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 for the benefit of society.

Programme Educational Objectives (PEOs)

PEO 1: To develop capability to understand the fundamentals of Science and Mechanical Engineering for analyzing the engineering problems with futuristic approach.

PEO 2: To foster a confident and competent post graduate capable to solve real life practical engineering problems fulfilling the obligation towards society.

PEO 3: To inculcate an attitude for identifying and undertaking developmental work both in industry as well as in academic environment with emphasis on continuous learning enabling to excel in competitive participations at global level.

PEO 4: To nurture and nourish effective communication and interpersonal skill to work in a team with a sense of ethics and moral responsibility for achieving goal.

PROGRAM OUTCOMES (POs)
M. Tech. in Mechanical Engineering

Compulsory PO

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: Clear insight to appreciate the multidisciplinary nature of the technological field in Mechanical engineering.

PO5: Develop an ability to work in team, apart from having awareness of social needs and professional code of conduct, ethics, and behavior.

COURSE INFORMATION SHEET

Course code: ME 507
Course title: Optimization Techniques
Pre-requisite(s): B.Tech. Engineering 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.	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: ME511
Course title: Finite Element Analysis
Pre-requisite(s): B. Tech Engineering 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.	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

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

Topics beyond syllabus/Advanced topics/Design:
Geometric and material nonlinear analyses.
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	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 COURSEDELIVERY 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 521**
Course title:	**Computational Methods in Engineering**
Pre-requisite(s):	**B.Tech. Engineering Mathematics**
Co- requisite(s):	**NIL**
Credits: 3	L: 3, T: 0, P: 0
Class schedule per week:	**03**
Class:	**M.Tech. (ALL)**
Semester / Level:	**I / 05**
Branch:	Mechanical Engineering
Name of Teacher:	

Course Objectives

This course enables the students:

A.	To learn different numerical techniques for solving problems in linear algebra, differential and integral calculus.
B.	To apply numerical methods for solving engineering problems.

Course Outcomes

After the completion of this course, students will 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.

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

R1 Joe D Hoffman, Numerical Methods for Engineer and Scientists, Marcel Dekker.

R2 S. P. Venkateshan and P. Swaminathan, Computational Methods in Engineering, Ane books.

Reference Books

T1 Gilbert Strang, Computational Science and Engineering, Wessley – Cambridge press.

T2 Steven C. Chapra, Applied Numerical Methods with MATLAB for Engineers and Scientists, Tata McGrawhill.

Gaps in the syllabus (to meet Industry/Profession requirements)
Approximate methods
POs met through Gaps in the Syllabus
PO (1)
Topics beyond syllabus/Advanced topics/Design
Asymptotic and perturbation methods
POs met through Topics beyond syllabus/Advanced topics/Design
PO (1)

	Course Delivery methods
CD1	Lecture by use of boards/LCD projectors
CD2	Tutorials/Assignments
CD3	Seminars
CD4	Mini projects/Projects
CD5	Laboratory experiments/teaching aids
CD6	Industrial/guest lectures
CD7	Industrial visits/in-plant training
CD8	Self- learning such as use of NPTEL materials and internets

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

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes				
	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

Mapping Between COs and Course Delivery (CD) methods			
CD	**Course Delivery methods**	**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors	CO1 – CO5	CD1
CD2	Tutorials/Assignments	CO1 – CO5	CD2
CD3	Seminars		
CD4	Mini projects/Projects		
CD5	Laboratory experiments/teaching aids		
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		

COURSE INFORMATION SHEET

Course code: ME 526
Course title: Fluid Power and Control
Pre-requisite(s): B.Tech 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 COURSEDELIVERY 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 549
Course title: Energy Simulation and Modelling
Pre-requisite(s): B. Tech Engineering 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.	Provide knowledge, understanding and application oriented skills on Energy, Modeling and Simulation.
2.	Study the various model in details which are useful for energy planning.
3.	Utilize the modeling techniques for simulating and helping in meeting electricity demand with minimum wastage.

Course Outcomes

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

CO1.	Understand the various energy policies.
CO2.	Analyze the different Input-Output and Econometric Models.
CO3.	Solve problems on various Optimization Models.
CO4.	Analyze the Process Analysis Models.
CO5.	Review the System Dynamic and Other Simulation Models

SYLLABUS

Module 1: INTRODUCTION

Energy policy analysis; need for energy modeling; classification of energy models; types of computer based tools for energy planning; national and rural energy planning; sectorial energy planning. (8L)

Module 2: INPUT-OUTPUT AND ECONOMETRIC MODELS

Types and Characteristics of I-O models; use of I-O models; IO transaction tables; method of estimation and sources of data; mathematical expression on the methodology of construction of I-O tables; case studies. Statistical estimation techniques; time series; regression analysis; advantages and limitations of econometric models; elastic ties of energy demand; case studies. (8L)

Module 3: OPTIMIZATION MODELS

Linear and non-linear optimization models; advantage and limitation of optimization models; case studies of linear optimization models for national and rural energy planning (8L)

Module 4: PROCESS ANALYSIS MODELS

End-use models; process analysis models for industrial, domestic and transport energy conservation; advantage and limitations of process analysis models; case studies. (8L)

Module 5: SYSTEM DYNAMIC AND OTHER SIMULATION MODELS

Concept of closed system; causal loop diagram; flow diagram and system equations; dynamic behavior of energy systems; advantages and limitations of simulation models; case studies. (8L)

Text Books

1. J.P. Weyant & T. A. Kuczmowski "Engineering- Economy Modeling: Energy Systems" Energy-The International Issue (Special issue an energy modeling), Pergaman Press. Vol. 15, No. ¾ PP 145-715, 1990.
2. Richard de Nenfville, " Applied Systems Analysis" Mc Graw Hill International Eds. 1990.

Reference Books

1. J. W. Forrester, "Principles of Systems" MIT Press, 1982.
2. Rene Codoni, Hi- Chun Park, K.V. Ramani, " Integrated Energy Planning: A Manual" Volume on policy planning, Asian & Pacific Development Center, Kuala Lumpur 1985.

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

Gaps in the syllabus (to meet Industry/Profession requirements) :
Improved Energy simulation technology
POs met through Gaps in the Syllabus: **PO3**

Topics beyond syllabus/Advanced topics/Design:
Cost effective Energy modelling
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	2	-	2
CO2	2	2	3	-	2
CO3	2	2	2	-	2
CO4	2	2	3	-	2
CO5	2	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 548
Course title: Computational Laboratory
Pre-requisite(s): B. Tech Engineering Mathematics
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.	Analyze engineering problems using finite element packages ANSYS andCOMSOL

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.	Analyze Plane stress, Plane strain, and torsion problems using finite elementpackage ANSYS
CO5.	Analyze plate and shell problems, and equation-based modelling using finiteelement 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'smethod.
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	50
Semester End Examination	50

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

Semester End Examination	**% Distribution**
Examination Experiment Performance	30
Quiz	20

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 COURSEDELIVERY 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 591
Course title: Modelling and Optimization Lab
Pre-requisite(s): B. Tech Engineering Mathematics
Co- requisite(s): Nil
Credits: 2 L: 0 T:O P: 4
Class schedule per week: 04
Class: M. Tech
Semester *I* Level:
Branch: Mechanical Engineering
Name of Teacher:

Course Objectives

This course enables the students to:

1	Provide exposure to modern computational techniques in optimization and heat transfer.
2	Apply computational methods for solving complex engineering problems.
3	Set the stage for future recruitment by potential employers in the field of simulation.

Course Outcomes

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

CO l.	Recognize the importance of optimization and heat transfer analysis.
CO2	Analyse optimal process parameters for maximization and minimization of suitable responses for engineering problem
CO3.	Solve optimal process parameters for maximization and minimization of suitable responses with mixed level of the parameters for engineering problem.
CO4.	Recognize how to handle different boundary conditions.
CO5.	Analyse computational heat transfer.

LIST OF EXPERIMENTS

1. Using suitable data from an engineering problem, find the optimal process parameters for maximization and minimization of suitable responses applying Taguchi Technique in MINITAB Software
2. Using suitable data from an engineering problem, find the optimal process parameters for maximization and minimization of suitable responses applying Response Surface Methodology in MINITAB Software
3. Using suitable data from an engineering problem, find the optimal process parameters for maximization and minimization of suitable responses applying Full Factorial Technique in MINITAB Software
4. Using suitable data from an engineering problem, find the optimal process parameters for maximization and minimization of suitable responses with mixed level of the parameters in MINITAB Software
5. Using suitable data from an engineering problem, find the optimal process parameters for maximization and minimization of suitable responses applying Artificial Neural Network in MATLAB Software
6. Using suitable data from an engineering problem, find the optimal process parameters for maximization and minimization of suitable responses applying Genetic Algorithm in MATLAB Software
7. Using suitable data from an engineering problem, to do heat transfer analysis under free convection mode in water glass using COMSOL Multiphysics Software
8. Using suitable data from an engineering problem, to do heat transfer analysis for evaporative cooling of water using COMSOL Multiphysics Software
9. Using suitable data from an engineering problem, to do heat transfer analysis for dynamic wall heat exchanger using COMSOL Multiphysics Software
10. Using suitable data from an engineering problem, to do heat transfer analysis for cooling and solidification of metal using COMSOL Multiphysics Software
11. Using suitable data from an engineering problem, to do heat transfer analysis for cooling and solidification of metal using COMSOL Multiphysics Software
12. Using suitable data from an engineering problem, to do heat transfer analysis for natural convection cooling of a vacuum flask using COMSOL Multiphysics Software

EVALUATION PROCEDURE

Direct Assessment

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

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

Semester End Examination	%
Examination Experiment Performance	30

Quiz	20

Assessment Components	COl	C02	C03	C04	COS
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment-

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

Course Delivery Methods

CDl	Lecture by use of boards projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CDS	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	**POl**	**P02**	**P03**	**P04**	**PO5**
COl	3	3	2	2	2
C02	3	3	2	2	2
C03	3	3	2	2	2
C04	3	3	2	2	2
COS	3	3	2	2	2

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
COl	CD1,CD3,CD6
C02	CDl,CD3,CD6
C03	CDl,CD3,CD6
C04	CD1,CD3,CD6
CO5	CDl,CD3,CD6

(Specialization: Heat Power Engineering)

COURSE INFORMATION SHEET

Course code: ME592
Course title: ADVANCED HEAT TRANSFER
Pre-requisite(s): B.E. /B. Tech. Heat Transfer
Co- requisite(s): Partial Differential Equations
Credits: 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.	To present a comprehensive and rigorous treatment of conductive, convective, and radiative heat transfer while retaining an engineering perspective.
2.	To lay the groundwork for subsequent studies in such fields as heat transfer systems and to prepare the students to effectively use of conductive, convective and radiation heat transfer analysis in the practice of engineering.
3.	To develop an intuitive understanding of conductive, convective and radiative heat transfer by emphasizing the engineering and engineering arguments.

Course Outcomes:

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

CO1	Identify modes of heat transfer and model basic heat transfer processes.
CO2	Apply different methods for solution of multi-dimensional engineering problems of conductive heat transfer.
CO3	Extend the similarity concept in velocity and thermal boundary layer for isothermal and non-isothermal cases.
CO4	Examine the basics of turbulence model and analogy between flow field and heat transfer.
CO5	Apply different methods for solution of radiative heat transfer problems in participating non-participating medium.

SYLLABUS

Module I:

Multidimensional conduction-I: Introduction, integral form of governing equation, differential form of governing equation, simplified form of energy equation, steady conduction in two dimensions: steady conduction in rectangle, steady conduction in a rectangle with heat generation, steady two-dimensional conduction in cylindrical co-ordinates, transient conduction in more than one dimension: Introduction, transient conduction in an infinitely long rectangular bar, transient heat conduction in a rectangular block in the form of a brick. (8L)

Module II:

Similarity concepts in heat transfer for laminar and turbulent flows; Boundary layer equations; Boundary layer integral equation; similarity and integral solutions of flow over isothermal and non-isothermal flat plate, Numerical solution of the laminar boundary layer flow over a flat plate and viscous dissipation effects on flow over a flat plate. (8L)

Module III:

Introduction to Turbulent Flows: governing equations, mixing length turbulence models, analogy solutions for heat transfer in turbulent flows, near walls region, transition from laminar to turbulent flow, analogy solution for boundary layer flows, numerical solution of turbulent boundary layer equations, viscous dissipation effects on turbulent boundary layer flow over a flat plate. (8L)

Module IV:

Thermal radiation: the physics of radiation, thermodynamics of black body radiation, Planck distribution, properties of the Planck distribution functions, shape factor of complicated geometry, use of graphs for finding shape factors, radiation irradiation method of enclosure analysis, Enclosure containing diffuse non-gray surfaces, gray enclosures containing diffuse and specular surfaces. (8L).

Module V:

Radiation in participating media: Introduction, definitions, equation of transfer, absorption of radiation in different media: transmittance of a solid slab, absorption of radiation by gases, radiation in an isothermal gray gas slab and the concept of mean beam length, radiation in a non-isothermal participating medium: radiation transfer in a gray slab, radiation equilibrium, solution of integral equation, enclosure analysis in the presence of an absorbing and emitting gas: zone method, example of zone analysis. (8L)

Books recommended:

TEXT BOOK

1.Heat Transfer, S. P. Venketeshan, Ane books Pvt. Ltd, 2016.

2. Y. A. Cengel and A. J. Ghajar, Heat and Mass Transfer, McGraw-Hill Education, 2014.

3.P. H. Oosthuizen and D. Naylor, An Introduction to convective Heat Transfer Analysis, 1999.

4..Radiative Heat Transfer, M. F. Modest, McGraw-Hill, Inc, 2013.

REFERENCE BOOK

1. Heat and Mass transfer, P. K. Nag, McGraw-Hill Publications, 2011.
2. Heat transfer, A. F. Mills and V. Ganeshan, Pearson Education, 2009.
3. Fundamental of heat and mass transfer by Sarit k das , Narosa publication, 2010.
4. Frank P. Incropera, David P. Dewitt, Principles of Heat and Mass transferr, John Wiley& Sons, 2011.
5. William M. Kays & Michael E Crawford, Convective Heat and Mass Transfer,McGraw-Hill Science/Engineering/Math, 1993.
6. Frank Kreith and Mark S. Bohn, Principles of Heat Transfer, West Publishing Company,1993

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

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

Multidimensional conduction in cylindrical and spherical coordinates.

POs met through Gaps in the Syllabus: **PO5**

Topics beyond syllabus/Advanced topics/Design:

Radiation in participating media.

