Department of Mechanical Engineering

Birla Institute of Technology, Mesra, Ranchi - 835215 (India)

Institute Vision

To become a Globally Recognized Academic Institution in consonance with the social, economic and ecological environment, striving continuously for excellence in education, research and technological service to the National needs.

Institute Mission

To educate students at Undergraduate, Post Graduate, Doctoral, and Post Doctoral levels to perform challenging engineering and managerial jobs in industry.

- To provide excellent research and development facilities to take up Ph.D. programmes and research projects.
- To develop effective teaching and learning skills and state of art research potential of the faculty.
- To build national capabilities in technology, education and research in emerging areas.
- To provide excellent technological services to satisfy the requirements of the industry and overall academic needs of society.

Department Vision

To become an internationally recognized Centre of excellence in academics, research and technological services in the area of Mechanical Engineering and related inter-disciplinary fields.

Department Mission

- Imparting strong fundamental concepts to students and motivate them to find innovative solutions to engineering problems independently
- Developing engineers with managerial attributes capable of applying latest technology with responsibility
- Creation of congenial atmosphere and excellent research facilities for undertaking quality research by faculty and students
- To strive for more internationally recognized publication of research papers, books and to obtain patent and copyrights
- To provide excellent technological services to industry.

Programme Educational Objectives (PEOs) – Design of Mechanical Equipments

PEO 1: To prepare post graduates who will have strong fundamentals of conventional mechanical design and modern computational techniques for analyzing and improving mechanical equipment.

PEO 2: To prepare post graduates who will be competent enough to work successfully in challenging industrial environment.

PEO 3: To prepare post graduates who will be leading researcher and excellent academician.

PEO 4: To prepare post graduates who will work in a team to carry out multidisciplinary research and will be able to present a substantial technical report.

PROGRAM OUTCOMES (POs)
M. Tech. in Mechanical Engineering (Design of Mechanical Equipments)

PO1: A graduate shall be able to independently carry out research/investigation and development work to solve practical problems.

PO2: A graduate shall be able to write and present a substantial technical report/document.

PO3: A graduate shall be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor programme.

PO4: A graduate shall have clear insight to appreciate the multidisciplinary nature of the technological field in design of mechanical equipment.

PO5: A graduate shall develop an ability to work in team, apart from having awareness of social needs and professional code of conduct, ethics and behaviour.

COURSE INFORMATION SHEET

Course code: ME 521
Course title: Computational Methods in Engineering
Pre-requisite(s): Mathematics course of UG level
Co- requisite(s): Nil
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 03
Class: M. Tech.
Semester / Level: I/05
Branch: Mechanical Engineering
Name of Teacher:

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.

Course Outcomes

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

CO1.	Understand several numerical techniques used in linear algebra.
CO2.	Solve systems of linear and nonlinear algebraic equations encountered in engineering problems.
CO3.	Evaluate differentiation and integration using different numerical techniques.
CO4.	Solve ordinary and partial differential equations using numerical methods
CO5.	Create new ideas in engineering computations.

SYLLABUS

Module 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)

Module 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)

Module 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)

Module 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)

Module 5:

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

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.

Course Evaluation:
Individual assignment, Seminar, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :
Approximate methods
POs met through Gaps in the Syllabus: **PO1**

Topics beyond syllabus/Advanced topics/Design:
Asymptotic and perturbation methods
POs met through Topics beyond syllabus/Advanced topics/Design: **PO1**

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	-	2	1	1
CO2	3	-	2	1	1
CO3	3	-	2	1	1
CO4	3	-	2	1	1
CO5	2	1	3	3	1

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

COURSE INFORMATION SHEET

Course code: ME 522
Course title: Advanced Mechanics of Solids
Pre-requisite(s): Strength of Materials
Co- requisite(s): Nil
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 03
Class: M. Tech.
Semester / Level: I/05
Branch: Mechanical Engineering
Name of Teacher:

Course Objectives

This course enables the students to:

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

Course Outcomes

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

CO1.	Understand the concept of tensor.
CO2.	Analyse advanced concept of stress and strain in structural problems.
CO3.	Apply the concept of different elastic functions to solve complex problems.
CO4.	Evaluate the influence of various geometric and loading parameters in plane stress and plane strain problems.
CO5.	Implement advanced concept of solid mechanics in torsion, plates and shells.

SYLLABUS

Module 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)

Module 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)

Module 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)

Module 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)

Module 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)

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

Course Evaluation:
Individual assignment, Seminar, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :
Variational and Complex Variables Methods
POs met through Gaps in the Syllabus: **PO1**

Topics beyond syllabus/Advanced topics/Design:
Nonlinear deformations of materials
POs met through Topics beyond syllabus/Advanced topics/Design: **PO1**

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	1	3	1	-
CO2	3	2	3	1	-
CO3	3	2	3	1	-
CO4	3	2	3	1	-
CO5	3	2	3	1	1

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

COURSE INFORMATION SHEET

Course code: ME 523
Course title: Applied Dynamics and Vibration
Pre-requisite(s): Nil
Co- requisite(s): Nil
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 03
Class: M.Tech.
Semester / Level: I/05
Branch: Mechanical Engineering
Name of Teacher:

Course Objectives

This course enables the students to:

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

Course Outcomes

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

CO1.	Demonstrate various principles related to kinematics and dynamics of rigid bodies in space.
CO2.	Apply classical mechanical approach to construct equations of motion for dynamical systems
CO3.	Evaluate gyroscopic couple for systems with simultaneous spin and precession.
CO4.	Design and analyse simple dynamical systems.
CO5.	Evaluate natural frequencies and mode shapes of single and multi DOF vibrating systems.

SYLLABUS

Module 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)

Module 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)

Module 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)

Module 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)

Module 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)

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.

Course Evaluation:
Individual assignment, Seminar, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :
Detailed dynamic analysis of continuous systems using classical mechanics.
POs met through Gaps in the Syllabus: **PO1, PO3, PO4**

Topics beyond syllabus/Advanced topics/Design:
Variational approach to obtain equation of motion for continuous dynamical systems.
POs met through Topics beyond syllabus/Advanced topics/Design: **PO1 to PO4**

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	3	1
CO2	3	2	3	3	1
CO3	3	2	3	1	1
CO4	3	1	3	3	1
CO5	3	1	3	2	1

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

COURSE INFORMATION SHEET

Course code: ME 524
Course title: Advanced Engineering Materials
Pre-requisite(s): Nil
Co- requisite(s): Nil
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 03
Class: M.Tech.
Semester / Level: I/05
Branch: Mechanical Engineering
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Identify the Discrepancy between 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 technology.
5.	Discuss about recyclability/disposability issues related to metals, glass, plastic & rubber and composite materials.

Course Outcomes

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

CO1.	Describe the Discrepancy between theoretical and observed yield stress of crystals.
CO2.	Determine the relation between dislocation movement and plastic flow
CO3.	Analyse the phenomenon of strain hardening in terms of dislocations and strain field interactions.
CO4.	Evaluate the working stress of a material.
CO5.	Discuss about recyclability/disposability issues related to metals, glass, plastic & rubber and composite materials.

