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 appropriate technology with responsibility.
- Creation of congenial atmosphere and ample research facilities for undertaking quality research to achieve national and international recognition by faculty and students.
- To strive for 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 analysing and improving mechanical equipments.

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: An ability to independently carry out research /investigation and development work to solve practical problems.

PO2: An ability to write and present a substantial technical report/document.

PO3: Students should 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 program.

PO4: Have clear insight to appreciate the multidisciplinary nature of the technological field in design of mechanical equipments.

PO5: 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: ME521
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

At 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. (8 L)

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. (8 L)

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. (8 L)

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.

(8 L)

Module 5:

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

(8 L)

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, Theory (Quiz and End semester) examinations

<u>Gaps in the syllabus (to meet Industry/Profession requirements)</u> :
Approximate methods
POs met through Gaps in the Syllabus: PO3

<u>Topics beyond syllabus/Advanced topics/Design:</u>
Asymptotic and perturbation methods
POs met through Topics beyond syllabus/Advanced topics/Design: PO3

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,CD6
CO2	CD1, CD6,CD7
CO3	CD1, CD2, CD3,CD6,CD7
CO4	CD1, CD3,CD6,CD7
CO5	CD1,CD2,CD3,CD4,CD5,CD7

COURSE INFORMATION SHEET

Course code: ME522
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. (8 L)

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. (8 L)

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. (8 L)

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. (8 L)

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. (8 L)

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, 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 : PO3

Topics beyond syllabus/Advanced topics/Design:
Nonlinear deformations of materials
POs met through Topics beyond syllabus/Advanced topics/Design: PO3

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,CD6
CO2	CD1, CD6,CD7
CO3	CD1, CD2, CD3,CD6,CD7
CO4	CD1, CD3,CD6,CD7
CO5	CD1,CD2,CD3,CD4,CD5,CD7

COURSE INFORMATION SHEET

Course code: ME523
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. (8 L)

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. (8 L)

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. (8 L)

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. (8 L)

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.

(8 L)

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, 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 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,CD6
CO2	CD1, CD6,CD7
CO3	CD1, CD2, CD3,CD6,CD7
CO4	CD1, CD3,CD6,CD7
CO5	CD1,CD2,CD3,CD4,CD5,CD7

COURSE INFORMATION SHEET

Course code: ME524
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.	To 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 materials.
CO5.	Discuss about recyclability/disposability issues related to metals, glass, plastic & rubber and composite materials.

SYLLABUS

MODULE-I

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. (8 L)

MODULE-II

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. (8 L)

MODULE-III

Strengthening Mechanism:

Introduction: 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. (8 L)

MODULE-IV

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. (8 L)

MODULE-V

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. (8 L)

Text books:

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

References Books:

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

Course Evaluation:
Individual assignment, 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 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,CD6
CO2	CD1, CD6,CD7
CO3	CD1, CD2, CD3,CD6,CD7
CO4	CD1, CD3,CD6,CD7
CO5	CD1,CD2,CD3,CD4,CD5,CD7

COURSE INFORMATION SHEET

Course code: ME525
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.	Lay the foundation to 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.	Lay the foundation to 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: I 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.

(8 L)

MODULE: II 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. (8 L)

MODULE: III 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.

(8 L)

MODULE: IV 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.

(8 L)

MODULE: V 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. (8 L)

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, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :
Vibration Control of a Flexible Robotic Manipulator
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: PO5

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,CD6
CO2	CD1, CD6,CD7
CO3	CD1, CD2, CD3,CD6,CD7
CO4	CD1, CD3,CD6,CD7
CO5	CD1,CD2,CD3,CD4,CD5,CD7

COURSE INFORMATION SHEET

Course code: ME527
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. (8 L)

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. (8 L)

Module3

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.

(8 L)

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.

(8 L)

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. (8 L)

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, 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 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,CD6
CO2	CD1, CD6,CD7
CO3	CD1, CD2, CD3,CD6,CD7
CO4	CD1, CD3,CD6,CD7
CO5	CD1,CD2,CD3,CD4,CD5,CD7

OPEN ELECTIVES

COURSE INFORMATION SHEET

Course code: ME582
Course title: DESIGN METHODOLOGY
Pre-requisite(s): NIL
Co- requisite(s):
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

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

(8 L)

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

(8 L)

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

(8 L)

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

(8 L)

Module 5

Documentation: Types and structures of research documentation, Approaches and guidelines for documenting and reporting research process and outcomes

(8 L)

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, Theory (Quiz and End semester) examinations

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

<u>Topics beyond syllabus/Advanced topics/Design:</u>
Characterisation of the composite materials.
POs met through Topics beyond syllabus/Advanced topics/Design: PO1 TO PO5

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

<u>MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES</u>

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

<u>MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD</u>

Course Outcomes	Course Delivery Method
CO1	CD1,CD6
CO2	CD1, CD6,CD7
CO3	CD1, CD2, CD3,CD6,CD7
CO4	CD1, CD3,CD6,CD7
CO5	CD1,CD2,CD3,CD4,CD5,CD7

COURSE INFORMATION SHEET

Course code: ME586
Course title: RELIABILITY IN DESIGN
Pre-requisite(s): NIL
Co- requisite(s):
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:
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.

(8 L)

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.

(8 L)

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.

(8 L)

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).

(8 L)

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.