POs met through Topics beyond syllabus/Advanced topics/Design: PO1, PO2 & 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	2	2	1
CO2	3	3	2	2	1
CO3	3	3	2	2	1
CO4	3	3	2	2	1
CO5	3	3	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,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 593
Course title: ADVANCED FLUID MECHANICS
Pre-requisite(s): B.E. /B. Tech. Fluid Mechanics
Co- requisite(s): Partial Differential Equation
Credits: L:3 T:0 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.	To present a comprehensive and rigorous treatment of classical incompressible and compressible fluid mechanics while retaining an engineering perspective.
2.	To lay the groundwork for subsequent studies in such fields as analysis of various types of fluid flows and to prepare the students to effectively use fluid mechanics theory in the practice of engineering.
3.	To develop an intuitive understanding of incompressible and compressible fluid mechanics by emphasizing the engineering and engineering arguments.
4.	To present a wealth of real world engineering examples to give students a feel for

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

CO1	Outline the concepts of descriptions of fluid flows, ideal and real fluids, system of control volume approach, incompressible and compressible fluid and flow properties.
CO2	Apply the appropriate fundamental laws of incompressible and compressible fluid dynamics to various flow passages and over the bodies.
CO3	Analyse various fluid dynamics problems pertaining to incompressible and compressible fluid flow.
CO4	Evaluate the applicability governing equations related to incompressible and compressible fluid flow where, an exact solution of the problem is possible.
CO5	Investigate the solutions obtained from the problems using usual conventional methods and with some software tools for validation of results.

SYLLABUS

MODULE- I

Description of fluid motion: Euler and Lagrangian description. Reynold's Transport theorem, rate of linear and angular strain, Mass, momentum and energy equations, Stream function and velocity potential function and its application. (8L)

MODULE-II

Navier-Stokes Equation: Derivation of Navier-Stokes equation, Exact solution of Navier- Stokes equations: Hagen-Poiseuille flow and Coutte flow, Flow between two rotating cylinders. Stokes first and second problem. (8L)

MODULE-III

Compressible Flow: Review of fundamentals, Mach number and its significance, subsonic and supersonic flows, concept of stagnation condition, one dimensional isentropic flow, governing equations, differential equations governing flow with area change, adiabatic flow, Normal Shock relations, Prandtl-Meyer equation, Rankine-Hugoniot relations, stationary and moving shock waves, weak and strong shocks, one dimensional diffusers.

(8L)

MODULE-IV

Oblique shock relations: Weak compression and expansion waves, compression shock wave and expansion fans, analysis of oblique shock wave, upstream and downstream velocity triangles, relation between deflection angle and wave angle, Tables and charts for oblique shock, working formulae, shock geometry, analysis of Prandtl-Meyer flow, Shock polar diagram.

(8L)

MODULE-V

Fanno flow: Fanno line, governing equations, limiting condition for a Fanno flow, chocking due to friction, Fanno relations for a perfect gas, change in entropy due to friction, performance of long ducts and variation of pressure ratios.

Rayleigh flow: Rayleigh line, governing equations, flow in duct with heating and cooling, significance of maximum entropy and enthalpy state, choking in Rayleigh flow.

(8L)

Recommended Books:

1. Fluid Mechanics by F.M. White.
2. Boundary Layer Theory by H. Schlichting.
3. Dynamics and Thermodynamics of Compressible flow by A.H. Shapiro.
4. Introductory Gas Dynamics by A.J. Chapman and W.F. Walker.
5. Fundamentals of Compressible flow by S.M. Yahya.
6. Introduction to Fluid Mechanics and Fluid Machines, Som S. K. Biswas G,Chakraborty S , Tata McGraw Hill, 2017.
7. Turbulence: An Introduction for Scientists and Engineers, Davidson P.A., OxfordPublication, 2015.

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

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

Detailed analysis of different transient fluid flow problems. Outline of various CFDsoftware used in industries.

POs met through Gaps in the Syllabus: **PO4 & PO5**

<u>Topics beyond syllabus/Advanced topics/Design:</u>

Turbulence in compressible and Multiphase flows, Simple fluid flow simulation methods.

POs met through Topics beyond syllabus/Advanced topics/Design: **PO4 & PO5**

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 –

3. Student Feedback on Faculty
4. 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	2	1	1
CO2	3	2	3	2	1
CO3	3	2	3	3	1
CO4	3	2	2	2	1
CO5	3	3	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 594
Course title: Experimental Methods in Thermal Engineering
Pre-requisite(s): B. Tech Heat Transfer, 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:

1.	Equip students with the knowledge of different experimental techniques used in thermal system.
2.	Provide the essential experimental background for design and data interpretation of the thermal systems.
3.	To understand various instruments used for data measurement in thermal systems.

Course Outcomes
After the completion of this course, students will be:

CO1	Discuss experimentation techniques for various thermal systems.
CO2	Discuss various instruments used for measuring different properties significant for evaluation of performance of thermal systems and to carry out uncertainty analysis.
CO3	Appraise the computing facilities for measurement and acquisition of data
CO4	Apply the experimental knowledge for various thermal systems
CO5	Appraise advanced measurement techniques and systems

Syllabus

Module 1:

Introduction: Experiments versus simulation, Experiments versus measurements, why conduct experiments, Details of an experimental set up, Global Versus local measurements; Static versus dynamic calibration, Forward versus inverse measurements.
(8L)

Module 2:

Uncertainty analysis: Types of errors and uncertainties, statistical basis of uncertainty, propagation of uncertainties, codes for uncertainty analysis. (8L)

Module 3:

Statistics and data interpretation: Population and samples, mean and standard deviation of mem, Estimators of population mean and standard deviation, Normal distribution, students t-distribution, Chi-squared distribution, Confidence levels and sample size selection, Regression analysis. (8L)

Module 4:

Introduction to design of experiments (DOE): Concepts, methodology examples. (8L)

Module 5:

Instruments: Specifications and characteristics, range, resolution, accuracy, precision, calibration traceability, time/frequency response, selection of instruments for measurements of physical quantities such as temperature, pressure, flow rate, sources of error.

Introduction and optical diagnostics: Image analysis and its application in particle tracking techniques. (8L)

Books:

1. Debin, E.O. Measurement systems – Application and Design, Tata McGraw Hill, New Delhi – 200004

2. Holman, J.P. Experimental methods for Engineering, Tata McGraw Hill.

3. Bouker, A.H. , and Lieberman, G.J. Engineering Statistics, Prentice Hall, New Jersey, 1972.

Gaps in the syllabus (to meet Industry/Profession requirements)
Designing the Thermal System

POs met through Gaps in the Syllabus: PO(1) to PO (3)

Topics beyond syllabus/Advanced topics/Design: Experimental approach

POs met through Topics beyond syllabus/Advanced topics/Design: PO (1) to PO(5)

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

	Course Delivery methods
CD1	Lecture by use of boards/LCD projectors
CD2	Tutorials/Assignments
CD3	Seminars
CD4	Mini projects/Projects
CD5	Laboratory experiments/teaching aids
CD6	Industrial/guest lectures
CD7	Industrial visits/in-plant training
CD8	Self- learning such as use of NPTEL materials and internets

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	**Program Outcomes**				
	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3	3	3	1	1
CO2	3	3	3	2	2
CO3	3	3	3	2	2
CO4	3	3	3	2	2
CO5	3	3	3	2	2

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

Mapping between Course Outcomes and Course Delivery method

Course Outcome	**Course Delivery Method**
CO1	CD1, CD2, CD3
CO2	CD1, CD2, CD3
CO3	CD1, CD2 CD3, CD7
CO4	CD1, CD2, CD3, CD8
CO5	CD1, CD2, CD3, CD8

COURSE INFORMATION SHEET

Course code: ME 504
Course title: Computational Fluid Dynamics
Pre-requisite(s): B. Tech Fluid Mechanics and Heat Transfer
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:

1.	Equip students with the knowledge base essential for application of computational fluid dynamics to engineering flow problems
2.	Provide the essential numerical background for solving the partial differential equations governing the fluid flow
3.	Develop students' skills of writing the CFD codes and use of commercial software package to solve practical and theoretical problems

Course Outcomes
After the completion of this course, students will be:

CO1	Understand the basic equations of fluid flow and heat transfer.
CO2	Apply different methods of discretisation for solution of governing equation.
CO3	Analyze convergence criteria used in multi-dimensional problem.
CO4	Explain different schemes for convergence of convection diffusion problems.
CO5	Evaluate Navier-Stokes equation by different algorithm.

SYLLABUS

Module-1: Computational approach to Fluid Dynamics and its comparison with experimental and analytical methods, A brief overview of the basic conservation equations for fluid flow and heat transfer, conservative and non-conservative forms of equation, classification of partial differential equations and pertinent physical behaviour, parabolic, elliptic and hyperbolic equations, role of characteristics. (8L)

Module-2: Common methods of discretization: an overview of finite difference, finite element and finite volume methods. Numerical solution of parabolic partial differential equations using finite- difference and finite volume methods: explicit and implicit schemes, consistency, stability and convergence. Numerical solution of systems of linear algebraic equations: general concepts of elimination and iterative methods, Gaussian elimination, LU decomposition, tridiagonal matrix algorithm. (8L)

Module-3: Jacobi and Gauss-Seidel iterations, necessary and sufficient conditions for convergence of iterative schemes, gradient search methods, steepest descent and conjugate gradient methods. The finite volume method of discretization for diffusion problems: one dimensional steady diffusion problems, specification of interface diffusivity, source-term linearization. Discretization of transient one-dimensional diffusion problems. (8L)

Module-4: Discretization for multi-dimensional diffusion problems. Solution of discretized equations using point and line iterations, strongly implicit methods and pre-conditioned conjugate gradient methods. Convection diffusion problems: Central difference, upwind, exponential, hybrid and power law schemes, concept of false diffusion, QUICK scheme. (8L)

Module-5: Numerical solution of the Navier-Stokes system for incompressible flows: stream- function vorticity and artificial compressibility methods, requirement of a staggered grid. MAC, SIMPLE, SIMPLEC and SIMPLER algorithms. An introduction to unstructured grid finite volume methods. Special topics: Turbulence and its modeling, interface/free-surface tracking methods. (8L)

Recommended books:

1. John A. Anderson, Jr., Computational Fluid Dynamics, The Basic with applications by
1. McGraw Hill International editions, Mechanical Engineering series, 2017.
2. Suhas Patankar, Numerical Methods in Fluid Flow & Heat Transfer, 1980.
3. H.K. Versteeg & W.Malalasekera, An Introduction to Computational Fluid Flow (Finite Volume Method), Printice Hall, 2008.
4. Ferziger and Peric, Computational Methods for Fluid Dynamic, Springer Publication, 1996.
5. Chuen-Yen Chow, An Introduction to Computational Fluid Mechanics, Wiley
6. Publication, 2011.
7. Murlidhar and Sundarrajan, Computational Fluid Flow & Heat Transfer, Narosa
8. Publication, 2009.
6. J. Blazek, Computational Fluid Dynamics by principles and applications, Elsevier Science Ltd, 2001.

Gaps in the syllabus (to meet Industry/Profession requirements)
Numerical approach to compressible and two phase flow

POs met through Gaps in the Syllabus: PO(1) to PO (3)

Topics beyond syllabus/Advanced topics/Design: Combustion related topics

POs met through Topics beyond syllabus/Advanced topics/Design: PO (1) and PO(3)

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

	Course Delivery methods
CD1	Lecture by use of boards/LCD projectors
CD2	Tutorials/Assignments
CD3	Seminars
CD4	Mini projects/Projects
CD5	Laboratory experiments/teaching aids
CD6	Industrial/guest lectures
CD7	Industrial visits/in-plant training
CD8	Self- learning such as use of NPTEL materials and internets

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes				
	PO1	PO2	PO3	PO4	PO5
CO1	3	2	3	1	1
CO2	3	2	3	1	1
CO3	3	3	3	2	2
CO4	3	3	3	2	2
CO5	3	3	3	2	1

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

Mapping between Course Outcomes and Course Delivery method

Course Outcome	Course Delivery Method
CO1	CD1, CD2, CD3
CO2	CD1, CD2, CD3
CO3	CD1, CD2 CD3, CD7
CO4	CD1, CD2, CD3, CD8
CO5	CD1, CD2, CD3, CD8

COURSE INFORMATION SHEET

Course code: ME561
Course title: CLASSICAL AND STASTICAL THERMODYNAMICS
Pre-requisite(s): B.E. /B. Tech. Thermodynamics
Co- requisite(s): Partial Differential Equations
Credits: 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.	To present a comprehensive and rigorous treatment of classical thermodynamics while retaining an engineering perspective.
2.	To lay the groundwork for subsequent studies in such fields as heat transfer and energy conversion systems and to prepare the students to effectively use thermodynamics in the practice of engineering.
3.	To develop an intuitive understanding of thermodynamics by emphasizing the engineering and engineering arguments.
4.	To present a wealth of real world engineering examples to give students a feel for how thermodynamics is applied in engineering practice.

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

CO1	Review and Apply the concepts of I and II law of thermodynamics.
CO2	Analyse and evaluate the concept of exergy in different thermodynamic cycles
CO3	Analyze the concept of Real Gases and Mixtures and to apply the thermodynamic relations of gas mixtures.
CO4	Evaluate the Thermodynamic properties of homogeneous mixtures.
CO5	Analyze the concept of statistical thermodynamics.

SYLLABUS

Module I:

Review of I and II Laws of Thermodynamics: Transient flow analysis, entropy balance for flow and non- flow systems, entropy generation. properties of pure substance, PVT surface, Third law of thermodynamics, Nerst heat theorem. (10L)

Module II:

Exergy Analysis: Concepts, exergy balance analysis for flow, non-flow and transient systems, exergy transfer, exergetic/Second Law efficiency, Second Law analysis of different thermal systems. (8L)

Module III:

Real Gases and Mixtures: Equations of state- vander wall's equation of state and other equation of state, virial expansion, Law of corresponding state, compressibility factor, reduced coordinate system and generalized compressibility chart.

Thermodynamic Relationships: First order phase transition and Clapeyron's equation, second order phase transition and Ehrenfest's equations, Maxwell's equations: equations for internal energy, enthalpy, entropy, specific heat, and Joule-Thomson coefficient. (9L)

Module IV:

Chemical Thermodynamics: Gibb's theorem, Gibb's function of mixture of inert ideal gases. Chemical equilibrium, Thermodynamics equation for phase, degree of Reaction, equation of reaction equilibrium, Law of Mass Action, Heat of Reaction and Vant hoff Isobar, Saha's equation for standard Gibb's function change, affinity. (8L)

Module V:

Statistical Thermodynamics: Importance of statistical anlysis, Stirling's approximation, Bose-Einstein statistics and Fermi-Dirac statistics, classical Maxwell-Boltzman model, equilibrium distribution, microscopic interpretation of heat and work, entropy, second law of thermodynamics, partition function and its properties. (8L)

Books recommended:

TEXT BOOK

1. P.K. Nag, Basic and Applied Thermodynamics, Tata McGraw-Hill Publishing Co. Ltd., 2010.
2. Yonus A Cengel and Michale A Boles, Thermodynamics: An Engineering Approach, McGraw Hill, 2002.
3. A. Bejan, Advanced Engineering Thermodynamics, John Wiley & Sons, 2006.