SYLLABUS

Module 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)

Module 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)

Module 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)

Module 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)

Module 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)

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.

Course Evaluation:
Individual assignment, Seminar, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :
Detailed analysis of materials used in industries. Outline of various parameters used in industries for manufacturing the materials.
POs met through Gaps in the Syllabus: **PO5**

Topics beyond syllabus/Advanced topics/Design:
Recycling of used materials and use of green manufacturing materials.
POs met through Topics beyond syllabus/Advanced topics/Design: **PO5**

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	2	2
CO2	3	2	2	1	1
CO3	3	2	2	2	1
CO4	3	2	2	3	2
CO5	3	2	1	3	3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

COURSE INFORMATION SHEET

Course code: ME 525
Course title: Robotic Manipulator Design
Pre-requisite(s): Engineering Mathematics, Engineering Mechanics.
Co- requisite(s): Nil
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 03
Class: M. Tech
Semester / Level: I/05
Branch: Mechanical Engineering
Name of Teacher:

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 unmodeled 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.

Course Outcomes

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

CO1.	Outline the structure of a typical robotic system, understand its link and joint parameters, and perform robot kinematics.
CO2.	Identify the geometric parameters of a serial robot by applying the knowledge of serial robot kinematics and generalized differential model of the robot.
CO3.	Identify the dynamic parameters of a serial robot by applying the knowledge of general form of dynamic equation of motion.
CO4.	Analyse planar and spatial parallel robots in context to its forward and inverse kinematics, and evaluate its singularity, condition number and manoeuvrability.
CO5.	Design a robotic manipulator and evaluate its primary and secondary workspace. Evaluate the performance of an industrial robot based on ISO standards.

SYLLABUS

Module 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)

Module 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)

Module 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)

Module 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)

Module 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)

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.

Course Evaluation:
Individual assignment, Seminar, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :
Robotic manipulator design with novel soft actuators.
POs met through Gaps in the Syllabus: **PO1**

Topics beyond syllabus/Advanced topics/Design:
Compliant structures, Force control, System Identification.
POs met through Topics beyond syllabus/Advanced topics/Design: **PO5**

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	2	2	2	3	2
CO2	3	3	3	3	2
CO3	3	3	3	3	2
CO4	3	3	3	3	2
CO5	3	3	3	3	3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

COURSE INFORMATION SHEET

Course code: ME 526
Course title: Fluid Power and Control
Pre-requisite(s): Fundamental of Fluid power control, Fluid Mechanics
Co- requisite(s): Nil
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 03
Class: M. Tech
Semester / Level: I/05
Branch: Mechanical Engineering
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Understand various aspects of Fluid power which starts with emphasis on fluid mechanics and governing laws.
2.	Be exposed to fundamentals and specific cases of control valves such as Direction, Pressure and Flow control.
3.	Be familiarized with Servo and Electro hydraulic valves briefly.
4.	Design and control hydraulic and pneumatic circuits.

Course Outcomes

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

CO1.	Understand the fundamental theoretical concepts governing fluid power.
CO2.	Recognise common hydraulic and pneumatic components (pumps, actuators, motors, valves, etc.), their use, symbols, and their performance characteristics.
CO3.	Identify the actual components and fluid power circuits found in common industrial applications.
CO4.	Formulate and analyse mathematical models of hydraulic and pneumatic circuits.
CO5.	Design and implement simple fluid power systems common in industrial applications using commercial components: circuits for directional, speed, pressure, force, and flow control.

SYLLABUS

Module 1:

Introduction to oil hydraulics and pneumatics, their structure, advantages and limitations. Properties of fluids, Fluids for hydraulic systems, governing laws. Distribution of fluid power, ISO symbols, energy losses in hydraulic systems. Applications, Basic types and constructions of Hydraulic pumps and motors. Pump and motor analysis. Performance curves and parameters. (8L)

Module 2:

Hydraulic actuators, types and constructional details, lever systems, control elements – direction, pressure and flow control valves. Valve configurations, General valve analysis, valve lap, flow forces and lateral forces on spool valves. Series and parallel pressure compensation flow control valves. Flapper valve Analysis and Design. (8L)

Module 3:

Proportional control valves and servo valves. Nonlinearities in control systems (backlash, hysteresis, dead band and friction nonlinearities). Design and analysis of typical hydraulic circuits. Regenerative circuits, high low circuits, Synchronization circuits, and accumulator sizing. Intensifier circuits Meter-in, Meter-out and Bleed-off circuits; Fail Safe and Counter balancing circuits, accessories used in fluid power system, Filtration systems and maintenance of system. (8L)

Module 4:

Components of pneumatic systems; Direction, flow and pressure control valves in pneumatic systems. Development of single and multiple actuator circuits. Valves for logic functions; Time delay valve; Exhaust and supply air throttling. (8L)

Module 5:

Components of pneumatic systems: Examples of typical circuits using Displacement – Time and Travel-Step diagrams. Will dependent control, Travel-dependent control and Time dependent control, combined control, Program Control, Electro-pneumatic control and air-hydraulic control, Ladder diagrams. Applications in Assembly, Feeding, Metalworking, materials handling and plastics working. (8L)

Text Books

1. Herbert E. Merritt: Hydraulic control systems, John Wiley and Sons Inc.
2. Fundamental of Fluid power control, Watson, Cambridge University press
3. Fluid Power Control, Jagadeesha T, Wiley India Limited

Reference Books

1. Blackburn,J. F.,G.Reethof, and J. L. Shearer, Fluid Power Control, Technology Press of M. I. T. and Wiley.
2. Anthony Esposito, "Fluid Power with applications", Pearson Education.
3. John Watton, "Fluid Power Systems: modeling, simulation and microcomputer control", Prentice Hall International.

Course Evaluation:
Individual assignment, Seminar, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :
Electrohydraulic Servo Mechanism.
POs met through Gaps in the Syllabus: **PO1 to PO3**

Topics beyond syllabus/Advanced topics/Design:
Mobile Fluid Power Systems Design with a Focus on Energy Efficiency.
POs met through Topics beyond syllabus/Advanced topics/Design: **PO1 & PO3**

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	1	3	3	1
CO2	3	1	3	3	-
CO3	3	1	2	3	-
CO4	3	1	3	3	-
CO5	3	1	3	3	-

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

COURSE INFORMATION SHEET

Course code: ME 527
Course title: Applied Tribology
Pre-requisite(s): Industrial Tribology
Co- requisite(s): Nil
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 03
Class: M. Tech
Semester / Level: I/05
Branch: Mechanical Engineering
Name of Teacher:

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.

Course Outcomes

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

CO1.	Understand the basic concepts of friction, wear, and lubrication.
CO2.	Apply the knowledge of surface texture parameters for selection of bearing materials.
CO3.	Write Reynold’s equation for various bearing problems and design thrust bearings.
CO4.	Design journal bearings and squeeze-film bearings.
CO5.	Design hydrostatic and rolling element bearings.

