify research topics.
5. Understand structures of research documentation.

SYLLABUS

Unit 1:

Introduction to design research: What and Why; Current issues with design research and the need for a design research methodology; Major facets of design and design research. Introduction to design research methodology - its main components, and examples to explain the components. (8L)

Unit 2:

Starting design research: Clarification of requirements: Identifying research topics, carrying out literature search, consolidating the topic into research questions and hypotheses, and developing a research plan. (8L)

Unit 3:

Descriptive study: Type, Processes for carrying out descriptive studies for developing an understanding a facet of design and its influences; Introduction to associated descriptive study real-time and retrospective research methods for data collection such as protocol analysis, questionnaire surveys, interviews etc; Introduction to quantitative and qualitative data analysis methods. (8L)

Unit 4:

Prescriptive study: Types, Processes for developing design support and associated prescriptive study research methods. Types of support evaluation; Processes for evaluating a design support, and associated Evaluation study research methods. (8L)

Unit 5:

Documentation: Types and structures of research documentation, Approaches and guidelines for documenting and reporting research process and outcomes. (8L)

Course Outcome

CO No	Course Outcome Description	Bloom's Level
CO1.	Determine type of research to be persuaded.	K2, K4
CO2.	Improve design aspects in a systematic way.	K4
CO3.	Develop a research plan.	K4
CO4.	Validate the improvements in a methodical manner.	K3, K4
CO5.	Document and report research process and outcomes.	K2, K4

CO-PO Mapping Matrix

PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	1	1	0	0	0	1	1	2
CO2	3	3	2	2	1	0	0	0	1	1	2
CO3	3	2	2	2	1	0	0	0	1	1	3
CO4	2	2	3	2	1	0	0	0	1	1	2
CO5	2	2	2	2	1	0	0	0	1	1	3
Average	2.6	2.2	2.2	1.8	1	0	0	0	1	1	2.4

KL- Bloom's Knowledge Level (K1, K2, K3, K4, K5, K6)

K1-Remember, K2- Understand, K3- Apply, K4- Analyze, K5- Evaluate, K6- Create

Text Books

1. The Future of Design Methodology, Editors: Birkhofer, Herbert (Ed.) Springer- Verlag, 2011.
2. Design Thinking Methodology, Emrah Yayici.
3. Universal Methods of Design: 100 Ways to Research Complex Problems, Develop Innovative Ideas, and Design Effective Solutions, Bruce Hanington and Bella Martin 2012

Reference Books

1. Blessing, L.T.M., Chakrabarti A. and Wallace, K.M. An Overview of Design Studies in Relation to a Design Research Methodology, Designers: the Key to Successful Product Development, Frankenberger & Badke-Schaub (Eds.), Springer-Verlag, 1998.

RENEWABLE ENERGY

Subject code:-	**MTME210-OE-II**	**IA Marks**	**30**
Number of Lecture Hours/Week:-	**04**	**Term End Exam Marks**	**70**
Total Number of Lecture Hours: -	**40**	**CREDITS**	**04**

Course Objectives

This course enables the students to:

1. Create awareness about sources of energy and able to estimate how long the available conventional fuel reserves will last.
2. Learn the fundamental concepts about solar energy systems and devices.
3. Design wind turbine blades and know about applications of wind energy for water pumping and electricity generation.
4. Understand the working of advanced renewable energy sources.

SYLLABUS

Unit 1: INTRODUCTION TO ENERGY STUDIES

Introduction, Energy science and Technology, Forms of Energy, Importance of Energy Consumption as Measure of Prosperity, Per Capita Energy Consumption, Roles and responsibility of Ministry of New and Renewable Energy Sources, Needs of renewable energy, Classification of Energy Resources, Conventional Energy Resources , Non- Conventional Energy Resources, World Energy Scenario, Indian Energy Scenario. (8L)

Unit 2: SOLAR ENERGY

Introduction, Solar Radiation, Sun path diagram, Basic Sun-Earth Angles, Solar Radiation Geometry and its relation, Measurement of Solar Radiation on horizontal and tilted surfaces, Principle of Conversion of Solar Radiation into Heat, Collectors, Collector efficiency, Selective surfaces, Solar Water Heating system , Solar Cookers , Solar driers, Solar Still, Solar Furnaces, Solar Greenhouse. Solar Photovoltaic, Solar Cell fundamentals, Characteristics, Classification, Construction of Unit, panel and array. Solar PV Systems (stand-alone and grid connected), Solar PV Applications. Government schemes and policies. (8L)

Unit 3: WIND ENERGY

Introduction, History of Wind Energy, Wind Energy Scenario of World and India. Basic principles of Wind Energy Conversion Systems (WECS), Types and Classification of WECS, Parts of WECS, Power, torque and speed characteristics, Electrical Power Output and Capacity Factor of WECS, Stand alone, grid connected and hybrid applications of WECS, Economics of wind energy utilization, Site selection criteria, Wind farm, Wind rose diagram. (8L)