REFERENCE BOOK

1. M. J. Moran and H. N. Shapiro, Fundamentals of Engineering Thermodynamics, John Wiley and Sons, 1999.
2. J. B. Jones and R. E. Duggan, Engineering Thermodynamics, Prentice-Hall of India, 1996.

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

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

Detailed analysis of different transient thermodynamics systems using software EES

POs met through Gaps in the Syllabus: **PO4 & PO5**

Topics beyond syllabus/Advanced topics/Design:

Irreversible thermodynamics.

POs met through Topics beyond syllabus/Advanced topics/Design: **PO1 & 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	3	3	3	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
FCO1	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: ME565
Course title: THEORY AND DESIGN OF I.C. ENGINES
Pre-requisite(s): B.E. /B. Tech. I.C. Engine
Co- requisite(s): NA
Credits: 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.	To explore the knowledge of performance parameters and its characteristics, variables effects the performance of engine and methods of improving engine performance of internal combustion engine.
2.	Examination and selection of different alternativefuel and its emissions and control.
3.	To explore principle of different electronic fuel injection system, supercharging and its effect on performance of internal combustion engine.
4.	To design and recommend low cost and high performance engine components, which finds applications in modern internal combustion engines.

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

CO1	To explain performance parameters and characteristics; and calculation of performance parameters.
CO2	Interpret different alternative fuels and its emissions, then the method to control these emissions.
CO3	Analyze different electronic fuel injection system, supercharging and its effect on performance of SI and CI engine.
CO4	Specify and interpret data of alternative fuels and its emission which effect the environment.
CO5	To design low cost and high performance cylinder, cylinder head,crank case piston, connecting rod, crank shaft and radiator of Internal combustion engine.

SYLLABUS

Module I:

Performance Parameters and Characteristics: Indicated and brake mean effective pressure, IP &BP, air standard, indicated and brake thermal, mechanical, relative, volumetric, scavenging, charge and combustion efficiencies, effect of spark timing, mixture composition ,load, speed, and compression ratio on engine performance and efficiency .Performance characteristics and variables affecting the performance characteristics, Methods of improving Engine performance, Performance maps.(8L)

Module II:

Alternate Fuels: Solid, Liquid and gaseous fuels, Liquid fuels- Alcohol, methanol, ethanol, reformulated gasoline, water gasoline mixture, Gaseous fuels- Hydrogen, natural gas, CNG,LPG, their advantages and disadvantages, Biogas, dual fuel operation. Emission from alternative fuels, status of alternative fuels in India.(8L)

Module III:

Air Capacity of Four-Stroke Engines and Supercharging: Ideal air capacity, volumetric efficiency, effect of engine variables on volumetric efficiency, supercharging for S.I. and C.I. engines, types of superchargers and their characteristics, exhaust supercharging, performance of supercharged engines. Multi-Point Fuel Injection (MPFI) system, Electronic Diesel Injection System, CRDI system and its advantages and disadvantages. (8L)

Module IV:

Engine Emissions and their control: Air pollution due to IC engines, Exhaust and non-exhaust emissions, HC, CO and NOx emissions and their causes, Photochemical smog, Particulates, Aldehyde, suplhur, lead, phosphorous emissions, Emission control methods.(8L)

Module V:

Engine Design: General design concept of IC engine, design of principal parts of IC engine cylinder head, pistons, connecting rod, crank shaft, radiator and fin.(8L)

Books recommended:

TEXT BOOK

1. Internal Combustion Engine, Ganesan,V., McGraw Higher Ed., 2012.
2. Internal Combustion Engines, Obert,E.F., International Textbook Co., 1968.
3. The Internal Combustion Engines in Theory and practice, Taylor,C.F., MIT Press, 1985.

REFERENCE BOOK

1. Internal Combustion Engines, Mathur,R.P. & Sharma,M.L., Dhanpat Rai Publication, 2014.
2. Diesel Engine Design, Purdey,H.F.P., Nabu Press, 2010.
3. Internal Combustion Engines, Maleev,V.L., McGraw-Hill Book Company, 1945.

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

Gaps in the syllabus (to meet Industry/Profession requirements) :
Performance parameters of IC engine, Air pollution of IC engine and design of IC parts.
POs met through Gaps in the Syllabus: **PO4 & PO5**

Topics beyond syllabus/Advanced topics/Design:
Air pollution of IC engine.
POs met through Topics beyond syllabus/Advanced topics/Design: **PO4 & 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	1	1	2	2
CO2	2	2	1	2	1
CO3	1	1	1	2	2
CO4	1	2	1	2	2
CO5	2	2	1	2	2

< 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 569**
Course title: **Advanced Refrigeration and Air Conditioning**
Pre-requisite(s): **B.Tech Thermodynamics / Refrigeration and Air Conditioning**
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:

1.	To explore the knowledge of solar geometry and heating load calculation of building for air conditioning purpose through different arrangements of building.
2.	Examination and selection of different air conditioning system and their performance
3.	To explore principle of design an air conditioning system and evaluate its components for their performance.
4.	To design and recommend low cost and high-performance air conditioning duct, which finds applications in modern industries, homes and offices.

Course Outcomes

After the completion of this course, students will be:

CO1	To explain fundamental of solar geometry and heating load calculation by direct and diffuse radiations
CO2	Interpret different heating sources of building and its calculations.
CO3	Analyse different air conditioning systems and economic application.
CO4	Specify, interpret data and design an air-conditioning system and its equipment in all aspect.
CO5	To design and recommend low cost and high-performance air conditioning duct which finds applications in modern industries, homes and offices; recognize the need to learn, to engage and to adapt in a world of constantly changing in air conditioning industry.

SYLLABUS

MODULE-I

Cooling and Heating Load Calculations - I: Estimation of Solar Radiation : Introduction to cooling and heating load calculations, Refrigeration loads due to Solar radiation and Solar geometry, Air mass system, Calculation of direct, diffuse and reflected radiation using ASHRAE solar radiation model and Air mass system, Effect of clouds. (8L)

MODULE-II

Cooling and Heating Load Calculations –II: Solar Radiation Through Fenestration Ventilation And Infiltration Need for fenestration in buildings and effects of fenestration on air conditioning systems, concepts of Solar Heat Gain Factor (SHGF) and Shading Coefficient, calculation of shaded area of fenestrations, Need for ventilation and recommended ventilation rates, Infiltration and causes for infiltration, Estimation of heat transfer rate due to infiltration and ventilation, comparison between natural ventilation and mechanical ventilation, characteristics of natural ventilation and estimation of airflow rate due to wind and stack effects, general guidelines for natural ventilation and forced ventilation using electric fans, interior air movement using interior fans.
(8L)

MODULE-III

Cooling and Heating Load Calculations - III: Heat Transfer Through Buildings - Fabric Heat Gain/Loss General aspects of heat transfer through buildings, steady state heat transfer through homogeneous, non-homogeneous walls, opaque walls and roofs with suitable initial and boundary conditions, semi-empirical methods based on Effective Temperature Difference or Cooling Load Temperature Difference, discuss the physical significance of decrement and time lag factors and present typical tables of CLTD for walls and roof. (8L)

MODULE-IV

Selection of Air Conditioning Systems: Introduction to thermal distribution systems and their functions, Selection criteria for air conditioning systems, Classification of air conditioning systems, Working principle, advantages, disadvantages and applications of all air systems, e.g. single duct, constant volume, and single/multiple zone system, single duct, dual duct, constant & variable air volume (VAV) systems, outdoor air control in all air systems, advantages/disadvantages & applications of all air systems, working principle, advantages, disadvantages and applications of all water systems, air-water systems, working principle, advantages, disadvantages and applications of unitary refrigerant based systems.
(8L)

MODULE-V

Transmission of Air in Air Conditioning Ducts: Air Handling Unit (AHU) and its functions, need for transmission aspects of air in air conditioning, airflow through air conditioning ducts, Bernoulli and modified Bernoulli equations, Static, dynamic, datum and total head, Fan Total Pressure (FTP) and power input to fan, estimation of pressure loss through air conditioning ducts,, Estimation of frictional pressure drop of circular and rectangular ducts using friction charts and equations, Estimation of dynamic pressure drop in various types of fittings, Static regain, Important requirements of an air conditioning duct, General rules for duct design, Classification of duct systems, Commonly used duct design methods, Principle of velocity method, Principle of equal friction method, Principle of static regain method.
(8L)

Text book:

1. Arora, C.P., Refrigeration and Air Conditioning, 3rd ed., Tata McGraw-Hill, 2010.

Reference books:

1. W.F. Stoecker and J. W. Jones, Refrigeration and Air Conditioning, McGraw Hill, New Delhi,1986.
2. R. D. Dossat, Principle of Refrigeration, 4th ed., Prentice-Hall, 1997.
3. Manohar Prasad, Refrigeration and Air Conditioning, New Age International, 2004.
4. W. P. Jones, Air conditioning engineering. 5th edition, Elsevier Butterworth-Heinemann, 2001.
5. Hand Book of Air conditioning and Refrigeration by Shan k. Wang, Tata McGraw-Hill

Gaps in the syllabus (to meet Industry/Profession requirements)
Designing of refrigeration and air conditioning duct system

POs met through Gaps in the Syllabus
PO1 TO PO5

Topics beyond syllabus/Advanced topics/Design
Air mass system, Cooling and Heating Load Calculations through sun radiation

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

	Course Delivery methods
CD1	Lecture by use of boards/LCD projectors
CD2	Tutorials/Assignments
CD3	Seminars
CD4	Mini projects/Projects
CD5	Laboratory experiments/teaching aids
CD6	Industrial/guest lectures
CD7	Industrial visits/in-plant training
CD8	Self- learning such as use of NPTEL materials and internets

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	**Program Outcomes**				
	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	1	2	1	2	2
CO2	2	2	1	2	2
CO3	2	2	2	2	2
CO4	2	2	1	2	2
CO5	2	2	2	2	2

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcome	**Course Delivery Method**
CO1	CD1, CD2, CD3
CO2	CD1, CD2, CD3
CO3	CD1, CD2 CD3, CD7
CO4	CD1, CD2, CD3, CD8
CO5	CD1, CD2, CD3, CD8

COURSE INFORMATION SHEET

Course code: ME573
Course title: Design of Thermal Systems
Pre-requisite(s): Fluid Mechanics and Heat Transfer
Co- requisite(s):
Credits: 3 L: 3, T: 0, P: 0
Class schedule per week: 03
Class: M.Tech
Semester / Level: II/05
Branch: Mechanical Engineering (Heat Power Engineering)
Name of Teacher:

Course Objectives
This course enables the students:
The course is designed to give students the design concepts and fundamental aspects of industrial thermal system simulation and optimization. Examination of optimum design criteria, their application and scrutiny of engineering decision.

Course Outcomes
After the completion of this course, students will be:

CO1	Outline the thermal and material characteristics for selection of materials for thermal systems.
CO2	Select suitable mathematical and physical model for different thermal equipment.
CO3	Analyse numerical model for system simulation for accuracy and validation.
CO4	Evaluate performance of thermal systems using optimization technique.
CO5	Testing the thermal systems performance using neural network, fuzzy logic and genetic algorithm.

SYLLABUS

Module-1: FORMULATION OF DESIGN PROBLEM:

Engineering design, Design variables, Constraint or Limitation, Requirement and specifications, Conceptual design, Steps in design process, Material properties and thermal characteristics for thermal systems, Selection and substitution of materials.(9L)

Module-2: MODELLING OF THERMAL SYSTEMS:

Basic features of modelling, Types of Models, Mathematical modelling, Physical modelling, Modelling Thermal equipment. (8L)

Module-3: NUMERICAL MODELING AND SIMULATION:

Development of a numerical model, Modeling of individual components, Merging of different models, Accuracy and validation, System simulation, Dynamic simulation of lumped system and large system. (9L

Module-4: ACCEPTABLE DESIGN OF THERMAL SYSTEM:

Initial design, Design strategies, Application illustrations with suitable examples, Optimization of thermal systems. (7L)

Module-5: USE OF ARTIFICIAL INTELLIGENCE TECHNIQUES:

Neural network, Fuzzy logic and genetic algorithm in thermal systems design and optimization with examples, Introducing idea of knowledge-based design in thermal systems. (9L)

TEXT BOOKS:

1. Design and Optimization of Thermal Systems, Y. Jaluria, R.C Press, 2007.
2. Optimization in Engineering Design, K. Deb, Prentice Hall, 2002.
3. Design of Thermal Systems, W.F Stoecker, McGraw-Hill, 1971.

REFERENCE BOOKS:

1. Thermal Design and Optimization, Bejan, G. Tsatsaronis, M.J Moran, Wiley, 1996.
2. Design and Simulation of Thermal Systems, N.V. Suryanarayana, McGraw Hill, 2002.

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

POs met through Gaps in the Syllabus: PO1 TO PO5

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design: PO1 TO PO7

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

CD	Course Delivery methods
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Tutorials/Assignments
CD3	Seminars
CD4	Mini projects/Projects
CD5	Laboratory experiments/teaching aids
CD6	Industrial/guest lectures
CD7	Industrial visits/in-plant training
CD8	Self- learning such as use of NPTEL materials and internets
CD9	Simulation

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes				
	PO1	PO2	PO3	PO4	PO5
CO1	2	1	3	3	2
CO2	3	2	3	3	2
CO3	3	3	3	2	2
CO4	3	3	3	3	2
CO5	3	3	3	3	2

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

Mapping between Course Outcomes and Course Delivery method

Course Outcome	Course Delivery Method
CO1	CD1, CD2, CD3
CO2	CD1, CD2, CD3
CO3	CD1, CD2 CD3, CD7
CO4	CD1, CD2, CD3, CD8
CO5	CD1, CD2, CD3, CD8

COURSE INFORMATION SHEET

Course code: ME 574
Course title: Advanced Turbo-Machines
Pre-requisite(s): Fluid Mechanics, Hydraulic Machines, Thermodynamics
Co- requisite(s):
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:

1.	To present a comprehensive and rigorous treatment of classical turbomachinery while retaining an engineering perspective.
2.	To lay the groundwork for subsequent studies in such fields as analysis of various turbomachines and energy conversion systems and to prepare the students to effectively use Fluid mechanics and thermodynamics theory in the practice of turbomachinery in engineering.
3.	To develop an intuitive understanding of turbomachinery by emphasizing the engineering and engineering arguments.
4.	To present a wealth of real world engineering examples to give students a feel for how turbomachinery theories are applied in engineering practice.

Course Outcomes
After the completion of this course, students will be:

CO1	Outline the fluid mechanics, thermodynamics concepts, system of control volume, to turbomachines
CO2.	Apply the appropriate fundamental laws of fluid dynamics, thermodynamics to various turbomachines
CO3.	Analyse various turbomachines for energy transfer
CO4.	Evaluate the performance of various turbomachines components
CO5.	Create optimum aerodynamic design/geometrical dimension of simple, complex turbomachines components using conventional methods and modern tools.