SYLLABUS

Module 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)

Module 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)

Module 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)

Module 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)

Module 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)

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.

Course Evaluation:
Individual assignment, Seminar, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :
Gas bearings, dry and starved bearings.
POs met through Gaps in the Syllabus: **PO1 to PO5**

Topics beyond syllabus/Advanced topics/Design:
Seals and condition monitoring.
POs met through Topics beyond syllabus/Advanced topics/Design: **PO1 to PO5**

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –
1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	1	2	2	2	2
CO2	1	3	3	2	2
CO3	2	3	3	3	3
CO4	2	3	3	3	3
CO5	3	3	3	3	3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

COURSE INFORMATION SHEET

Course code: ME 528
Course title: Advanced Solid Mechanics and Vibration lab
Pre-requisite(s): Nil
Co- requisite(s): Nil
Credits: 2 L: 0 T: 0 P: 4
Class schedule per week: 04
Class: M.Tech.
Semester / Level: I/05
Branch: Mechanical Engineering
Name of Teacher:

Course Objectives

This course enables the students to:

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

Course Outcomes

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

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.

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 (RumulFatigue 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
Experiment 11: To understand beating phenomenon in weakly coupled pendulum
Experiment 12: To determine balancing masses and their orientation for an unbalanced wheel in wheel Balancing Machine

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	60
Semester End Examination	40

Continuous Internal Assessment	% Distribution
Day to day performance & Lab files	30
Quiz (es)	10
Viva	20

Semester End Examination	% Distribution
Examination Experiment Performance	30
Quiz	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	-	3
CO2	3	3	3	-	3
CO3	3	3	3	-	3
CO4	2	3	2	2	3
CO5	3	3	3	1	3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD3,CD6
CO2	CD1,CD3, CD6
CO3	CD1, CD3,CD6
CO4	CD1,CD3,CD6
CO5	CD1,CD3,CD6

COURSE INFORMATION SHEET

Course code: ME 529
Course title: Computational Methods Laboratory
Pre-requisite(s): Nil
Co- requisite(s): Nil
Credits: 2 L: 0 T: 0 P: 4
Class schedule per week: 04
Class: M.Tech.
Semester / Level: I/05
Branch: Mechanical Engineering
Name of Teacher:

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

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.

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 OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	60
Semester End Examination	40

Continuous Internal Assessment	% Distribution
Day to day performance & Lab files	30
Quiz (es)	10
Viva	20

Semester End Examination	% Distribution
Examination Experiment Performance	30
Quiz	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	2	1	2	1	-
CO2	2	1	2	1	-
CO3	2	1	2	1	-
CO4	3	1	2	1	1
CO5	3	1	2	1	1

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD6,CD7
CO2	CD1, CD6,CD7
CO3	CD1, CD6,CD7
CO4	CD1, CD6,CD7
CO5	CD1, CD6,CD7

COURSE INFORMATION SHEET

Course code: ME 531
Course title: Theory of Elasticity
Pre-requisite(s): ME 522– Advanced Mechanics of Solids
Co- requisite(s): Nil
Credits: 4 L: 3 T: 1 P: 0
Class schedule per week: 04
Class: M. Tech.
Semester / Level: II/05
Branch: Mechanical Engineering
Name of Teacher:

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.

Course Outcomes

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

CO1.	Analyse finite and nonlinear elastic deformation behaviour of solid material.
CO2.	Implement the idea of linear and nonlinear constitutive equations in the field of elasticity of materials.
CO3.	Apply mathematical principles (Poisson's equation, Green's theorem, etc.) to solve three-dimensional problems.
CO4.	Understand variational and complex variable method for solving elasticity problems.
CO5.	Create new ideas in the area of theory of elasticity.

SYLLABUS

Module 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)

Module 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)

Module 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)

Module 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)

Module 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)

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

Course Evaluation:
Individual assignment, Seminar, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :
Fourier transform methods in elasticity.
POs met through Gaps in the Syllabus: **PO1**

Topics beyond syllabus/Advanced topics/Design:
Molecular approach in elasticity.
POs met through Topics beyond syllabus/Advanced topics/Design: **PO1**

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	-	3	2	-
CO2	3	-	3	1	-
CO3	3	-	3	2	-
CO4	3	-	3	1	-
CO5	3	1	3	3	1

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

COURSE INFORMATION SHEET

Course code: ME 532
Course title: Fracture Mechanics
Pre-requisite(s): Nil
Co- requisite(s): Nil
Credits: 4 L: 3 T: 1 P: 0
Class schedule per week: 04
Class: M. Tech.
Semester / Level: II /05
Branch: Mechanical Engineering
Name of Teacher:

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

Course Outcomes

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

CO1.	Demonstrate basics of Fracture Mechanics
CO2.	Apply linear elastic approach to analyse crack propagation
CO3.	Apply numerical technique to analyse fracture in composite materials
CO4.	Analyse deformation and fracture in viscoelastic materials
CO5.	Develop Mathematical Models to predict and arrest crack

SYLLABUS

Module 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)

Module 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)

Module 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)

Module 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)

Module 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)

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

Course Evaluation:
Individual assignment, Seminar, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :
Fracture and fatigue control.
POs met through Gaps in the Syllabus: **PO3**

Topics beyond syllabus/Advanced topics/Design:
Deformation and fracture mechanics of engineering materials.
POs met through Topics beyond syllabus/Advanced topics/Design: **PO1 to PO5**

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	1	3	1	3	-
CO2	3	2	3	3	-
CO3	3	2	3	3	-
CO4	3	2	3	2	3
CO5	3	3	3	3	3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

COURSE INFORMATION SHEET

Course code: ME 533
Course title: Automatic Control
Pre-requisite(s): Engineering Mathematics, Engineering Mechanics
Co- requisite(s): Nil
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 03
Class: M. Tech.
Semester / Level: II /05
Branch: Mechanical Engineering
Name of Teacher:

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)

Course Outcomes

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

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.
CO2.	Apply the knowledge of proportional, derivative and integral controllers to design a controller and analyse its stability.
CO3.	Analyse a control system using root-locus and apply root locus method to design a control system.
CO4.	Analyse a control system using frequency response (bode-plots) and evaluate the stability of a controller using Nyquist criterion.
CO5.	Design a servo-system based on state-space representation and define its controllability and observability.

SYLLABUS

Module 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)

Module 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)

Module 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)

Module 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)

Module 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)

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.

Course Evaluation:
Individual assignment, Seminar, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :
Cost effective automation.
POs met through Gaps in the Syllabus: **PO3**

Topics beyond syllabus/Advanced topics/Design:
Compliant structures, Force control, System Identification.
POs met through Topics beyond syllabus/Advanced topics/Design: **PO3**

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	2	3	2	3	2
CO2	2	3	3	3	2
CO3	2	3	3	3	2
CO4	3	3	3	3	2
CO5	3	3	3	3	3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

COURSE INFORMATION SHEET

Course code: ME 534
Course title: Mechanics Of Composite Materials
Pre-requisite(s): Nil
Co- requisite(s): Nil
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 03
Class: M. Tech.
Semester / Level: II /05
Branch: Mechanical Engineering
Name of Teacher:

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.