Unit 4: BIOMASS ENERGY

Introduction, Biomass energy, Photosynthesis process, Biomass fuels, Biomass energy conversion technologies and applications, Urban waste to Energy Conversion, Biomass Gasification, Types and application of gasifier, Biomass to Ethanol Production, Biogas production from waste biomass, Types of biogas plants, Factors affecting biogas generation, Energy plantation, Environmental impacts and benefits, Future role of biomass , Biomass programs in India. (8L)

Unit 5: ADVANCED RENEWABLE ENERGY SOURCES

Introduction to advanced renewable energy, Hydropower, Wave Energy, Tidal Energy, Ocean Thermal Energy, Geothermal Energy, Bio-fuels, Animal Energy. (8L)

Course Outcomes

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

CO No	Course Outcome Description	Bloom's Level
CO1.	Understand of renewable and non-renewable sources of energy.	K2, K4
CO2.	Gain knowledge about working principle of various solar energy systems	K4
CO3.	Understand the application of wind energy and wind energy conversion system.	K4
CO4.	Develop capability to do basic design of bio gas plant.	K3, K4
CO5.	Understand the applications of different advanced renewable energy sources.	K2, K4

CO-PO Mapping Matrix

PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	1	1	0	0	0	1	1	2
CO2	3	3	2	2	1	0	0	0	1	1	2
CO3	3	2	2	2	1	0	0	0	1	1	3
CO4	2	2	3	2	1	0	0	0	1	1	2
CO5	2	2	2	2	1	0	0	0	1	1	3
Average	2.6	2.2	2.2	1.8	1	0	0	0	1	1	2.4

KL- Bloom's Knowledge Level (K1, K2, K3, K4, K5, K6)

K1-Remember, K2- Understand, K3- Apply, K4- Analyze, K5- Evaluate, K6- Create

Text Books

1. Sukhatme. S.P., Solar Energy, Tata McGraw Hill Publishing Company Ltd., New Delhi, 1997.
2. B. H. Khan, Non-Conventional Energy Resources, , The McGraw Hill
3. G N Tiwari, R K Mishra, Advanced renewable energy sources, RSC Publishing, 2012

4. Twidell, J.W. & Weir, A. Renewable Energy Sources, EFN Spon Ltd., UK, 2006.
5. S. P. Sukhatme and J.K. Nayak, Solar Energy – Principles of Thermal Collection and Storage, Tata McGraw-Hill, New Delhi.
6. Garg, Prakash, Solar Energy, Fundamentals and Applications, Tata McGraw Hill.

Reference Books

1. G.D. Rai, Non-Conventional Energy Sources, Khanna Publications, New Delhi, 2011.
2. Godfrey Boyle, "Renewable Energy, Power for a Sustainable Future", Oxford University Press, U.K., 1996.
3. Khandelwal, K.C., Mahdi, S.S., Biogas Technology – A Practical Handbook, Tata McGraw-Hill, 1986.
4. Tiwari. G.N., Solar Energy – "Fundamentals Design, Modeling & Applications", Narosa Publishing House, New Delhi, 2002.
5. Freris. L.L., "Wind Energy Conversion Systems", Prentice Hall, UK, 1990.
6. Frank Krieth & John F Kreider, Principles of Solar Energy, John Wiley, New York

THESIS PART-I

Subject code:-	**MTME301**	**IA Marks**	
Number of Lecture Hours/Week:-	**04**	**Term End Exam Marks**	
Total Number of Lecture Hours: -	**40**	**CREDITS**	**20**

Course Objectives

This course enables the students to:

1. Solve real world problems and challenges.
2. Solve the various research challenges in the field of Energy Technology.
3. Create awareness among the students of the characteristics of several domain areas where their project ideas could help humanity.
4. Improve the team building, communication and management skills of the students

Course Outcomes

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

CO No	Course Outcome Description	Bloom's Level
CO1.	Demonstrate a sound technical knowledge of their selected project topic.	K2, K4
CO2.	Undertake problem identification, formulation and solution.	K4
CO3.	Design engineering solutions to complex problems utilizing a systems approach.	K4
CO4.	Communicate with engineers and the community at large in written and oral forms.	K3, K4
CO5.	Demonstrate the knowledge, skills and attitudes of a professional engineer.	K2, K4

THESIS PART-II

Subject code:- MTME401	**IA Marks**
Number of Lecture Hours/Week:- 04	**Term End Exam Marks**
Total Number of Lecture Hours: - 40	**CREDITS 20**

Course Objectives

This course enables the students to:

1. Solve real world problems and challenges.
2. Solve the various research challenges in the field of Energy Technology.
3. Create awareness among the students of the characteristics of several domain areas where their project ideas could help humanity.
4. Improve the team building, communication and management skills of the students

Course Outcomes

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

CO No	Course Outcome Description	Bloom's Level
CO1.	Demonstrate a sound technical knowledge of their selected project topic.	K2, K4
CO2.	Undertake problem identification, formulation and solution.	K4
CO3.	Design engineering solutions to complex problems utilizing a systems approach.	K4
CO4.	Communicate with engineers and the community at large in written and oral forms.	K3, K4
CO5.	Demonstrate the knowledge, skills and attitudes of a professional engineer.	K2, K4