SYLLABUS

Module 1

Introduction to turbomachines, classification of turbomachines, momentum, and moment of momentum theory applied to moving blades, change in total enthalpy and total pressure, velocity triangles for radial and axial flow turbomachines. Basic aerofoil theory applied to turbomachines, free , forced vortex and mean streamline theory, non-dimensional performance parameters, specific speed, flow coefficient and head coefficient. Concept of turbomachines design using modern tools like (T-AXI®, AxSTREAM®, CAESES®, VISTA®) as a design tools. (8L)

Module 2

Steam and gas turbines: Steam flow through nozzles, critical pressure ratio, and choking of nozzles, throat and exit areas for optimum discharge, impulse and reaction stage, flow of steam through turbine blades, velocity diagrams, stage and other efficiencies, condition for maximum efficiency of a single stage turbine, compounding of steam turbines. Axial flow gas turbines, stage losses, Soderbergs correlation, choice of reaction, pitch controlled blades, stress in turbine rotor blades, turbine characteristics and performance. (8L)

Module 3

Rotary Fans, Blowers and Compressors : Introduction,, centrifugal blower , types of vane shape , size and speed of machine, vane shape and efficiency, vane shape and stresses, vane shape and characteristics, actual performance characteristics, slip coefficient. Fan laws and characteristics, Centrifugal compressor, Performance of centrifugal compressors, compressibility and prewhirl, Axial flow compressor: compressor cascade, performance, axial-flow compressor performance, preheat in compressors, application of reversible rotary fan for ventilation and its performance. (8L)

Module 4

Hydraulic Turbines, hydraulic power utilization, hydrograph and water power, classification of water turbines, The Pelton wheel, velocity triangles, turbine efficiency and volumetric efficiency, working proportions of Pelton wheels , Francis and Deriaz turbines, velocity triangles and efficiencies, draft tube theory, cavitation, Propeller and Kaplan turbines, characteristics, application of aerofoil theory to propeller blades, design of Pelton, Francis and Kaplan turbine components. (8L)

Module 5

Centrifugal, Axial-Flow and Mixed flow pumps: Basic performance parameters, differential equations of the flow in a pump, flow kinematics in pumps, losses in pumps. Similarity laws of pumps, affinity laws, specific speed of a pumps, suction capability of pumps, cavitation in pumps, modeling of pumps, axial thrust and its balancing, radial thrust and its consequences, adjustment of pumps' work by changing of rotation speed and by swiveling of impeller's blades, Hydraulic design of a centrifugal, axial and mixed flow pumps, main dimensions' calculation, calculations of meridional cut and blade cuts of an impeller. (10L)

Text Books:

1. S. M. Yahya, Turbines, Compressors & Fans, Tata-McGraw Hill Co., 1983.
2. V. Kadambi and Manohar Prasad, An Introduction to energy conversion, Volume III - Turbo machinery, New Age International Publishers (P) Ltd., 2011.
3. D. G. Shepherd, Principles of Turbo Machinery, The Macmillan Company, 1956.

Reference Books:

1. S. L. Dixon and C. Hall, Fluid Mechanics and Thermodynamics of Turbomachinery, Elsevier, 1966.
2. William W Peng, Fundamentals of Turbomachinery, John Wiley & Sons, Inc., 2008.
3. M.S.Govindgouda & A.M.Nagaraj, A Text book of Turbomechanics-, -M.M.Publications.

Online Resources: http://nptel.ac.in/courses/112106200/18#
http://nptel.ac.in/courses/112106175/Module%204/Lecture%2034.pdf
http://nptel.ac.in/courses/Webcourse-contents/IIT-KANPUR/machine/ui/Course_home-1.htm
http://nptel.ac.in/downloads/101101058/

Gaps in the syllabus (to meet Industry/Profession requirements)
Detailed discussion on different testing procedure as per standards

POs met through Gaps in the Syllabus: PO (1-5)

Topics beyond syllabus/Advanced topics/Design
Use of CFD software to design turbomachine components.

POs met through Topics beyond syllabus/Advanced topics/Design: PO (1-5)

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

	Course Delivery methods
CD1	Lecture by use of boards/LCD projectors
CD2	Tutorials/Assignments
CD3	Seminars
CD4	Mini projects/Projects
CD5	Laboratory experiments/teaching aids
CD6	Industrial/guest lectures
CD7	Industrial visits/in-plant training
CD8	Self- learning such as use of NPTEL materials and internets

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	**Program Outcomes**				
	PO1	PO2	PO3	PO4	PO5
CO1	3	2	2	1	1
CO2	3	2	3	2	1
CO3	3	2	3	3	1
CO4	3	2	2	2	1
CO5	3	3	3	2	1

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

Mapping between Course Outcomes and Course Delivery method

Course Outcome	**Course Delivery Method**
CO1	CD1, CD2, CD3
CO2	CD1, CD2, CD3
CO3	CD1, CD2 CD3, CD7
CO4	CD1, CD2, CD3, CD8
CO5	CD1, CD2, CD3, CD8

COURSE INFORMATION SHEET

Course code: ME 579
Course title: Design and Analysis of Heat Exchangers
Pre-requisite(s): Heat and Mass Transfer.
Co- requisite(s):
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:

1.	To familiarize the students with the various applications of heat exchangers.
2.	To lay the groundwork for subsequent studies in construction, design, performance and testing of Heat Exchangers.

Course Outcomes
After the completion of this course, students will be:

CO1	Outline the physics of the Heat Exchangers.
CO2	Analyze the mathematical treatment of typical heat exchangers.
CO3	Apply LMTD methods in the design of heat exchangers and analyze the importance of LMTD approach over AMTD approach.
CO4	Evaluate the Effectiveness of the heat exchangers and analyze the performance of double-pipe counter flow (hair-pin) heat exchangers.
CO5	Design and analyze the shell and tube heat exchanger and classify cooling towers and explain their technical features.

SYLLABUS

MODULE 1

Introduction to Heat Exchangers: Definition, Applications, Various methods of classification of heat exchangers with examples. (7L)

MODULE 2

General Back-bone Equation for heat exchangers: Derivation from steady-state steady-flow considerations.

Mathematical treatment of Heat Exchangers: Concept of Overall Heat Transfer Coefficient, Derivation of the concerned equations, Fouling, Fouling Factor, Factors contributing to fouling of a heat exchanger, Effects of fouling. (8L)

MODULE 3

Logarithmic Mean Temperature Difference: Expression for the same for single pass parallel-flow and single-pass counter flow heat exchangers – Derivation from first principles, Special Cases, LMTD for a single-pass cross-flow heat exchanger – Nusselt's approach, Chart solutions of Bowman et al. pertaining to LMTD analysis for various kinds of heat exchangers, Arithmetic Mean Temperature Difference [AMTD], Relation between AMTD and LMTD, Logical Contrast between AMTD and LMTD, LMTD of a single-pass heat exchanger with linearly varying overall heat transfer coefficient [U] along the length of the heat exchanger. (9L)

MODULE 4

Hair-Pin Heat Exchangers: Introduction to Counter-flow Double-pipe or Hair-Pin heat exchangers, Industrial versions of the same, Film coefficients in tubes and annuli, Pressure drop, Augmentation of performance of hair-pin heat exchangers, Series and Series-Parallel arrangements of hair-pin heat exchangers, Comprehensive Design Algorithm for hair-pin heat exchangers.

Effectiveness: Effectiveness-Number of Transfer Units Approach, Derivations of expressions for effectiveness of single-pass parallel-flow and counter-flow heat exchangers, Physical significance of NTU, Heat capacity ratio, Different special cases of the above approach, Chart solutions of Kays and London pertaining to Effectiveness-NTU approach.(9L)

MODULE 5

Optimum Design: Criteria for optimisation of heat exchangers, constraints, feasible and optimum design, optimization based on volume, weight, cost, entropy generation and thermoeconomics; Brief introduction to some traditional and non-traditional optimisation techniques. (9L)

Text books:

1. Donald Q. Kern, Process Heat Transfer, McGraw – Hill, New York (1983).
2. F. P. Incropera and D. P De Witt, Fundamentals of Heat and Mass Transfer John Wiley and Sons, New York (2012).

Reference books:

1. W.M. Kays and A.L. London, Compact Heat Exchangers McGraw-Hill, NewYork (1964).
2. W. M. Rosenhow, J. P. Hartnett and Y. I. Cho, Handbook of Heat Transfer by McGraw Hill (1997).

Gaps in the syllabus (to meet Industry/Profession requirements):
Micro-channel heat exchangers

POs met through Gaps in the Syllabus : PO1-5

Topics beyond syllabus/Advanced topics/Design
Design and application of Micro-channel Heat exchangers

POs met through Topics beyond syllabus/Advanced topics/Design: PO1-5

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

	Course Delivery methods
CD1	Lecture by use of boards/LCD projectors
CD2	Tutorials/Assignments
CD3	Seminars
CD4	Mini projects/Projects
CD5	Laboratory experiments/teaching aids
CD6	Industrial/guest lectures
CD7	Industrial visits/in-plant training
CD8	Self- learning such as use of NPTEL materials and internets

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes				
	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	2	1
CO2	3	3	3	3	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 Outcome	Course Delivery Method
CO1	CD1, CD2, CD3
CO2	CD1, CD2, CD3
CO3	CD1, CD2 CD3, CD7
CO4	CD1, CD2, CD3, CD8
CO5	CD1, CD2, CD3, CD8

COURSE INFORMATION SHEET

Course code: ME 595
Course title: Thermo-Fluids Lab
Pre-Requisite: B.Tech Thermodynamics, Fluid Mechanics
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 demonstrate the basic phenomenon of heat transfer and fluid flow, to interpret the experimental results in a logical manner, to develop innovative methodologies of solving thermo-fluid problems and to compose precautionary measures while dealing with fluid flow and heat transfer equipment and problems.

Course Outcomes

After the completion of this course, students will be able to:

CO1.	Apply and demonstrate the basic laws of heat transfer and fluid flow under different modes/conditions.
CO2.	Analyze problems involving steady state heat-flow transfer.
CO3.	Evaluate heat and fluid flow coefficients under difference modes/conditions.
CO4.	Analyze the output generated from the thermo-fluid equipments for fruitful conclusions.
CO5.	Assess the importance of thermo-fluids experiments so as to solve the engineering problems.

List of Experiments

1. To determine the convective heat transfer coefficient during cooling of a hot tube in a tube bank undercross flow of air.
2. To demonstrate (i) the effect of constant current source and constant voltage source on temperature measurement by resistance change of a PRT or RTD and (ii) the effect of two, three and four wire connection on temperature measurement in PRT or RTD.
3. To verify Stefan-Boltzmann law and then to determine emissivity of a non-black surface.
4. To determine the characteristic curve of Peltier element and to find out its cooling and heating capacity and the coefficient of performance of Peltier device
5. To demonstrate the effect of the air flow rate in the humidity measurement under humidifying and dehumidifying processes.
6. To determine the thermal conductivity of a liquid by air calibration method.
7. To calibrate a subsonic wind tunnel.
8. To draw the velocity profile with the boundary layer over a flat plate and to determine boundary layer thickness using a subsonic wind tunnel.
9. To measure pressure distributions around an airfoil using a subsonic wind tunnel.
10. To measure the drag and lift of an aerofoil at various angle of attack using a subsonic wind tunnel.
11. To visualize the wake behind a circular cylinder using water tunnel.

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	**Program Outcomes**				
	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3	3	3	2	2
CO2	3	3	3	2	2
CO3	3	3	3	2	2
CO4	3	3	3	2	2
CO5	3	3	3	2	2

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

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
Day to day performance & Lab files	30
Quiz (es)	10
Viva	10

Semester End Examination	% Distribution
Examination Experiment Performance	30
Quiz	20

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	Industrial visits/in-plant training

Mapping between Course Outcomes and Course Delivery method

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

COURSE INFORMATION SHEET

Course code: ME 596
Course title: Thermal Engineering Lab
Pre-requisite(s): B.Tech Thermodynamics, IC Engines
Co- requisite(s):
Credits: 2 L: 0 T:O P: 4
Class schedule per week: 04
Class: M. Tech
Semester *I* Level: II/05
Branch: Mechanical Engineering
Name of Teacher:

Course Objectives

This course enables the students to:

1	Be familiar with various types of Internal Combustion Engines, different measurement systems, refrigeration system fuel cell and solar thermal equipment
2	Be confident on how to perform experiments related Internal Combustion Engines, different measurement systems, refrigeration system fuel cell and solar thermal equipment.
3	Study performance characteristics of various I.C. Engines, refrigeration systems fuel cell and solar thermal equipment.

Course Outcomes

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

CO l.	Understand the procedure to conduct experiments related to Internal Combustion Engines, different measurement systems, refrigeration system, fuel cell and solar thermal equipment.
CO2	Interpreting various parameters influence the performance of the Internal Combustion Engines, refrigeration and solar energy equipment
CO3.	Analyze the observations made through experiments
CO4.	Apply the experimental knowledge how to perform the experiments in different manner.
CO5.	Predicting the sources of errors and minimizing them in the experiments

List of experiments:

Experiment 1: Performance study and analysis of Combustion characteristics (P-9) diagram of 3-cylinder, 4-stroke M.P.F.I. petrol engine.

Experiment 2: Performance study with bended fuel on Mahindra 4-cylinder, 4-stroke Diesel engine.

Experiment 3: Analysis of exhaust gas emission on Diesel and Petrol Engine using AVL gas analysis.

Experiment 4: Performance evaluation of vapour absorption refrigeration system.

Experiment 5: Performance evaluation of variable load refrigeration rig at different flow rate of refrigerant and evaporator temperature.

Experiment 6: Performance evaluation of Peltier element at different flow rate of water in cooling and heating side of heat exchanger

Experiment 7: Characteristics of fuel cell with the help of resistive load or DC-DC converter

Experiment 8: To demonstrate the 1-V and P-V characteristics of PV module with varying radiation and temperature level.

Experiment 9: To demonstrate the 1-V and P-V characteristics of series and parallel combination of PV module.

Experiment 10: Performance study of thermos siphon type solar water heater.

Experiment 11: Output power variation of fuel cell with change in Hydrogen supply

Experiment 12: Evaluate Fuel cell system performance with only DC load connected to the charge controller with battery bank

EVALUATION PROCEDURE

Direct Assessment

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

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

Semester End Examination	%
Examination Experiment Performance	30
Quiz	20

Assessment Components	COl	C02	C03	C04	COS
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment-

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

Course Delivery Methods

CDl	Lecture by use of boards projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CDS	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	POl	P02	P03	P04	PO5
COl	3	3	2	2	2
C02	3	3	2	2	2
C03	3	3	2	2	2
C04	3	3	2	2	2
COS	3	3	2	2	2

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
COl	CD1,CD3,CD6
C02	CDl,CD3,CD6
C03	CDl,CD3,CD6
C04	CD1,CD3,CD6
CO5	CDl,CD3,CD6

(Specialization: Energy Technology)

COURSE INFORMATION SHEET

Course code: ME542
Course title: Fuel Technology
Pre-requisite(s): B.Tech Thermodynamics
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.	Present a comprehensive and rigorous study of fuel while retaining an engineering perspective.
2.	Lay the groundwork for subsequent studies in such fields as coal, petroleum and to prepare the students to effectively use fuel in the practice of engineering.
3.	Develop an intuitive understanding of fuel technology by emphasizing the physics and physical arguments.