Course Outcomes

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

CO1.	Correlate requirement of composite materials.
CO2.	Understand applicability and mechanics of composite materials under various conditions.
CO3.	Characterize necessity of choice of various components of composite materials and their forms like filler, fibre, nano etc. with relative properties.
CO4.	Apply various techniques for suitable composite material with required enhanced properties.
CO5.	Evaluate the performance composite materials for engineering applications.

SYLLABUS

Module 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)

Module 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)

Module 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)

Module 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)

Module 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)

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

Course Evaluation:
Individual assignment, Seminar, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :
Various composite materials, their properties and applications.
POs met through Gaps in the Syllabus: **PO1 to PO5**

Topics beyond syllabus/Advanced topics/Design:
Characterisation of the composite materials
POs met through Topics beyond syllabus/Advanced topics/Design: **PO1 to PO5**

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	1	3	2	1
CO2	3	1	2	2	1
CO3	3	1	3	2	1
CO4	3	1	2	2	1
CO5	3	1	2	2	1

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

COURSE INFORMATION SHEET

Course code: ME535
Course title: Finite Element Analysis
Pre-requisite(s): Engineering Mathematics, Fundamentals of Programming Language, Mechanics of materials, Thermodynamics
Co- requisite(s): Nil
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 03
Class: M. Tech.
Semester / Level: II /05
Branch: Mechanical Engineering
Name of Teacher:

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.

Course Outcomes

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

CO1.	Understand the basics of Finite Element Analysis, viz. Continuous and discrete systems.
CO2.	Evaluate structural problems using energy methods.
CO3.	Analyze different approaches and theorems to structural problems in finite elements for two dimensions.
CO4.	Implement the concept of Iso-parameteric mapping in sub-modeling, sub-structuring using finite element programming.
CO5.	Apply the concept of Finite Element Methods in different practical engineering analysis.

SYLLABUS

Module 1: Overview of engineering systems

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

Module 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)

Module 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)

Module 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)

Module 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)

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.

Course Evaluation:
Individual assignment, Seminar, Theory (Quiz and End semester) examinations

<u>Gaps in the syllabus (to meet Industry/Profession requirements)</u>:
Finite Element Analysis in three-dimensional problem.
POs met through Gaps in the Syllabus: **PO1 & PO3**

<u>Topics beyond syllabus/Advanced topics/Design:</u>
Geometric and material nonlinear analyses.
POs met through Topics beyond syllabus/Advanced topics/Design: **PO1 & PO3**

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

<u>Direct Assessment</u>

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	1	3	1	-
CO2	3	1	3	-	-
CO3	3	1	3	-	-
CO4	3	1	3	-	-
CO5	3	1	3	3	1

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD2,CD6
CO2	CD1,CD2, CD6
CO3	CD1, CD2,CD6
CO4	CD1,CD2,CD6
CO5	CD1,CD2,CD6

COURSE INFORMATION SHEET

Course code: ME536
Course title: Nonlinear Vibrations
Pre-requisite(s): Nil
Co- requisite(s): Nil
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 03
Class: M. Tech.
Semester / Level: II /05
Branch: Mechanical Engineering
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Understand dynamics of nonlinear systems.
2.	Analyse free and forced vibration characteristics of nonlinear systems.
3.	Learn approximation methods to analyse nonlinear systems

Course Outcomes

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

CO1.	Demonstrate understanding of linear stability and bifurcation of nonlinear systems.
CO2.	Apply knowledge of perturbation methods for approximate solutions of nonlinear systems.
CO3.	Apply knowledge of heuristic methods for approximate solutions of nonlinear systems.
CO4.	Analyse parametrically excited nonlinear systems.
CO5.	Pursue active research in the field of nonlinear vibration.

SYLLABUS

Module 1: Linear Stability and Bifurcation

Overview of linear and nonlinear vibrations, Types and sources of nonlinearities in mechanical systems, Phase space and trajectories, Linear stability analysis and phase space, introduction to basics of bifurcations of two (and higher) dimensional systems. (10L)

Module 2: Perturbation Methods

Regular perturbation method, Poincare-Linstedt method, method of averaging, Method of multiple scales; Application to Duffing and van der Pol equations. (8L)

Module 3: Heuristic Methods

Harmonic balance method, Equivalent linearization method, Galerkin Method, Collocation Techniques, Application with examples. (7L)

Module 4: Floquet Theory for Parametrically excited Systems

Parametrically excited systems, stability of periodic solutions, Meissner equation, Mathieu-Hill equation, Determination of Floquet multipliers. (7L)

Module 5: Forced Nonlinear Systems

Forced vibration of Duffing oscillator for sub-harmonic resonance, Forced vibration of van der Pol Oscillator, Poincare maps, Lyapunov exponents for maps and flows. (8L)

Text Books

1. S. H. Strogatz, Nonlinear Dynamics and Chaos, Levant Books, 2007
2. D. W. Jordan and P. Smith, Nonlinear Ordinary Differential Equations, Oxford University Press, Fourth edition.
3. L. Meirovitch, Methods of Analytical Dynamics, Dover Publications.

Reference Books

1. A. H. Nayfeh and D. T. Mook, Nonlinear Oscillations, John Wiley and Sons Inc., 1995.

Course Evaluation:
Individual assignment, Seminar, Theory (Quiz and End semester) examinations

<u>Gaps in the syllabus (to meet Industry/Profession requirements)</u> :
Application of Method of multiple scales to higher dimensional systems
POs met through Gaps in the Syllabus: **PO1, PO3 & PO4**

Topics beyond syllabus/Advanced topics/Design:
Discussion on chaotic systems.
POs met through Topics beyond syllabus/Advanced topics/Design: **PO1 to PO4**

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	2	1
CO2	3	2	3	3	1
CO3	3	2	3	3	1
CO4	3	2	3	2	1
CO5	3	3	3	3	2

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD2,CD6
CO2	CD1,CD2, CD6
CO3	CD1, CD2,CD6
CO4	CD1,CD2,CD6
CO5	CD1,CD2,CD6

COURSE INFORMATION SHEET

Course code: ME537
Course title: Robotics Laboratory
Pre-requisite(s): Engineering Mathematics, Engineering Mechanics, MATLAB
Co- requisite(s): Nil
Credits: 2 L: 0 T: 0 P: 4
Class schedule per week: 04
Class: M.Tech.
Semester / Level: II/05
Branch: Mechanical Engineering
Name of Teacher:

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.

Course Outcomes

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

CO1.	Be acquainted with standard industrial robot, safe handling, its sub-systems and prepare application programs for standard industrial tasks.
CO2.	Apply the knowledge of robot kinematics to identify the kinematic parameters of standard industrial robot
CO3.	Analyse a given robot system using virtual simulation tools and interpret the results of kinematics, forward and inverse dynamics.
CO4.	Design and create pneumatic and electro-pneumatic circuits using PLC.
CO5.	Build up an aptitude to troubleshoot any unknown problem in a standard electro-pneumatic circuit.