(8 L)

Text Book

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 Book

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, 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, PO3, PO4

Topics beyond syllabus/Advanced topics/Design:

Nonlinear deformations of materials

POs met through Topics beyond syllabus/Advanced topics/Design: PO1 TO PO4

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,CD6
CO2	CD1, CD6,CD7
CO3	CD1, CD2, CD3,CD6,CD7
CO4	CD1, CD3,CD6,CD7
CO5	CD1,CD2,CD3,CD4,CD5,CD7

COURSE INFORMATION SHEET

Course code: ME 583
Course title: Renewable Sources of Energy
Pre-requisite(s): Basic of Physics, Chemistry and Mathematics
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.	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 OTEC system and different possible ways of extracting energy from ocean; know about Biomass energy, mini-micro hydro systems and geothermal energy system.

Course Outcomes

After 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 renewable energy sources like ocean thermal, hydro, geothermal energy etc.

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: HYDRO POWER AND OTHER RENEWABLE ENERGY SOURCES

Hydropower: Introduction, Capacity and Potential, Small hydro, Environmental and social impacts. Tidal Energy: Introduction, Capacity and Potential, Principle of Tidal Power, Components of Tidal Power Plant, Classification of Tidal Power Plants. Ocean Thermal Energy: Introduction, Ocean Thermal Energy Conversion (OTEC), Principle of OTEC system, Methods of OTEC power generation. Geothermal Energy: Introduction, Capacity and Potential, Resources of geothermal 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. Twidell, J.W. & Weir, A. Renewable Energy Sources, EFN Spon Ltd., UK, 2006.
4. S. P. Sukhatme and J.K. Nayak, Solar Energy – Principles of Thermal Collection and Storage, Tata McGraw-Hill, New Delhi.
5. 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, 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 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: ME 584
Course title: Energy Management and Auditing
Pre-requisite(s): Basic of Physics, Chemistry and Mathematics
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.	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

After 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.	Analyse energy conservation related to environmental issues.
CO5.	Carry out Auditing of energy equipment and to prepare energy flow diagrams and energy audit report

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: CASE STUDIES

Study of 4 to 6 cases of Energy Audit & Management in Industries (Boilers, Steam System, Furnaces, Insulation and Refractories, Refrigeration and Air conditioning, Cogeneration, Waste Heat recovery etc.). (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, 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 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: ME528
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 phenomena.
3.	Understand creep phenomena.
4.	Understand vibration characteristics.
5.	Understand dynamics of machines.

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

1. To determine surface hardness of mechanical components using micro hardness testing machine
2. To determine creep properties of materials (Lead, polymer materials) in room temperature
3. To determine change of rate of deformation of a sample (Lead, polymer materials) at different temperature.
4. To determine fatigue strength of material under tensile load (Rumul Fatigue Testing Machine)
5. To determine fatigue strength of material under compressive load (Rumul Fatigue Testing Machine)
6. To determine fatigue strength of material under flexural load (Rumul Fatigue Testing Machine)
7. To determine the properties of materials under tensile load in Instron
8. To determine the properties of materials under compressive load in Instron
9. To determine the properties of materials under flexural load in Instron
10. To determine secondary mass and spring stiffness for forced tuned vibration absorber
11. To understand beating phenomenon in weakly coupled pendulum
12. To determine balancing masses and their orientation for a unbalanced wheel in wheel Balancing Machine

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

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,CD6
CO2	CD1, CD6,CD7
CO3	CD1, CD2, CD3,CD6,CD7
CO4	CD1, CD3,CD6,CD7
CO5	CD1,CD2,CD3,CD4,CD5,CD7

COURSE INFORMATION SHEET

Course code: ME529
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.	Solve a system of linear equation by direct and iterative methods.
2.	Understand decompositions of a matrix like LU and QR.
3.	Apply explicit and implicit methods of solving differential equations.
4.	Determine the stability of a system of differential equations using eigenvalues.
5.	Find the characteristic of a P.D.E. and then to apply suitable method.

Course Outcomes

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

CO1.	Solve system of linear algebraic equations.
CO2.	Solve system of stiff and non-stiff differential equation.
CO3.	Solve non-linear system of equations.
CO4.	Analysis of system of differential equations based on its Eigen values
CO5.	Solve partial differential equations with different characteristics.

List of Experiments

Experiment 1: To solve linear system of equations using Gaussian elimination.
Experiment 2: To solve linear system of equations using Gauss Seidel and Jacobi iterative method.
Experiment 3: Numerical Integration using Trapezoidal rule and Simpson rule.
Experiment 4: Numerical Integration using Romberg Integration and Quadrature formula.
Experiment 5: Applying conjugate gradient method to solve linear system of equations.
Experiment 6: Determining the stability of system of differential equations using its Eigen values.
Experiment 7: Using Crank Nicolson for solving system of differential equations**.**
Experiment 8: Using Runge-Kutta method for solving autonomous system of differential equations.
Experiment 9: Solving stiff differential using Backward Difference Method**.**
Experiment 10: Solving Hyperbolic partial differential equation.
Experiment 11: Solving parabolic partial differential equation.
Experiment 12: Solving elliptic partial differential equation.

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

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

<u>MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES</u>

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
CO2	CD1, CD6,CD7
CO3	CD1, CD2, CD3,CD6,CD7
CO4	CD1, CD3,CD6,CD7
CO5	CD1,CD2,CD3,CD4,CD5,CD7