Course Outcomes

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

CO1.	Classify various type of fuel.
CO2.	Analyze coal from technical prospective.
CO3.	Examine the liquid fuel extraction methods.
CO4.	Explain the production methodology of gaseous fuels
CO5.	Analyse various nuclear fuels.

SYLLABUS

Module 1: INTRODUCTION TO FUEL

Different fuel energy resources, it's Indian and global perspective, Classification of Solid, liquid and gaseous fuels, Combustion appliances for solid, liquid and gaseous fuels. (8L)

Module 2: ORIGIN AND FORMATION OF COAL

Different theories on coal formation, Coal as a source of energy and chemicals in India, Coal preparation, Carbonization, Gasification and liquefaction of coal and lignite, Fundamentals of coal combustion, combustion stoichiometry, Flue gas composition, Fundamentals of coal gasification, producer gas, water gas. (8L)

Module 3: EXTRACTION OF LIQUID FUELS

Petroleum and its derived products, Petroleum refining processes, Interconversion of fuels, Liquid fuel resources, world and Indian statistics, methods for characterization of crude oil and its products, refinery operations, testing of liquid fuels, industrial process design, utilization of petroleum products, synthetic liquid fuels. (8L)

Module 4: PRODUCTION OF GASEOUS FUELS

Natural gases and its derivatives, sources, potential, Gas hydrates Different types of gaseous fuels and its resources and their characteristics, principles of manufacturing of gaseous fuels from coal and oil, kinetics and mechanism of gasification, production of industrial fuel gases, rich gases such as SNG, purification, storage and transportation of gaseous fuels. (8L)

Module 5: NUCLEAR FUELS

Oxide fuel, Metal fuel, Ceramic fuel, liquid fuel, Refused-derived fuel, Bio-fuels: Biomass, Algae, biodiesel, Alcohol Fuels: Methanol, Ethanol, Butanol, Propane, etc.
(8L)

Text Books

1. J.G. Speight and B. Ozum, Petroleum Refining Process, CRC Press, 2009.
2. J. G. Speight, The Chemistry and Technology of Coal, CRC Press, 2013.

Reference Books

1. F. Peter, Fuels and Fuel Technology, Wheaten & Co. Ltd., 1st edition, 1965.
2. S. Sarkar, Fuels and Combustion, Orient Longman, 2nd edition, 1990.
3. J. G. Speight, The chemistry & Technology of Petroleum, 4th edition, CRC Press, 2006.

4. Ke Liu, C. Song and V. Subramani, Hydrogen and Syngas Production and Purification Technologies, John Wiley & Sons, 2010

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

Gaps in the syllabus (to meet Industry/Profession requirements) :
Clean Coal technology
POs met through Gaps in the Syllabus: **PO3**

Topics beyond syllabus/Advanced topics/Design:
Advance nuclear 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	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: ME 543
Course title: Energy Conversion System
Pre-requisite(s): B. Tech Thermodynamics
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.	Critically examine the technology of energy systems that will be acceptable in a world faced with global warming, local pollution, and declining supplies of oil.
2.	Focus on renewable energy sources and other non-carbon/reduced-carbon emitting sources.
3.	Analyse both the devices and the overall systems are analyzed.

Course Outcomes

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

CO1.	Analyze the solar thermal conversion system.
CO2.	Evaluate the solar thermal conversion systems for high temperature applications.
CO3.	Analyze the Photovoltaic & Bio-Energy Conversion Systems
CO4.	Design the Fuel cells.
CO5.	Examine various Electric Energy Conversion Systems.

SYLLABUS

Module 1: SOLAR THERMAL CONVERSION SYSTEM

Relevance of solar thermal power generation; Components of solar thermal power plant, Design and performance, characteristics of different solar concentrator types suitable for thermal power generation. (8L)

Module 2: SOLAR THERMAL CONVERSION SYSTEM FOR HIGH TEMPERATURE APPLICATIONS

Types of solar thermal conversion system used in high temperature application, Tracking of solar concentrators; performance characterization of solar concentrators both line focus and point focus, Comparative analysis of the both mode focus system, Optical design and concentration characteristics of line and point focus based system. (8L)

Module 3: THERMAL ENERGY CONVERSION & BIO-ENERGY CONVERSION SYSTEMS:

Thermo-electric generator, Concepts and design considerations of MHD generators, Cycle analysis of MHD systems, Thermionic power conversion and plasma diodes, Thermo chemical Conversion. Bio-energy conversion, bio methanation technology, Thermo chemical conversions. . (8L)

Module 4: FUEL CELL TECHNOLOGY

Overview of fuel cells, Fuel cell thermodynamics, fuel cell efficiency, Fuel cell characterization, Fuel cell modelling and system integration, Balance of plant, Hydrogen production from renewable sources and storage, life cycle analysis of fuel cells. (8L)

Module 5: ELECTRIC ENERGY CONVERSION SYSTEM

Generation of electricity using different sources, Transmission and distribution losses, AC to DC and DC to AC conversions, Electric motors: Types, losses, efficiency, Lightning systems, Diesel generating systems. (8L)

Text Books

1. S. S. L. Chang, Energy Conversion, Prentice Hall, 1963.
2. S. W. Angrist, Direct Energy Conversion, Pearson, 1982.
3. R. J. Rosa, Magneto hydrodynamic Energy Conversion, Springer, 1987.
4. V. S. Bagotsky, Fuel Cell Problems and Solutions, John Wiley & Sons, 2009.

Reference Books

1. Kettani, M.A., Direct energy conversion, Addison-Wesley, Reading, Mass, 1970
2. Green M.A., Solar Cells, Prentice-Hall, Englewood Cliffs, 1982

3. Hand book Batteries and Fuel Cells. Linden, McGraw Hill, 1984.

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

Gaps in the syllabus (to meet Industry/Profession requirements) :
Cost reduction in the fuel cell technology
POs met through Gaps in the Syllabus: **PO3**

Topics beyond syllabus/Advanced topics/Design:
Advance energy conversion process
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	2	-	2
CO2	1	2	3	-	2
CO3	1	2	2	-	2
CO4	1	2	2	-	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: ME544
Course title: Wind Energy
Pre-requisite(s): Basic of Physics 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.	Understand the technologies that are used to harness the power of the wind.
2.	Develop an intuitive understanding of wind turbine design criterion and its conversion system.
3.	Discuss the positive and negative aspects of wind energy in relation to natural and human aspects of the environment.

Course Outcomes

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

CO1.	Explain the existing wind energy potential.
CO2.	Analyze the various aerodynamic loads and its design criterion on wind turbine system.
CO3.	Describe the existing Wind Energy Conversion System.
CO4.	Analyze the control mechanism of wind turbine.
CO5.	Understand the application of wind energy with case studies and its environmental impacts.

SYLLABUS

Module 1: BASICS OF WIND ENERGY TECHNOLOGY

Wind statistics- Measurements and data Presentation, Historical developments, latest developments, state of art of wind energy technology, turbine rating, economic analysis of wind turbine, Indian scenario and worldwide developments, present status and future trends. Wind turbine aerodynamics. (8L)

Module 2: CHARACTERISTICS OF WIND ENERGY

Nature of atmospheric winds- Wind resource characteristics and assessment– Anemometry, speed frequency distribution, effect of height, wind rose, Weibull distribution, atmospheric turbulence, gust wind speed, effect of topography. effect of Reynolds's number, actuator disc, Betz coefficient, design of wind turbine blade, effect of stall and blade tip speed ratio and coefficient of torque. (8L)

Module 3: WIND ENERGY CONVERSION SYSTEM (WECS)

Rotor Selection, Annual Energy Output, HAWT, VAWT, Rotor Design Considerations-Number of Blades, Blade Profile -2/3 Blades and Teetering, Coning- Upwind/Downwind, Power Regulation, Yaw System- Tower, Synchronous and Asynchronous Generators and Loads, Integration of Wind Energy Converters to Electrical Networks, Inverters- Testing of WECS, WECS Control System - Requirements and Strategies. . (8L)

Module 4: CONTROL MECHANISMS

Pitch control, yaw control, Electrical and Mechanical aerodynamic braking, teeter mechanism. Wind turbine dynamics with DC and AC generators: induction and synchronous generators, variable speed operation, effect of wind turbulence. Case study of design of wind mill. (8L)

Module 5: WIND ENERGY APPLICATION

Wind pumps - Performance analysis, design concept and testing, Principle of WEG- Stand alone, grid connected and hybrid applications of WECS, Economics of wind energy utilization, Wind energy in India- Case studies, environmental impacts of wind farms. (8L)

Text Books

1. Steve Parker, "Wind power", Gareth Stevens Publishing, 2004.
2. Freris L.L., Wind Energy Conversion Systems, Prentice Hall 1990.
3. Spera D.A., Wind Turbine Technology: Fundamental Concepts of Wind Turbine Engineering, ASME Press, NY 1994.

Reference books

1. Wind Energy Engineering *Trevor M. Letcher* ISBN: 978-0-12-809451-8
2. Paul Gipe, “Wind Energy Comes of Age”, John Wiley & Sons Inc., 2000.
3. Tony Burton, Nick Jenkins, David Sharpe, Ervin Bossanyi, “Wind Energy Handbook”, 2nd ed., John Wiley & Sons, 2011.
4. Paul A Lin, “Onshore and offshore wind energy”, Wiley, 2011.

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

Gaps in the syllabus (to meet Industry/Profession requirements) :
Modelling of wind turbine
POs met through Gaps in the Syllabus: **PO3**

Topics beyond syllabus/Advanced topics/Design:
New materials for the wind turbine blade
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: ME545
Course title: Solar Passive Architecture
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.	Present a comprehensive and rigorous study of Solar passive architecture while retaining an engineering perspective.
2.	Lay the groundwork for subsequent studies in such fields as solar passive architecture and to prepare the students to effectively use solar passive architecture in the practice of engineering.
3.	Develop an intuitive understanding of fuel technology by emphasizing the physics and physical arguments.

Course Outcomes

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

CO1.	Outline the need of solar passive architecture.
CO2.	Explain the passive solar heating of buildings
CO3.	Discuss the passive solar cooling of the building
CO4.	Explain the Climate And Human Thermal Comfort
CO5.	Point out the building rating systems

SYLLABUS

Module 1: INTRODUCTION

Need for passive architecture - Building form and functions – General aspects of solar passive heating and cooling of buildings – Thumb rules - Thermal comfort – Sun's motion - Building orientation and design – Heat transfer in buildings. (8L)

Module 2: PASSIVE SOLAR HEATING OF BUILDINGS

Direct gain – Indirect gain – Isolated gain - Passive heating concept - Thermal modeling of passive concepts – Thermal storage wall and roof – Sunspace – Prediction of heating loads in a building. . (8L)

Module 3: PASSIVE COOLING OF BUILDINGS

Passive cooling concept - Solarium Passive cooling - Ventilation cooling - Nocturnal radiation cooling -Evaporative cooling - Roof surface evaporative cooling (RSEC) - Direct evaporative cooling using drip-type (desert) coolers – Radiation cooling - Earth coupling - Basic principles and systems. . . (8L)

Module 4.: CLIMATE AND HUMAN THERMAL COMFORT

Factors affecting climate - Climatic zones and their characteristics - Urban climate - Microclimate - Implications of climate on building design - Principles of energy conscious design - Building materials - Embodied energy of building materials - Alternative building materials (8L)

Module 5: BUILDING RATING SYSTEMS

Zero energy building concept and rating systems - Energy conservation building codes – Energy management of buildings – Green globe assessment Standards –BREEAM – CASBEE – Green star–Review of CDM Techniques - GRIHA and others (8L)

Text Books

1. Jan F. Kreider, The solar heating design process: active and passive systems, McGraw-Hill, 2007.
2. David A. Bainbridge, Ken Haggard, Kenneth L. Haggard, Passive Solar Architecture: Heating, Cooling, Ventilation, Daylighting, and More Using Natural Flows, Chelsea Green Publishing, 2011.
3. N.K. Bansal, G. Hauser, G. Minke. Passive Building Design: A Handbook of Natural Climatic Control. . Elsevier Science. 1994.

Reference Books

1. HP Garg and J Prakash: Solar Energy: Fundamentals and Applications, Tata McGraw Hill, 2010.
2. Tom P. Hough, Trends in Solar Energy Research, Nova Publishers, 2006.
3. Source Wikipedia, Books LIc, Solar Architecture: Passive Solar Building Design,

Active Solar, Daylighting, Passive House, Cool Roof, Earthship, Solar Air Conditioning, General Books LLC, 2010.
4. JA Duffie and WA Beckman: Solar Engineering of Thermal Processes, Third Edition, John Wiley & Sons, 2006.
5. S Sukhatme and J Nayak: Solar Energy: Principles of Thermal Collection and Storage, Third Edition, Tata McGraw Hill, 2008.

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

Gaps in the syllabus (to meet Industry/Profession requirements) :
Low cost solar passive heating and cooling
POs met through Gaps in the Syllabus: **PO3**

Topics beyond syllabus/Advanced topics/Design:
Modelling of Solar passive architecture
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: ME546
Course title: Hydrogen Energy System
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.	Provide comprehensive and logical knowledge of hydrogen production, storage and utilization.
2.	Develop skills in critical thinking and reasoning about issues associated with hydrogen fuel.
3.	Understand hydrogen generation techniques and hydrogen economy.
4.	Emphasize on the hydrogen energy safety techniques.

Course Outcomes

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

CO1.	Demonstrate the basic concepts of Hydrogen Energy.
CO2.	Illustrate the various hydrogen storage & transportation techniques.
CO3.	Examine the usage of Hydrogen Energy in various day to day applications.
CO4.	Usage of Hydrogen Energy in Advanced Applications.
CO5.	Analyze the safety issues related to use of hydrogen as fuel.

SYLLABUS

Module 1: HYDROGEN PROPERTIES AND PRODUCTION PROCESSES

Physical and Chemical properties of hydrogen. Production from fossil fuels, Steam, water. Advanced production methods- production using nuclear energy and renewable, photochemical, photocatalytic, hybrid, etc. (8L)

Module 2: HYDROGEN STORAGE, HANDLING & TRANSPORTATION

Storage Technologies, Compressed hydrogen, Cryo-adsorption, Liquid hydrogen, Slush hydrogen, Underground hydrogen storage, Hydrogen tank, Automotive Onboard hydrogen storage, Hydrogen transportation methods, Challenges associated with hydrogen transport. (8L)

Module 3: HYDROGEN UTILIZATION

I.C. Engines, power plant, gas turbines, hydrogen burners, domestic and marine applications, durability studies, field trials and effect on environment, Current use scenario, eco-friendly nature. . . (8L)

Module 4: ADVANCED TECHNOLOGIES

Fuel cells, Hydrogen Vehicles, Hydrogen Powered Cars, Hydrogen Powered planes, Hydrogen powered rockets. (8L)

Module 5: HYDROGEN SAFETY

History of accident, Safety barrier diagram, Hydrogen safety codes and standards, Hydrogen sensing, risk analysis, safety in handling, safety management. Hazard spotting and evaluation. . (8L)

Text Books

1. M. Ball and M. Wietschel, The Hydrogen Economy Opportunities and Challenges, Cambridge University Press, 2009
2. Ram B. Gupta, Hydrogen Fuel: Production, Transport, and Storage, CRC Press-Taylor & Francis, 2008
3. Peschka, Walter, Liquid hydrogen: fuel of the future, Springer-Verlag Wien, 1992.
4. Kenneth D., Jr.; Edeskuty, F. J. Williamson, Recent Developments in Hydrogen Technology, CRC Press, 1986.