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 OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	60
Semester End Examination	40

Continuous Internal Assessment	% Distribution
Day to day performance & Lab files	30
Quiz (es)	10
Viva	20

Semester End Examination	% Distribution
Examination Experiment Performance	30
Quiz	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	2	3	3	3	3
CO2	2	3	3	3	3
CO3	3	3	3	3	2
CO4	3	3	3	3	3
CO5	3	3	3	3	3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD3,CD6,CD7
CO2	CD1,CD3,CD6,CD7
CO3	CD1,CD3,CD6,CD7
CO4	CD1,CD3,CD6,CD7
CO5	CD1,CD3,CD6,CD7

COURSE INFORMATION SHEET

Course code: ME600
Course title: Thesis Part I
Pre-requisite(s): Nil
Co- requisite(s): Nil
Credits: 8 L: T: P:
Class schedule per week:
Class: M.Tech.
Semester / Level: III/06
Branch: Mechanical Engineering
Name of Teacher:

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:

CO1.	Demonstrate a sound technical knowledge of their selected project topic.
CO2.	Undertake problem identification, formulation and solution.
CO3.	Design engineering solutions to complex problems utilizing a systems approach.
CO4.	Communicate with engineers and the community at large in written and oral forms.
CO5.	Demonstrate the knowledge, skills and attitudes of a professional engineer.

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	60
Semester End Examination	40

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	3	2
CO2	3		3	3	2
CO3	3		3	3	2
CO4	1	3	3	3	2
CO5	3	3	3	3	2

< 34% = 1, 34-66% = 2, > 66% = 3

COURSE INFORMATION SHEET

Course code: ME612
Course title: Optimization Techniques
Pre-requisite(s): Mathematics, Basics of operation research
Co- requisite(s): Nil
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 03
Class: M. Tech.
Semester / Level: III /06
Branch: Mechanical Engineering
Name of Teacher:

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.

Course Outcomes

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

CO1.	Understand and formulation of various engineering optimization problem.
CO2.	Analyse the single variable optimization algorithm.
CO3.	Analyse the multi variable optimization algorithm.
CO4.	Analyse the constrained optimization algorithm.
CO5.	Design and modelling of specialized algorithm.

SYLLABUS

Module 1: Introduction

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

Module 2: Single variable optimization algorithms

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

Module 3: Multi variable optimization algorithms

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

Module 4: Constrained Optimization algorithms

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

Module 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)

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.

Course Evaluation:
Individual assignment, Seminar, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :
Various optimization techniques
POs met through Gaps in the Syllabus: **PO1 to PO5**

Topics beyond syllabus/Advanced topics/Design:
Practical aspect of optimization
POs met through Topics beyond syllabus/Advanced topics/Design: **PO1 to PO5**

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	2	3	3	1
CO2	3	2	3	2	1
CO3	2	2	3	3	1
CO4	3	3	3	2	1
CO5	3	3	3	3	1

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD2,CD6
CO2	CD1,CD2, CD6
CO3	CD1, CD2,CD6
CO4	CD1,CD2,CD6
CO5	CD1,CD2,CD6

COURSE INFORMATION SHEET

Course code: ME613
Course title: Vibration of Continuous Systems
Pre-requisite(s): Engineering Mathematics, Engineering Mechanics, Basic Mechanical Vibration
Co- requisite(s): Nil
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 03
Class: M. Tech.
Semester / Level: III /06
Branch: Mechanical Engineering
Name of Teacher:

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.

Course Outcomes

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

CO1.	Define various continuous systems viz. strings, bars, beams, plates
CO2.	Formulate those continuous systems-using various techniques
CO3.	Solve the continuous systems under free and forced vibration conditions.
CO4.	Calculate the response of the systems.
CO5.	Analyse the response of the systems of various practical applications.

SYLLABUS

Module 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)

Module 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)

Module 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)

Module 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)

Module 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)

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.

Course Evaluation:
Individual assignment, Seminar, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :
Vibration in industrial applications.
POs met through Gaps in the Syllabus: **PO3**

Topics beyond syllabus/Advanced topics/Design:
Torsional Vibration of Shafts, Vibration of Shells.
POs met through Topics beyond syllabus/Advanced topics/Design: **PO3**

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	2	2	2	2	1
CO2	2	3	3	2	1
CO3	3	3	3	3	1
CO4	3	3	3	3	1
CO5	3	3	3	3	1

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD2,CD6
CO2	CD1,CD2, CD6
CO3	CD1, CD2,CD6
CO4	CD1,CD2,CD6
CO5	CD1,CD2,CD6

COURSE INFORMATION SHEET

Course code: ME614
Course title: Rotor Dynamics
Pre-requisite(s): Mechanical Vibrations
Co- requisite(s): Nil
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 03
Class: M. Tech.
Semester / Level: III /06
Branch: Mechanical Engineering
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Understand the rotor dynamics phenomena with the help of simple rotor models and subsequently the modern analysis methods for real life rotor systems.
2.	Model and analyse the rotor-bearing dynamics

Course Outcomes

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

CO1.	Write the equation of motion for vibration problems
CO2.	Solve the equation of motion for free lateral response of simple rotor models
CO3.	Model a rotor using Finite Elements method and generate elemental and global matrices
CO4.	Analyse the free lateral response of complex rotor systems and comprehend the features of Eigenvalues and Eigenvectors
CO5.	Analyse the forced lateral response and critical speeds of complex rotor systems

SYLLABUS

Module 1: Introduction to Rotor Dynamics

Rotating machine components, introduction to vibration analysis, single degree of freedom systems, multi degree of freedom systems, imposing constraints and model reduction, time series analysis, the Fourier transform, the discrete Fourier transform. (8L)

Module 2: Free Lateral Response of Simple Rotor Models

Co-ordinate systems, gyroscopic couples, dynamics of a rigid rotor on flexible supports, a rigid rotor on isotropic flexible supports, complex co-ordinates, a rigid rotor on anisotropic flexible supports, forward and backward whirl, natural frequency maps, the effect of damping in the supports, simple model of a flexible rotor. (8L)

Module 3: Finite Element Modelling

Defining generalized co-ordinates, finite element modelling of discrete components, axial deflection in a bar, lateral deflection of a beam, developing general element matrices, assembling global matrices, general finite element models. (8L)

Module 4: Free Lateral Response of Complex Systems

Co-ordinate systems, disk elements, shaft elements, Euler-Bernoulli beam theory, including shear and rotary inertia effects, the effect of axial loading, mass and stiffness matrices for shaft elements, gyroscopic effects, the effect of torque, tapered shaft elements, rotor couplings, bearings, seals and rotor-stator interactions, modelling foundations and stators, assembly of the full equations of motion, free response of complex systems, features of eigenvalues and eigenvectors. (8L)

Module 5: Forced Lateral Response and Critical Speeds

Modeling out-of-balance forces and moments, response of a rigid rotor on isotropic supports to out-of-balance forces, response of a Jeffcott rotor to out-of-balance forces, response of an isotropic rotor system to out-of-balance moments, response of a rigid rotor on anisotropic supports to out-of-balance forces and moments, forward and backward whirl orbits, complex rotor models, forces on the supports due to rotor vibration, response to ground vibration, critical speeds, mode shapes associated with critical speeds, maps of critical speeds and mode shapes. (8L)

Text Books

1. Friswell, M. I., Penny, J. E. T., Garvey, S. D., Lees, A. W. Dynamics of rotating machines. Cambridge University Press, 2010.