Reference Books

1. M.K.G. Babu, K.A. Subramanian, Alternative Transportation Fuels: Utilization in Combustion Engines, CRC Press, 2013
2. Kazunari Sasaki et al. Hydrogen Energy Engineering: A Japanese Perspective-Springer, 2016

3. David Anthony James Rand, Ronald Dell, Hydrogen Energy: Challenges and Prospects, RSC Publishers, 2008

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

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

Topics beyond syllabus/Advanced topics/Design:
Modelling of the hydrogen energy storage 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: ME550
Course title: Bioconversion and Processing of Waste
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 Objective:

1	To give an idea about different biomass and other solid waste materials as energy source
2	To give an idea about processing and utilization for recovery of energy and other valuable products.
3	To give comprehensive knowledge of how wastes are utilized for recovery.

Course Outcome:

CO1	Explain the fundamentals of bioconversion and processing of waste
CO2	Analyze the various biological conversion methodologies
CO3	Analyze the different types conversion methodologies
CO4	Explain the various waste processing method.
CO5	Estimate the economics aspect in the bioconversion and waste processing

Syllabus

Module 1:

Introduction: Biomass and solid wastes, Broad classification, Sources of Bio mass, Production of biomass, biomass yield comparison, photosynthesis, world scenario, Environmental effects.

(8)

Module 2:

Biological Conversion: Biodegradation and biodegradability of substrate - Biochemistry and process parameters of biomethanation - Biomethanation Process - Bioconversion of substrates into alcohol - Methanol & ethanol Production - Organic acids – Solvents - Amino acids - ntibiotics etc, agro chemical conversion.

(8)

Module 3:
Other Conversions: Thermo chemical conversion of biomass, conversion to solid, liquid and gaseous fuels, pyrolysis, gasification, combustion, Enzymatic Fermentation, Gas/liquid Fermentation, Acid hydrolysis and hydrogenation. (8)
Module 4:

Waste processing: Separation of components of solid wastes, handling and processing techniques, composting technique, recycling, Agro and forestry residues utilization through conversion routes, Use of biodegradable waste. (8)

Module 5:

Design and Economics: Economics of biogas plant with their environmental and social impacts, Biogas digester types - Digester design and biogas utilization, Fuel conversion into electricity, Climate change Impact, case studies, Conversion of municipal waste into petrol.

(8)

TEXT BOOKS:

1.S.Samir, R.Zaborsky, Biomass Conversion Processes for Energy and Fuels, New York, Plenum Press, 1981.
2.H.D.Joseph, P.Joseph, H.John, Solid Waste Management, New York, Van Nostrand, 1973.
3.Jianzhong Sun et al. Biological Conversion of Biomass for Fuels and Chemicals:Explorations from Natural Utilization Systems (Energy and Environment Series), RSC Publishing, 2013.

REFERENCE BOOKS:

1.G.Tchobanoglous, H.Theisen, S.V.Tchobanoglous, G.Theisen, H.V.Samuel, Integrated Solid Waste management: Engineering Principles and Management issues, New York, McGraw Hill, 1993.

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

Gaps in the syllabus (to meet Industry/Profession requirements) :
Case study on bioconversion and waste processing in industry

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

Topics beyond syllabus/Advanced topics/Design:
System modelling of the waste processing unit.
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
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	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, 34-66% = 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: ME551
Course title: Solar Photovoltaic System
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: III /06
Branch: Mechanical Engineering
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Introduce students to the various aspects of PV technologies.
2.	Enable students to understand the working principle of Photovoltaic Solar Cells.
3.	Make students familiar about the different solar cell technologies.
4.	Emphasize about the different materials and recent advances in Solar PV technology.
5.	Develop understanding of solar PV systems in power generation.

Course Outcomes

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

CO1.	Demonstrate the basic concepts of Photovoltaic Cells.
CO2.	Illustrate the working principles of Photovoltaic Solar Cells.
CO3.	Analyze the different Solar Cell Technologies.
CO4.	Compare the current research fields in Solar Photovoltaic.
CO5.	Design the Solar PV Systems.

SYLLABUS

Module 1: FUNDAMENTALS OF PHOTOVOLTAIC CELLS

Solar cell working, General Types, Testing of Solar cells, Materials used for manufacturing, manufacturing processes involved for fabrication, Decreasing cost of PV cells, present scenario, Solar cells, modules, panels and systems. (8L)

Module 2: PHOTOVOLTAIC CELLS WORKING

Review of semiconductor physics and Operating principle, Design of solar cells-Cell parameters limits, Losses in solar cells, Solar cell design for high Isc, Voc and FF, PV device characterization. Factors affecting the efficiency of solar cell, Strategies to enhance the efficiency of solar cell. Environmental effects of Photovoltaic. (8L)

Module 3: SOLAR CELL TECHNOLOGIES

First, Second and Third Generation PV Silicon based technologies. Manufacturing processes (wafer, cell and module) for Solar cells. Concept of multi-junction or tandem cells, concentrating technologies, Optics for concentrators, PV-Tracking Requirements, High concentrator solar cells. (8L)

Module 4: RECENT ADVANCES

Emerging solar cell technologies (Organic PV, Hetero junction with intrinsic thin film – HIT - Quantum dots - Dye Sensitized Solar cell - Perovskite solar cells etc). (8L)

Module 5: PV MODULE AND PV SYSTEM APPLICATIONS

Solar PV system, Batteries for PV systems -DC to DC and DC to AC converters-charge controllers, stand alone, hybrid and grid connected system, Standalone PV systems (Lighting, Water Pumping etc.), Design methodology of PV off grid and grid connected systems, Load estimation and System Sizing, Design of roof top solar PV power plants. (8L)

Text Books

1. Mertens K. ,2013, Photovoltaics: Fundamentals, Technology and Practice, Wiley
2. Solanki C. S. ,2009, Solar Photovoltaics: Fundamentals, Technologies and Applications, Prentice Hall India

Reference Books

1. Mukerjee A. K. and Thakur N. ,2011, Photovoltaic systems: analysis and design, PHI
2. V Barbec, V.Dyakonov, J. Parisi, N.S. Saricifttci, 2003, Organic photovoltaics: Concepts and realization, Springer Verlag
3. Tiwari G N, 2012, Solar Energy: Fundamentals, Design, Modelling and Application

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

Gaps in the syllabus (to meet Industry/Profession requirements) :
Cost effective improved solar photovoltaic system
POs met through Gaps in the Syllabus: **PO3**

Topics beyond syllabus/Advanced topics/Design:
Improved modelling of the solar photovoltaic 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	-	2	2	-	2
CO2	2	2	2	-	2
CO3	-	2	3	-	2
CO4	-	2	3	-	2
CO5	2	2	2	-	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: ME554
Course title: Energy Management and Auditing
Pre-requisite(s): B. Tech 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.	Present a problem oriented 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 of 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 equipments and 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, 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	3	-	2
CO2	1	2	3	-	2
CO3	1	2	3	-	2
CO4	-	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: ME555
Course title: Energy Storage Technology
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: II /05
Branch: Mechanical Engineering
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Present a comprehensive and rigorous study of energy storage technology while retaining an engineering perspective.
2.	Lay the groundwork for subsequent studies in such fields as thermal energy storage, electrochemical energy storage, magnetic and electric energy storage systems and to prepare the students to effectively use energy storage in the practice of engineering.
3.	Develop an intuitive understanding of energy storage technology by emphasizing the physics and physical arguments.

Course Outcomes

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

CO1.	Outline the various type of energy storage system.
CO2.	Analyze the electrochemical energy storage systems.
CO3.	Examine the magnetic and electric energy storage systems.
CO4.	Explain the sensible heat thermal energy storage
CO5.	Estimation of latent heat thermal energy storage.

SYLLABUS

Module 1: ENERGY STORAGE

Need of energy storage, Different modes of Energy Storage. Potential energy: Pumped hydro storage; KE and Compressed gas system: Flywheel storage, compressed air energy storage; Electrical and magnetic energy storage: Capacitors, electromagnets; Chemical Energy storage: Thermo-chemical, photo-chemical, bio-chemical, electro-chemical, fossil fuels and synthetic fuels. Hydrogen for energy storage. Solar Ponds for energy storage. (8L)

Module 2: ELECTROCHEMICAL ENERGY STORAGE SYSTEMS

Batteries: Primary, Secondary, Lithium, Solid-state and molten solvent batteries; Lead acid batteries; Nickel Cadmium Batteries; Advanced Batteries. Role of carbon Nano-tubes in electrodes. (8L)

Module 3: MAGNETIC AND ELECTRIC ENERGY STORAGE SYSTEMS

Superconducting Magnet Energy Storage (SMES) systems; Capacitor and Batteries: Comparison and application; Super capacitor: Electrochemical Double Layer Capacitor (EDLC), principle of working, structure, performance and application, role of activated carbon and carbon Nano-tube. (8L)

Module 4: SENSIBLE HEAT THERMAL ENERGY STORAGE

SHS mediums; Stratified storage systems; Rock-bed storage systems; Thermal storage in buildings; Earth storage; Energy storage in aquifers; Heat storage in SHS systems; Aquifers storage. (8L)

Module 5: LATENT HEAT THERMAL ENERGY STORAGE

Phase Change Materials (PCMs); Selection criteria of PCMs; Stefan problem; Solar thermal LHTES systems; Energy conservation through LHTES systems; LHTES systems in refrigeration and air-conditioning systems; Enthalpy formulation; Numerical heat transfer in melting and freezing process. (8L)

Text Books

1. Robert, Huggins. Energy Storage: Fundamentals, Materials and Applications. Springer Press 2016.
2. Richard Baxter. Energy storage. PennWell Corp. (September 10, 2005). Elsevier

Reference Books

1. Ahmed Zobaa, Energy storage: technologies and applications. Intech Open, 2014
2. David Elliott. Energy Storage Systems. IOP Publishing, Bristol, UK 2014

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

Gaps in the syllabus (to meet Industry/Profession requirements) :
Energy Storage application for Grid application
POs met through Gaps in the Syllabus: **PO3**

Topics beyond syllabus/Advanced topics/Design:
Advance energy storage 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	-	2	3	-	2
CO2	1	2	3	-	2
CO3	1	2	3	-	2
CO4	-	2	3	-	2
CO5	-	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 576
Course title: Advanced Energy Technology
Pre-requisite(s): Thermodynamics
Co- requisite(s):
Credits: 3 L:3, T: 0, P: 0
Class schedule per week: 03
Class: M. Tech
Semester / Level: II/05
Branch: Mechanical Engineering (Heat Power Engineering)
Name of Teacher:

Course Objectives

This course enables the students:

1.	To provide basic knowledge of combined and cogeneration power cycle used for integrated power generation.
2.	To give the student knowledge and understanding of the principles involved in modern, developing and emerging forms of energy conversion and storage systems.
3.	The course provides knowledge to the thermal engineering student the rational use of energy and energy Efficient systems which can results in significant reductions in energy consumption.

Course Outcomes

After the completion of this course, students will be:

CO1	Understand the working principle of combined and cogeneration power cycle used for integrated power generation.
CO2	Understand different advanced energy storage systems.
CO3	Apply different methods for production and applications of hydrogen energy and coal gas.
CO4	Analyse economic and environmental aspects of energy conservation in power plants and waste heat recovery.
CO5	Evaluating the performance characteristics and relative efficiency of fuel cells.

SYLLABUS

Module 1: Total energy system for industry, Integrated gasification combined cycle plant, combined cycle power plant with cogeneration, fuels for combined cycle power plants. Natural gas cycles, Integrated power generation. Cogeneration principles. (10L)

Module 2: Advanced energy storage systems – Mechanical energy storage, chemical energy storage, Electromagnetic energy storage, electrostatic energy storage, Thermal energy storage and biological storage. (7L)

Module 3: Hydrogen Energy – Properties of hydrogen; hydrogen production – Thermo-chemical methods, Electrolysis of water, thermolysis of water and biophotolysis; Storage of hydrogen, delivery, conversion, applications and safety issues, present status. (7L)

Module 4: Clean Coal technologies – Coal washing, gasification etc., application of coal gas in heat engines and gas turbines, Pressurized fluidized bed combustion. Coal bed methane. Energy conservation opportunities in power plants, economic and environmental aspects of energy conservation in power plants, economic load sharing of power plants, waste heat utilization. (10L)

Module 5: Fuel Cell- Principles, classification of fuel cells, working of different types of fuel cells, fuels for fuel cells, Development stages and relative performances of various fuel cells, efficiency, V-I Characteristics of fuel cell, fuel cell power plant, environmental effects. (10L)

Text & Reference Books:

1. M.M. EL-Halwagi, Biogas Technology- Transfer and diffusion, Elsevier Applied science Publisher, New York, 1984.
2. D.O Hall and R.P. Overeed, Biomass – regenerable energy, John Willy and Sons Ltd. New York. 1987.
3. D. Y. Goswami, F. Kreith and J. F. Kreider, Principles of Solar Engineering, Taylor and Francis, Sec. Ed.2000.
4. G. Rai, Non-Conventional Energy Sources, Khanna Publishers.
5. Fuel Cells, by W. Vielstich, translated by D. J. G. Ives, Willey Interscience, 1965.
6. Microbial Fuel Cells, by B. E. Logan, John Willey & Sons, 2008.
7. I. Boustead and G. F. Hancock, Handbook of Industrial Energy Analysis, Ellis Horwood Ltd., A division of John Wiley and Sons, 1979.

Gaps in the syllabus (to meet Industry/Profession requirements)
Advanced applications of hydrogen fuel and fuel cell in industry, load sharing analysis to solar power plant.

POs met through Gaps in the Syllabus: PO1 TO PO5

Topics beyond syllabus/Advanced topics/Design :
Advanced applications of hydrogen energy and fuel cells.