Reference Books

1. Krämer, E. Dynamics of rotors and foundations. Springer, 2013.
2. Rao, J. S. Rotor dynamics. New Age International, 1996.

Course Evaluation:
Individual assignment, Seminar, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :
Asymmetric rotors.
POs met through Gaps in the Syllabus: **PO1 to PO5**

Topics beyond syllabus/Advanced topics/Design:
Balancing, axial and torsional vibrations
POs met through Topics beyond syllabus/Advanced topics/Design: **PO1 to PO5**

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	1	2	2	2	-
CO2	1	3	3	2	-
CO3	2	3	3	3	-
CO4	2	3	3	3	-
CO5	2	3	3	3	1

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD2,CD6
CO2	CD1,CD2, CD6
CO3	CD1, CD2,CD6
CO4	CD1,CD2,CD6
CO5	CD1,CD2,CD6

COURSE INFORMATION SHEET

Course code: ME615
Course title: Wave Propagation
Pre-requisite(s): Nil
Co- requisite(s): Nil
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 03
Class: M. Tech.
Semester / Level: III /06
Branch: Mechanical Engineering
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Review basics of Vibration Problems
2.	Solve one-dimensional wave problems
3.	Apply wave solutions to various mechanical system
4.	Analyse vibration, and wave propagation in membrane

Course Outcomes

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

CO1.	Understand vibration in various systems
CO2.	Analyse one-dimensional wave problems
CO3.	Apply wave solution to continuous mechanical systems
CO4.	Analyse wave propagation in membrane structure
CO5.	Design system comprise of fluid and solid interaction

SYLLABUS

Module 1: Introduction and Overview

Vibration in Discrete System: Single Degree of Freedom System, Multi Degree of Freedom System. Hamilton Principle; Variation Formulation. Longitudinal and Transverse vibration in String; Longitudinal, Transverse and torsional vibration of Euler-Bernoulli's beam. (8L)

Module 2: One-dimensional wave equation

d'Alembert's solution of the initial value problem, solution of initial value problem using Fourier transform. Harmonic waves and wave impedance; Energetics of wave motion. Scattering of waves: Reflection at a boundary, scattering at a finite impedance. (8L)

Module 3: Application of wave solution

Impulsive start of a bar, step-forcing of bar with boundary damping, axial collision of bar, string on a compliant foundation, axially translating string. (6L)

Module 4: Dynamics of membrane

Newton formulation, Variation formulation. Waves in membranes: wave in cartesian coordinates, wave in polar coordinates, Energetics of membrane waves, initial value problem for infinite membranes, reflection of plane waves. (8L)

Module 5: Waves in fluids

Acoustic waves in fluids: The acoustic wave equation, planar acoustic waves, Energetics of planar acoustic waves, reflection and refraction of planar acoustic waves, spherical and cylindrical waves, waves in wave guides, acoustic waves in a slightly viscous fluid. (8L)

Text Books

1. Vibration and Waves in Continuous Mechanical Systems, P. Hagedorn and A. DasGupta, John Wiley & Sons, Ltd

Reference Books

1. Computational Methods in structure Dynamics, Leonard Meirovitch

Course Evaluation:
Individual assignment, Seminar, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :
Theoretical and experimental correlation of mechanical waves with regards to industry.
POs met through Gaps in the Syllabus: **PO3**

Topics beyond syllabus/Advanced topics/Design:
Wave propagation simulations.
POs met through Topics beyond syllabus/Advanced topics/Design: **PO1 to PO5**

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	2	3	1	3	2
CO2	3	2	3	3	3
CO3	3	2	3	3	3
CO4	3	2	3	2	3
CO5	3	3	3	3	3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD2,CD6
CO2	CD1,CD2, CD6
CO3	CD1, CD2,CD6
CO4	CD1,CD2,CD6
CO5	CD1,CD2,CD6

COURSE INFORMATION SHEET

Course code: ME616
Course title: CAD Lab
Pre-requisite(s): Nil
Co- requisite(s): Nil
Credits: 2 L: 0 T: 0 P: 4
Class schedule per week: 04
Class: M.Tech.
Semester / Level: III/06
Branch: Mechanical Engineering
Name of Teacher:

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

Course Outcomes

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

CO1.	Perform solid modeling of mechanical parts.
CO2.	Model assemblies of mechanical equipments.
CO3.	Generate Drawing / Orthographic View.
CO4.	Develop program for 2-D and 3-D transformation.
CO5.	Develop programs for design, drawing and plotting of machine element.

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 OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	60
Semester End Examination	40

Continuous Internal Assessment	% Distribution
Day to day performance & Lab files	30
Quiz (es)	10
Viva	20

Semester End Examination	% Distribution
Examination Experiment Performance	30
Quiz	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	2	2	3	2	1
CO2	2	2	3	2	1
CO3	2	2	3	2	1
CO4	2	2	3	2	1
CO5	2	2	3	2	1

$< 34\% = 1$, $34\text{-}66\% = 2$, $> 66\% = 3$

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD6,CD7
CO2	CD1,CD6,CD7
CO3	CD1,CD6,CD7
CO4	CD1,CD6,CD7
CO5	CD1,CD6,CD7

COURSE INFORMATION SHEET

Course code: ME650
Course title: Thesis Part II
Pre-requisite(s): Nil
Co- requisite(s): Nil
Credits: 16 L: T: P:
Class schedule per week:
Class: M.Tech.
Semester / Level: IV/06
Branch: Mechanical Engineering
Name of Teacher:

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:

CO1.	Demonstrate a sound technical knowledge of their selected project topic.
CO2.	Undertake problem identification, formulation and solution.
CO3.	Design engineering solutions to complex problems utilizing a systems approach.
CO4.	Communicate with engineers and the community at large in written and oral forms.
CO5.	Demonstrate the knowledge, skills and attitudes of a professional engineer.

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	60
Semester End Examination	40

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	3	2
CO2	3		3	3	2
CO3	3		3	3	2
CO4	1	3	3	3	2
CO5	3	3	3	3	2

< 34% = 1, 34-66% = 2, > 66% = 3

OPEN ELECTIVES

COURSE INFORMATION SHEET

Course code: ME582
Course title: Design Methodology
Pre-requisite(s): Nil
Co- requisite(s): Nil
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 03
Class: M. Tech
Semester / Level: I/II /05
Branch: Mechanical Engineering
Name of Teacher:

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.

Course Outcomes

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

CO1.	Determine type of research to be persuaded.
CO2.	Improve design aspects in a systematic way.
CO3.	Develop a research plan.
CO4.	Validate the improvements in a methodical manner.
CO5.	Document and report research process and outcomes.

SYLLABUS

Module 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)

Module 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)

Module 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)

Module 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)

Module 5:

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

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.

Course Evaluation:
Individual assignment, Seminar, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :
Cost effective design methods.
POs met through Gaps in the Syllabus: **PO3**

Topics beyond syllabus/Advanced topics/Design:
Advanced design methods.
POs met through Topics beyond syllabus/Advanced topics/Design: **PO3**

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	3	2		2
CO2	1	3	2		2
CO3	1	3	2		1
CO4	2	3	2		1
CO5	2	3	2		3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD2,CD6
CO2	CD1,CD2,CD6
CO3	CD1,CD2,CD6
CO4	CD1,CD2,CD6
CO5	CD1,CD2,CD6

COURSE INFORMATION SHEET

Course code: ME583
Course title: Renewable Energy
Pre-requisite(s): Basic of Physics, Chemistry and Mathematics
Co- requisite(s): Nil
Co- requisite(s): Nil
Credits: 3   L: 3   T: 0   P: 0
Class schedule per week: 03
Class: M. Tech
Semester / Level: I/II /05
Branch: Mechanical Engineering
Name of Teacher:

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.

Course Outcomes

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

CO1.	Understand of renewable and non-renewable sources of energy.
CO2.	Gain knowledge about working principle of various solar energy systems
CO3.	Understand the application of wind energy and wind energy conversion system.
CO4.	Develop capability to do basic design of bio gas plant.
CO5.	Understand the applications of different advanced renewable energy sources.

SYLLABUS

Module 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)

Module 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 module, panel and array. Solar PV Systems (stand-alone and grid connected), Solar PV Applications. Government schemes and policies.

(8L)

Module 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)

Module 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)

Module 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)

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

Course Evaluation:

Individual assignment, Seminar, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :

High temperature solar thermal application

POs met through Gaps in the Syllabus: **PO3**

Topics beyond syllabus/Advanced topics/Design:

Advance bio fuels

POs met through Topics beyond syllabus/Advanced topics/Design: **PO3**

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	1	2	3	-	2
CO2	1	2	3	-	2
CO3	1	2	3	-	2
CO4	2	2	3	-	2
CO5	1	2	3	-	2

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD2,CD6
CO2	CD1,CD2, CD6
CO3	CD1, CD2,CD6
CO4	CD1,CD2,CD6
CO5	CD1,CD2,CD6

COURSE INFORMATION SHEET

Course code: ME584
Course title: Energy Management Principles and Auditing
Pre-requisite(s): Basic of Physics, Chemistry and Mathematics
Co- requisite(s): Nil
Co- requisite(s): Nil
Credits: 3   L: 3   T: 0   P: 0
Class schedule per week: 03
Class: M. Tech
Semester / Level: I/II /05
Branch: Mechanical Engineering
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Gain introductory knowledge of Energy management and energy audit.
2.	Understand basic concepts of Energy conservation.
3.	Understand Energy efficiency and cost benefit.

Course Outcomes

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

CO1.	Outline energy management system and related policies and Acts.
CO2.	Apply the concept of Energy Management in energy related issues.
CO3.	Work with energy management system and energy audit of whole system.
CO4.	Analyze energy conservation related to environmental issues.
CO5.	Carry out Auditing of relevant interdisciplinary systems.

SYLLABUS

Module 1: INTRODUCTION

Energy and Sources of energy, Energy consumption and GDP, Costs of exploration and utilization of resources, Energy pricing, Energy demand and supply, National energy plan, Need for Energy Policy, National and State level Energy Policies. Basic concepts of Energy Conservation and its importance, Energy Strategy for the Future, The Energy Conservation Act and its Features, Energy conservation in household, Transportation, Agricultural, Service and Industrial sectors, Lighting, HVAC Systems. (8L)

Module 2: ENERGY MANAGEMENT

History of Energy Management, Definition and Objective of Energy Management and its importance. Need of energy management, General Principles of Energy Management, Energy Management Skills, and Energy Management Strategy. Energy Management Approach. Understanding Energy Costs, Benchmarking, Energy performance, Matching energy usage to requirements, Maximizing system efficiency, Optimizing the input energy requirements, Fuel and Energy substitution. Organizing, Initiating and Managing an energy management program. Roles, responsibilities and accountability of Energy Managers. (8L)

Module 3: ENERGY AUDIT

Energy audit concepts, Definition, Need and Types of energy audit. Energy Audit Approach and Methodology. Systematic procedure for technical audit. Understanding energy audit costs, Benchmarking and Energy Performance. Energy audit based on First law and Second law of thermodynamics, Mass and Energy balances, Availability analysis, Evaluation of energy conserving opportunities, Economic analysis and life cycle costing. Duties and responsibilities of energy auditors. Energy audit instruments and their usage for auditing**.** Report-writing, preparations and presentations of energy audit reports. (8L)

Module 4: ENERGY CONSERVATION AND ENVIRONMENT

Energy conservation areas**,** Energy transmission and storage, Plant Lecture wise energy optimization Models, Data base for energy management, Energy conservation through controls, Computer aided energy management, Program organization and methodology. Energy environment interaction, Environmental issues, Global Warming, Climate Change Problem and Response, Carbon dioxide emissions, Depletion of ozone layer, Governments Regulations, Energy Economy interaction. Energy Conservation in Buildings, Energy Efficiency Ratings & ECBC (Energy Conservation Building Code). (8L)

Module 5: INTERDISCIPLINARY CASE STUDIES

Study of 4 to 6 cases of Energy Audit & Management in Industries (Mechanical, Chemical and other systems). (8L)

Text Books

1. Amlan Chakrabarti, Energy Engineering and Management, PHI, Eastern Economy Edition.
2. Smith CB, Energy Management Principles, Pergamon Press, New York.
3. Hamies, Energy Auditing and Conservation; Methods, Measurements, Management & Case study, Hemisphere, Washington
4. L. C. Witte, P. S. Schmidt and D. R. Brown, Industrial Energy Management and Utilization, Hemisphere Publications, Washington.

Reference Books

1. W.R.Murphy, G.Mckay, Energy Management, Butterworths.
2. C.B.Smith Energy Management Principles, Pergamon Press.
3. L.C. Witte, P.S. Schmidt, D.R. Brown , Industrial Energy Management and Utilization, Hemisphere Publication, Washington
4. Archie, W Culp , Principles of Energy Conservation, McGraw Hill
5. Munasinghe, Mohan Desai, Ashok V, Energy Demand: Analysis, Management and Conservation, Wiley Eastern Ltd., New Delhi.