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

	Course Delivery methods
CD1	Lecture by use of boards/LCD projectors
CD2	Tutorials/Assignments
CD3	Seminars
CD4	Mini projects/Projects
CD5	Laboratory experiments/teaching aids
CD6	Industrial/guest lectures
CD7	Industrial visits/in-plant training
CD8	Self- learning such as use of NPTEL materials and internets

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes				
	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	2	1
CO2	3	3	3	3	2
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 Outcome	Course Delivery Method
CO1	CD1, CD2, CD3
CO2	CD1, CD2, CD3
CO3	CD1, CD2 CD3, CD7
CO4	CD1, CD2, CD3, CD8
CO5	CD1, CD2, CD3, CD8

COURSE INFORMATION SHEET

Course code: ME547
Course title: Energy Laboratory I
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.	Expose students to the real working environment and get acquainted with the literature available of the various research challenges in the field of Energy Technology.
2.	Promote and develop presentation skills and import a knowledgeable society.
3.	Set the stage for future recruitment by potential employers.

Course Outcomes

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

CO1.	Locate the I-V and P-V characteristic with variation in temperature and radiation under series and parallel combination.
CO2.	Predicting the effect of shading and using of bypass and blocking diode.
CO3.	Calculate the work out and power flow in the standalone PV system with various combinations.
CO4.	Deducing the discharge and charge characteristic of battery.
CO5.	Perform case studies of solar system establishments.

List of Experiments

Experiment 1: To demonstrate the I-V and P-V characteristics of PV module with varying radiation and temperature level.
Experiment 2: To demonstrate the I-V and P-V characteristics of series and parallel combination of PV modules.
Experiment 3: To show the effect of variation in tilt angle on PV module power.
Experiment 4: To demonstrate the effect of shading on module output power.
Experiment 5: To demonstrate the working of diode as Bypass diode and blocking diode.

Experiment 6: Workout power flow calculations of stand-alone PV system of DC load with battery.
Experiment 7: Workout power flow calculations of stand-alone PV system of AC load with battery.
Experiment 8: Workout power flow calculations of stand-alone PV system of DC and AC load with battery.
Experiment 9: To draw the charging and discharging characteristics of battery.
Experiment 10: Comparative performance study solar plan at BIT Mesra.

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	-	2
CO2	3	3	3	-	2
CO3	3	3	3	-	2
CO4	3	3	3	-	2
CO5	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,CD3,CD6
CO2	CD1,CD3, CD6
CO3	CD1, CD3,CD6
CO4	CD1,CD3,CD6
CO5	CD1,CD3,CD6

COURSE INFORMATION SHEET

Course code: ME558
Course title: Energy Laboratory II
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: II/05
Branch: Mechanical Engineering
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Be aware of the immediate market opportunities and challenges in fuel cell systems, and the current state of the art.
2.	Gain hands-on experience of different types of Solar Thermal Energy Systems.
3.	Set the stage for future recruitment by potential employers.

Course Outcomes

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

CO1.	Evaluate performance of fuel cells.
CO2.	Operate and maintain the existing fuel cell systems.
CO3.	Train personnel in the method and development of fuel cell technology.
CO4.	Calculate the various parameters in the inside solar water heater.
CO5.	Provide training in operation and maintenance of solar thermal energy equipment.

List of Experiments

Experiment 1: Characteristics of fuel cell with the help of resistive load or DC-DC converter
Experiment 2: Output power variation of fuel cell with change in Hydrogen supply
Experiment 3: Evaluate Fuel cell system performance with only DC load connected to the charge controller with battery bank.
Experiment 4: Evaluate Fuel cell System performance with only AC load connected to the inverter with battery bank.
Experiment 5: Evaluation of U_L, F_R and η in thermosyphonic mode of flow with fixed input parameters.
Experiment 6: Evaluation of U_L, F_R and η and drawing of different curves in forced mode of flow at different flow rate.

Experiment 7: Evaluation of U_L, F_R and η in forced mode of flow at different radiation level Maximum radiation level.
Experiment 8: Evaluation of U_L, F_R and η in thermosyphonic mode of flow with different wind speed.
Experiment 9: Evaluation of U_L, F_R and η and drawing different curves in forced mode of flow at different flow rate.
Experiment 10: Evaluation of U_L, F_R and η in forced mode of flow at different tilt angle.

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	-	2
CO2	3	3	3	-	2
CO3	3	3	3	-	2
CO4	3	3	3	-	2
CO5	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,CD3,CD6
CO2	CD1,CD3, CD6
CO3	CD1, CD3,CD6
CO4	CD1,CD3,CD6
CO5	CD1,CD3,CD6

(Specialization: Design of Mechanical Equipments)

COURSE INFORMATION SHEET

Course code: ME 597
Course title: Theory of Elasticity and Plasticity
Pre-requisite(s): B. Tech 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: II/05
Branch: Mechanical EngineeringName 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 plasticity.

Course Outcomes

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

CO1.	Analyse the stress and strain relations and in Cartesian coordinate systems.
CO2.	Implement the idea of Solving the 2D Cartesian coordinate system using generalized Hooks law and Airy's stress functions.
CO3.	Apply mathematical principles to determine the stress and strain relations and in polar coordinate systems
CO4.	Understand to solve elementary problems of axi-symetry and 3D Coordinate systems.
CO5.	Create new ideas in the area of theory of elasticity.

SYLLABUS

Module- I Plane stress and plane strain problems. General stress and strain equations (Equilibrium and compatibility equations). Two dimensional problems in rectangular coordinates.
(8L)

Module- II Stress and strain components, differential equation, equilibrium equations and compatibility equations in polar coordinate. Stress distribution for axisymmetric problems. Pure bending of curved bars, thick walled cylinder. Concentrated force at a point of straight boundary. Force acting on the end of a wedge. Concentrated force acting on a beam. Effect of circular holes on stress distributions in plates.

(8L
)

Module- III Stress and strain in three dimensions: Principles stresses, maximum shearing stress, principal axes of strain. Stretching of prismatical bar by its own axis. Elementary problems of elasticity in three dimensions.
(8L)

Module- IV Torsion of non-circular prismatic bars. Saint Venant's theory. Various analogies. Torsion of hollow and thin section. Application of energy methods.
(8L)

Module- V Introduction to the theory of plasticity., the yield criteria of metals, stress space representation of yield criteria. stress-strain relations plastic potential, flow rules and maximum work hypothesis. Two-dimensional plastic flow problems. Incompressible two-dimensional flow, stresses in plastic materials in condition of plane strain, equation of equilibrium the simplest slip-line fields.
(8L)

Text Books

1: Theory of Elasticity, S.P. Timoshenko and J.N. Goodier, Tata McGraw Hill, 2010, 3rd ed.

2: Advanced Mechanics of Solids, L.S Srinath, Tata McGraw Hill, 2008, 2nd ed.

3: Theory of Plasticity, J. Chakrabarty, Elsevier, 2008, 3rd ed.

Reference Books

1. Plasticty Theory, J. Lubliner

2. Fundamentals of the theory of plasticity, L. M. Kachanov

3. Plasticity: Fundamentals and applications, P. M. Dixit and U. S. Dixit

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 COURSEDELIVERY 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 503**
Course title:	**Advanced Stress Analysis**
Pre-requisite(s):	**B.Tech 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:	**II/05**
Branch:	**Mechanical Engineering**
Name of Teacher:	

Course Objectives

This course enables the students:

A.	To get familiar with the fundamentals of solid mechanics.
B.	To understand mathematical formulations of several problems.
C.	To develop the ability to formulate the problems and apply appropriate numerical schemes.
D.	To clearly understand the difference as well as suitability to apply the RANS and scale resolving approach.
E.	To be able to implement the concepts using simple CFD codes.

Course Outcomes

After the completion of this course, students will be able to:

1.	To understand the fundamentals of CFD.
2.	To develop an intuitive understanding of the CFD techniques.
3.	To understand the fundamentals of turbulence modelling.
4.	To learn fundamentals on the near-wall modelling approach.
5.	To apply the CFD concepts on real-world problems.

Syllabus

Module 1: Components of stress at a point; Tensorial character; Cauchy’s stress relations; Principal stresses and stress invariants; Octahedral stress components; Homogeneous and deviatoric stress components; Equilibrium equations; Boundary conditions. (8 L)

Module 2: Components of strain at a point; Tensorial character; Principal strains and strain invariants; Strain-displacement relations; Compatibility conditions; Generalized Hooke’s law; Engineering and Lemi’s elastic constants; Plane stress and plane strain problems; Biharmonic equation. (8 L)

Module 3: Yield criteria; Stress space; Tresca’s and Von-Mises’ theories of failure; Yield curveson π-plane; Analysis of fundamental equation of plasticity; The equation of plasticity for a plain strain;

The influence of the mean stress on the shear strength; Characteristics and slip lines as a method of determining stresses; Properties of slip lines. (8 L)

Module 4: Principle of superposition; Uniqueness theorem; St. Venant's principle; Stress function; Plane problems in Cartesian coordinates; Solutions by polynomials; Plane problems inpolar coordinates; Complex stress functions. (8 L)

Module 5: Applications – *Torsion of bars*: Saint-Venant's free torsion; Torsion of circular, elliptical and rectangular sections; Membrane analogy. *Bending of plates*: Variation of stress within a plate; The governing equation for plate deflection; Strain energy of plates. *Shells*: Symmetrically loaded shells of revolution; Strain energy in bending and stretching of shells; Axisymmetrically loaded circular cylindrical shells. (8 L)

TEXT BOOKS:

T1. L.S. Srinath, *Advanced Mechanics of Solids*, 3rd Ed. Tata McGraw-Hills Publishing Company Ltd., 2008.

T2. S.P. Timoshenko, J.N. Goodier, *Theory of Elasticity*, 3rd Ed., McGraw-Hill Book Company, 1970.

T3. A.C. Ugural, *Stresses in Beams, Plates, and Shells*, 3rd Ed., CRC Press, 2009.

REFERENCE BOOKS:

R1. A.P. Boresi, R.J. Schmidt, *Advanced Mechanics of Materials*, 6th Ed., John Wiley & Sons Inc., 2002.

R2. A. Tselikov, *Stress and Strain in Metal Forming*, MIR Publishers, 1967.

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

Solution to more complex problems like propagation of waves in a continuous media, and anisotropic elasticity.

POs met through Gaps in the Syllabus

PO1 TO PO5

Topics beyond syllabus/Advanced topics/Design

NA

POs met through Topics beyond syllabus/Advanced topics/Design

PO1 TO PO5

	Course Delivery methods
CD1	Lecture by use of boards/LCD projectors
CD2	Tutorials/Assignments
CD3	Seminars
CD4	Mini projects/Projects
CD5	Laboratory experiments/teaching aids

CD6	Industrial/guest lectures
CD7	Industrial visits/in-plant training
CD8	Self- learning such as use of NPTEL materials and internets

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

Mapping of Course Outcomes onto Program Outcomes

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

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1-5	CD1
CD2	Tutorials/Assignments	CO1-5	CD2
CD3	Seminars	-	-
CD4	Mini projects/Projects	-	-
CD5	Laboratory experiments/teaching aids	-	-
CD6	Industrial/guest lectures	-	-
CD7	Industrial visits/in-plant training	-	-
CD8	Self- learning such as use of NPTEL materials and internets	-	-
CD9	Simulation		

COURSE INFORMATION SHEET

Course code: ME 506
Course title: Applied Tribology
Pre-requisite(s): B.Tech Machine Design
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
EngineeringName 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 andLubrication, Second Edition. John Wiley & Sons, Ltd, 2008.

Reference Books

1. B. J. Hamrock, S. R. Schmid, B. O. Jacobson. Fundamental of Fluid FilmLubrication. 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 522R1
Course title:	Advanced Mechanics of Solids
Pre requisite:	**B.Tech** 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:	**II/05**
Branch:	Mechanical Engineering
Name of Teacher:	

Course Objectives

This course enables the students:

A.	To understand the advanced concept of stress-strain behaviour of materials.
B.	To apply mathematical concept in practical solid mechanics problems.

Course Outcomes

After the completion of this course, students will 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 the Advanced Mechanics of Solids 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. **(8 Lectures)**

Module 2: Analysis of Stress: Definition and notation of stress, Cauchy stress tensor, equations of equilibrium, principal stresses and stress invariants, stress deviator tensor, octahedral stress components. **(8 Lectures)**

Module 3: Analysis of Strain: 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. **(8 Lectures)**

Module 4: Two-dimensional problems: Plane stress and plane strain problems, generalized plane stress, Anti-plane strain, Airy stress function, polar coordinate formulation and solutions. **(8 Lectures)**

Module 5: Applications: Torsion of noncircular shafts: Warping and Prandtl stress function. Plates and shells – Fundamental equations. **(8 Lectures)**

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

Gaps in the syllabus (to meet Industry/Profession requirements)
Variational and Complex Variables Methods
POs met through Gaps in the Syllabus
PO (a)
Topics beyond syllabus/Advanced topics/Design
Nonlinear deformations of materials
POs met through Topics beyond syllabus/Advanced topics/Design
PO (a)

	Course Delivery methods
CD1	Lecture by use of boards/LCD projectors
CD2	Tutorials/Assignments
CD3	Seminars
CD4	Mini projects/Projects
CD5	Laboratory experiments/teaching aids
CD6	Industrial/guest lectures
CD7	Industrial visits/in-plant training
CD8	Self- learning such as use of NPTEL materials and internets

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

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes				
	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

COURSE INFORMATION SHEET

Course code: ME 523R1
Course title: Applied Dynamics and Vibration
Pre-requisite(s): B.Tech Theory of Machines
Co- requisite(s):
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:

A.	To understand dynamics of rigid body and its applications.
B.	To understand the transformation of vectors, and its applications in Classical Mechanics.
C.	To apply the Principle of Virtual Work to determine equation of motion
D.	To analyse free and forced vibration of single-degree-of-freedom systems.
E.	To analyse Vibration of Multi-Degree-of-Freedom systems and application of FEM in Vibration Problems.

Course Outcomes

After the completion of this course, students will be able to:

1.	Demonstrate various principles related to kinematics and dynamics of rigid bodies.
2.	Understand the approach of Classical Mechanics
3.	Apply Virtual Work approach to construct equations of motion for dynamical systems
4.	Evaluate Vibration Parameters of single-degree-of-freedom systems.
5.	Design and analysis of multi DOF vibrating systems.