Course Evaluation:

Individual assignment, Seminar, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :

Cost effective energy management

POs met through Gaps in the Syllabus: **PO3**

Topics beyond syllabus/Advanced topics/Design:

Advance energy auditing system

POs met through Topics beyond syllabus/Advanced topics/Design: **PO3**

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	1	2	3	-	2
CO2	1	2	3	-	2
CO3	1	2	3	-	2
CO4	1	2	3	-	2
CO5	1	2	3	-	2

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD2,CD6
CO2	CD1,CD2, CD6
CO3	CD1, CD2,CD6
CO4	CD1,CD2,CD6
CO5	CD1,CD2,CD6

COURSE INFORMATION SHEET

Course code: ME585
Course title: Industrial Robotics
Pre-requisite(s): Engineering Mathematics, Engineering Mechanics.
Co- requisite(s): Nil
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 03
Class: M. Tech
Semester / Level: I/II /05
Branch: Mechanical Engineering
Name of Teacher:

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.

Course Outcomes

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

CO1.	Outline the structure of a typical robotic system, understand its link and joint parameters, and perform robot kinematics.
CO2.	Identify the geometric parameters of a serial robot by applying the knowledge of serial robot kinematics and generalized differential model of the robot.
CO3.	Identify the dynamic parameters of a serial robot by applying the knowledge of general form of dynamic equation of motion.
CO4.	Analyse planar and spatial parallel robots in context to its forward and inverse kinematics, and evaluate its singularity, condition number and manoeuvrability.
CO5.	Design a robotic manipulator and evaluate its primary and secondary workspace. Evaluate the performance of an industrial robot based on ISO standards.

SYLLABUS

Module 1:

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

Module 2:

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

Module 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)

Module 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)

Module 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)

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.

Course Evaluation:

Individual assignment, Seminar, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements):
Cost effective performance analysis of robots.
POs met through Gaps in the Syllabus: **PO3**

Topics beyond syllabus/Advanced topics/Design:
Performance analysis of robots.
POs met through Topics beyond syllabus/Advanced topics/Design: **PO3**

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	2	2	2	3	2
CO2	3	3	3	3	2
CO3	3	3	3	3	2
CO4	3	3	3	3	2
CO5	3	3	3	3	3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD2,CD6
CO2	CD1,CD2,CD6
CO3	CD1,CD2,CD6
CO4	CD1,CD2,CD6
CO5	CD1,CD2,CD6

COURSE INFORMATION SHEET

Course code: ME586
Course title: Reliability in Design
Pre-requisite(s): Nil
Co- requisite(s): Nil
Credits: 3   L: 3   T: 0   P: 0
Class schedule per week: 03
Class: M. Tech
Semester / Level: I/II /05
Branch: Mechanical Engineering
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Understand role of reliability evaluation.
2.	Identify reliability assessment techniques that may provide guidance for robust designs.
3.	Apply common concepts from statistics in design.
4.	Explore types of maintenance.
5.	Assess reliability of components and systems.

Course Outcomes

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

CO1.	Perform reliability improvement and life tests.
CO2.	Recommend how further analysis, testing, or quality control may increase safety and efficiency of a structural design.
CO3.	Evaluate and apply statistical methods to structural design.
CO4.	Design for maintainability and its considerations.
CO5.	Formulate and solve reliability-based structural optimization problems.

SYLLABUS

Module 1: RELIABILITY BASICS

Basic Concepts of Reliability, Definition of Reliability, Role of Reliability evaluation, Design for reliability, Design under uncertainty, Why use probabilistic methods, Success stories, bath-tub-curve, system reliability, reliability improvement, maintainability and availability, Life tests, Acceptance sampling based on life tests. (8L)

Module 2: RELIABILITY IN DESIGN AND DEVELOPMENT

Introduction to Design of Experiments (DOE) and Taguchi Method, Failure mode and effects analysis, Basic symbols, Fault Tree construction and analysis, Monte Carlo Simulation, Human factors in design and design principles. (8L)

Module 3: RELIABILITY MANAGEMENT

Objectives of maintenance, types of maintenance, Maintainability, factors affecting maintainability, system down time, availability - inherent, achieved and operational availability (Numerical treatment). Introduction to Reliability Centered Maintenance. Design for maintainability and its considerations, Reliability and costs, Costs of Unreliability. (8L)

Module 4: SYSTEM RELIABILITY ANALYSIS

Reliability Improvement, Redundancy, element redundancy, unit redundancy, standby redundancy types of stand by redundancy, parallel components single redundancy, multiple redundancies (problems). (8L)

Module 5: LIFE TESTING & RELIABILITY ASSESSMENT

Censored and uncensored field data, burn-in testing, acceptance testing, accelerated testing, identifying failure distributions & estimation of parameters, reliability assessment of components and systems. (8L)

Text Books

1. Nikolaidis E., Ghiocel D. M., Singhal S., Engineering Design Reliability Handbook, CRC Press, Boca Raton, FL, 2004.
2. McPherson J.W., Reliability Physics and Engineering: Time to Failure Modeling, 2nd Edition, Springer, 2013.
3. Ebeling, C. E., An Introduction to Reliability and Maintainability Engineering, Waveland Press, Inc., 2009 (ISBN 1-57766-625-9).
4. Bryan Dodson, Dennis Nolan, Reliability Engineering Handbook, Marcel Dekker Inc, 2002.
5. Kapur, K. C., and Lamberson, L. R., Reliability in Engineering Design, John Wiley and Sons, 1977.

Reference Books

1. Reliability toolkit: Commercial practices edition. Reliability Analysis Center, 1995.
2. Blischke, Wallace R., and DN Prabhakar Murthy. Reliability: modeling, prediction, and optimization. Vol. 767. John Wiley & Sons, 2011.
3. Leemis, Lawrence M. Reliability: probabilistic models and statistical methods. Prentice-Hall, Inc., 1995.
4. Modarres, Mohammad, Mark P. Kaminskiy, and Vasiliy Krivtsov. Reliability engineering and risk analysis: a practical guide. CRC press, 2009.
5. O'Connor, Patrick, and Andre Kleyner. Practical reliability engineering. John Wiley & Sons, 2011.
6. Singiresu S Rao, Reliability Engineering, Pearson Education, 2014, ISBN: 978-0136015727.
7. Webpage : https://goremote.itap.purdue.edu/Citrix/XenApp/auth/login.aspx

Course Evaluation:

Individual assignment, Seminar, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :

Cost effective reliable design methods.

POs met through Gaps in the Syllabus: **PO3**

Topics beyond syllabus/Advanced topics/Design:

Advanced methods for reliable design.

POs met through Topics beyond syllabus/Advanced topics/Design: **PO3**

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
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CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	2	2	2	-	1
CO2	2	2	3	-	1
CO3	2	2	2	3	1
CO4	2	2	2	-	1
CO5	2	3	3	3	1

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD2,CD6
CO2	CD1,CD2,CD6
CO3	CD1,CD2,CD6
CO4	CD1,CD2,CD6
CO5	CD1,CD2,CD6