Syllabus

Module 1

Kinematics and Kinetics of Rigid Bodies: Vectors, Rectilinear and Curvilinear motion of particle(s), Plane motion of Rigid body: Linear Momentum, Moment of Momentum, Kinetic and Potential Energy. [8L]

Module 2

Classical Mechanics: Frame of reference, coordinate systems, five term acceleration, Coordinate transformation, Rotating frames, Rotation tensor, Axis angle relation, Euler angles, Practical examples. [8L]

Module 3

Classical Mechanics: Generalized coordinates, constraints, Principle of Virtual Work, Lagrange multiplier, d'Alembert's principle, Hamilton's Principle, Lagrange's equation of motion. [8L]

Module 4

Introduction to Vibration: Basic elements of vibration: Free vibration; undamped and damped vibration, Logarithmic decrement. Forced vibration, Magnification factor, Base excitation, Rotating Imbalance. [8L]

Module 5

Vibration of Multi DOF System: Two DOF system, forced vibration, Dynamic vibration absorber, Free and forced multi DOF system, String Vibration. Application of FEM in Vibration Problems. [8L]

Text Books:

1. Elements of Vibration Analysis, Leonard Meirovitch, McGraw Hill Education, Second edition.
2. Engineering. Mechanics by Irving H. Shames, P H I. Ltd.
3. Methods of Analytical Dynamics, Leonard Meirovitch, Dover Publications

Reference Books:

1. Theory of Vibration with Applications, W. T. Thomson, M. D. Dahleh, and C. Padmanabhan, Pearson, Fifth edition.
2. Mechanical Vibrations, S.S. Rao, Pearson India Education Services Pvt Ltd. Fourth edition.
3. Engineering Mechanics: Dynamics, J. L. Meriam and L. G. Kraige, John Wiley and Sons Inc., Seventh edition.
4. Intermediate Dynamics, Indian Institute of Technology Kanpur, A. Chatterjee.
5. Classical Dynamics, D. T. Greenwood, Dover Publications Inc.
6. Engineering Mechanics: Dynamics, R. C. Hibbeler, Pearson

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
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Industrial/guest lectures
Industrial visits/in-plant training
Self- learning such as use of NPTEL materials and internets
Simulation

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

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcomes	Program Outcomes				
	PO1	PO2	PO3	PO4	PO5
1	2	3	2	3	1
2	3	3	3	2	1
3	3	2	3	1	1
4	3	1	3	3	1
5	3	1	3	2	1

Mapping Between COs and Course Delivery (CD) methods				
CD	**Course Delivery methods**		**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors/OHP projectors		CO1-5	CD1
CD2	Tutorials/Assignments		CO1-5	CD2
CD3	Seminars		-	-
CD4	Mini projects/Projects		-	-
CD5	Laboratory experiments/teaching aids		-	-
CD6	Industrial/guest lectures		-	-
CD7	Industrial visits/in-plant training		-	-
CD8	Self- learning such as use of NPTEL materials and internets		-	-
CD9	Simulation			

COURSE INFORMATION SHEET

Course code: ME 524
Course title: Advanced Engineering Materials
Pre-requisite(s): B.Tech Materials Science
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.	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 COURSEDELIVERY 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 525R1
Course title: Robotics Manipulator Design
Pre-requisite(s): B.Tech Kinematics and Dynamics of Machines
Co- requisite(s): NIL
Credits: 3 L: 3 T: 0 P: 0Class
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 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 dynamic parameters of a serial robot by applying the knowledge of general form of dynamic equation of motion.
CO3.	Analyse planar and spatial parallel robots in context to its forward and inverse kinematics, and evaluate its singularity, condition number and manoeuvrability.
CO4.	Design a robotic manipulator and evaluate its primary and secondary workspace. Evaluate the performance of an industrial robot based on ISO standards.
CO5.	Determine the trajectory planning of the robot manipulator, and its motion control using various control techniques.

SYLLABUS

Module 1:

Introduction to serial and parallel robot structure, standard kinematic notations, transformation matrices, link and joint parameters, forward and inverse kinematics, Euler angles, The Jacobian matrix, Link velocities, Jacobian computation, Acceleration analysis, Singularity and Redundant robots. (8L)

Module 2:

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 3:

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 4:

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)

Module 5:

Trajectory planning: Cartesian and Joint space trajectories, Cubic, Quintic polynomial, Point to Point and Continuous path planning. Introduction to various control techniques, open-loop and closed-loop control, proportional (P) control, Integral (I) control, Derivative (D) control, PI control, PD control, PID control, State space representation. (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	3
CO4	3	3	3	3	3
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: ME 532R1
Course title: Fracture Mechanics
Pre-requisite(s): B.Tech Strength of Materials, Machine Design
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

Fracture Mechanics

Proposed CO

CO1	Learn physical intuition necessary to idealize a complicated practical Fracture problem
CO2	Apply Westergaard Solution to solve the idealized problem.
CO3	Evaluate materials' strength with crack
CO4	Develop Fail Safe Design using different method
CO5	Determine Fracture Parameters using FEM and Experiment

Syllabus

Module I:

Introduction: Fracture Phenomena in Nature and Engineering, Brittle and Ductile Fracture, Modes of Fracture Failure, Damage Tolerance, Crack Growth and Fracture Mechanisms; The stress at the crack tip; Griffith Theory of Fracture; Energy Release Rate; Stable and unstable crack growth; R-curve for brittle crack; Thin plate vs Thick plate; Critical Energy release rate. (8L)

Module II:

Stress Intensity Factor: Introduction, Stress and Displacement Fields in Isotropic Elastic Materials; Stress Intensity Factor, Mathematical Background (Airy's stress function); Westergaard's Approach and its application, Edge Cracks, Embedded Cracks, The Relation between G1 and K1, Critical Stress Intensity Factor, Bending and Twisting of Cracked Plates (8 L)

Module III:

Anelastic Deformation at the Crack Tip: Investigation at the Crack Tip, Approximate Shape and Size of the Plastic Zone, Effective Crack Length, Effect of Plate Thickness J-Integral: Relevance and Scope, Applications to Engineering Problems (8L)

Module IV:

Crack Tip Opening Displacement: Relationship between CTOD, Kr and Gr for Small Scale Yielding, Equivalence between CTOD and J- Integral (8L)

Module V:

Test Methods: KIc-Test Technique, Test Methods to Determine J1c, Test Methods to Determine G1c and GIIc, Determination of Critical CTOD, Fatigue Failure and Environment-assisted Fracture, Finite Element Analysis of Cracks in Solids: Direct Methods to Determine Fracture Parameters, Indirect Methods to Determine Fracture Parameters (8L)

Text Books:

1. Elements of Fracture Mechanics, Prashant Kumar, Tata McGraw Hill, New Delhi, India, 2009.

Reference Book

1.Elementary Engineering Fracture Mechanics, David Broek, Kluwer Academic Publishers
2. Fatigue of Materials, S. Suresh, Cambridge University Press

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

Mapping between COs and Course Delivery (CD) methods			
CD	**Course delivery methods**	**Course outcome**	**Course delivery method**
CD1	Lecture by use of boards/LCD projectors	CO 1-5	CD 1
CD2	Tutorials/Assignments	CO 1-5	CD 2
CD3	Seminars	-	-
CD4	Mini projects/Projects	-	-
CD5	Laboratory experiments/teaching aids	-	-
CD6	Industrial/guest lectures	-	-
CD7	Industrial visits/in-plant training	-	-
CD8	Self- learning such as use of NPTEL materials and internets	-	-
CD9	Simulation	-	-

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcomes	**Program Outcomes**				
	PO1	PO2	PO3	PO4	PO5
1	3	3	2	3	3
2	3	3	2	2	-
3	3	2	3	1	3
4	3	2	3	3	3
5	3	3	3	2	3

COURSE INFORMATION SHEET

Course code: ME 533
Course title: Automatic Control
Pre-requisite(s): B.Tech Engineering Mathematics
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 538R1
Course title: Rotor Dynamics
Pre-requisite(s): B.Tech Kinematics and Dynamics of Machines
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 rotor dynamics phenomena with the help of simple rotor models
2.	Model and analyze 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 and obtain natural frequencies
CO2.	Solve the equation of motion for the response of Jeffcott rotor models
CO3.	Analyze the lateral response and stability of rotor systems supported on fluid film bearings
CO4.	Solve the equation of motion for free lateral response of rotor models with four degrees of freedom
CO5.	Model and solve rotor-bearing problems using Finite Elements method

SYLLABUS

Module 1: Introduction to Rotor Dynamics

Rotating machine components, introduction to vibration analysis, free and forced vibration of single degree of freedom systems, two degree of freedom systems, and multi degree of freedom systems, eigenvalue analysis. (8L)

Module 2: The Jeffcott Rotor

Undamped Jeffcott rotor, equation of motion, free whirling, unbalance response, response to external forces in the frequency domain, Jeffcott rotor with flexible bearings, Jeffcott rotor with bearing damping. (8L)

Module 3: Rotors with Oil-film Bearings

Hydrodynamic bearing theory, short bearing theory, stiffness and damping coefficients, rotors mounted on fluid film bearings, stability. (8L)

Module 4: Rotor Models with four degree of freedom

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 5: Finite Element Modelling

Defining generalized co-ordinates, finite element modelling of discrete components, lateral deflection of a beam, disk elements, shaft elements, modelling foundations and stators, assembly of the full equations of motion, free response of complex systems. (8L)

Textbooks

1. Friswell, M. I., Penny, J. E. T., Garvey, S. D., Lees, A. W. Dynamics of rotating machines. Cambridge University Press, 2010.
2. Krämer, E. Dynamics of rotors and foundations. Springer, 2013.

Reference Books

1. 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: ME537
Course title: Robotics Laboratory
Pre-requisite(s): B.Tech Engineering Mathematics, Engineering Mechanics
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	50
Semester End Examination	50

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

Semester End Examination	% Distribution
Examination Experiment Performance	30
Quiz	20

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 COURSEDELIVERY 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: ME 528
Course title: Advanced Solid Mechanics and Vibration lab
Pre-requisite(s): B.Tech Strength of Materials
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.	Determine material properties.
2.	Understand fatigue and creep phenomena.
3.	Understand vibration characteristics and friction induced vibration.

Course Outcomes

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

CO1.	Determine surface hardness and scratch 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.	Analyze dynamics 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 the scratch hardness of materials using a scratch tester.
Experiment 3: To determine creep properties of materials (Lead, polymer materials) in room temperature
Experiment 4: To determine change of rate of deformation of a sample (Lead, polymer materials) at different temperature.
Experiment 5: To determine endurance limit of materials under axial cyclic load.
Experiment 6: To determine endurance limit of materials under flexural load
Experiment 7: To determine fracture toughness of CT specimen.
Experiment 8: To determine the properties of materials under tensile load in
Instron Experiment 9: To determine the properties of materials under compressive load in Instron.
Experiment 10: To determine the properties of materials under flexural load in Instron. **Experiment 11:** To determine secondary mass and spring stiffness for forced tuned vibration absorber.
Experiment 12: To understand beating phenomenon in weakly coupled pendulum.
Experiment 13: To determine balancing masses and their orientation for an

unbalanced wheel in wheel Balancing Machine.

Experiment 14: To determine the coefficient of friction in stick slip condition of self-excited friction induced vibration at different normal load and material pair combination.

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
Day to day performance & Lab files	10
Quiz (es)	20
Viva	20

Semester End Examination	% Distribution
Examination Experiment Performance	30
Quiz	20

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 COURSEDELIVERY 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

(Specialization: Computer Aided Analysis and Design)

COURSE INFORMATION SHEET

Course code: ME 597
Course title: Theory of Elasticity and Plasticity
Pre-requisite(s): B. Tech 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: 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 plasticity.

Course Outcomes

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

CO1.	Analyse the stress and strain relations and in Cartesian coordinate systems.
CO2.	Implement the idea of Solving the 2D Cartesian coordinate system using generalized Hooks law and Airy's stress functions.
CO3.	Apply mathematical principles to determine the stress and strain relations and in polar coordinate systems
CO4.	Understand to solve elementary problems of axi-symetry and 3D Coordinate systems.
CO5.	Create new ideas in the area of theory of elasticity.

SYLLABUS

Module- I Plane stress and plane strain problems. General stress and strain equations (Equilibrium and compatibility equations). Two dimensional problems in rectangular coordinates. (8L)

Module- II Stress and strain components, differential equation, equilibrium equations and compatibility equations in polar coordinate. Stress distribution for axisymmetric problems. Pure bending of curved bars, thick walled cylinder. Concentrated force at a point of straight boundary. Force acting on the end of a wedge. Concentrated force acting on a beam. Effect of circular holes on stress distributions in plates. (8L)

Module- III Stress and strain in three dimensions: Principles stresses, maximum shearing stress, principal axes of strain. Stretching of prismatical bar by its own axis. Elementary problems of elasticity in three dimensions. (8L)

Module- IV Torsion of non-circular prismatic bars. Saint Venant's theory. Various analogies. Torsion of hollow and thin section. Application of energy methods. (8L)

Module- V Introduction to the theory of plasticity., the yield criteria of metals, stress space representation of yield criteria. stress-strain relations plastic potential, flow rules and maximum work hypothesis. Two-dimensional plastic flow problems. Incompressible two-dimensional flow, stresses in plastic materials in condition of plane strain, equation of equilibrium the simplest slip-line fields. (8L)

Text Books

1: Theory of Elasticity, S.P. Timoshenko and J.N. Goodier, Tata McGraw Hill, 2010, 3rd ed.

2: Advanced Mechanics of Solids, L.S Srinath, Tata McGraw Hill, 2008, 2nd ed.

3: Theory of Plasticity, J. Chakrabarty, Elsevier, 2008, 3rd ed.

Reference Books

1. Plasticty Theory, J. Lubliner

2. Fundamentals of the theory of plasticity, L. M. Kachanov

3. Plasticity: Fundamentals and applications, P. M. Dixit and U. S. Dixit

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 –

3. Student Feedback on Faculty
4. 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 COURSEDELIVERY 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 502
Course title: Advanced Computer Aided Design
Pre-requisite(s): B.Tech. Machine Design
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:

A.	To understand the transformation techniques and solid modelling.
B.	To generate the Synthetic Curves.
C	To develop programs for design and drawing of Machine Elements.

Course Outcomes

After the completion of this course, students will be able to:

CO1.	Understand the concept of solid modeling and transformation techniques.
CO2.	Understand how to transfer data in CAD system.
CO3.	Apply the knowledge to generate surface patches, synthetic surfaces.
CO4.	Understand how to generate different curves.
CO5.	Apply the knowledge to develop programs for design and drawing of Machine Elements.

Syllabus

MODULE: I Review of 2D representation in CAD Homogeneous representation; Translation, Scaling, Reflection, Rotation, Shearing in 3D; Projections; Introduction to assembly modelling, IGES, STEP & DXF data exchange format. (8 L)

MODULE: II Representation of surface patches; Analytic surfaces; Synthetic surfaces; Surface modelling; Solid entities; CSG approach of solid modelling; Boolean operations; B-rep approach of Solid Modelling; Boundary evaluation technique. (8 L)

MODULE: III Synthetic Curves: Concept of continuity, cubic spline curve, Bezier curve, B-Spline curve and NURBS. (8 L)

MODULE: IV Animation and Collaborative Design: Mechanism and Animation, Collaborative Design Principles, Approaches, Tools, Design Systems. (8 L)

MODULE: V Development of programs for design and drawing of Machine Elements: Shafts, Gears,Pulleys, Flywheel, Connecting rods. (8 L)

TEXT BOOKS:
T1. Mastering CAD/CAM by Ibrahim Zeid, Tata McGraw-Hill
T2. Computer Graphics by Donald Hearn and M. Pauline Baker, Prentice Hall of India Pvt. Ltd. Delhi

REFERENCE BOOKS:

R 1. CAD/CAM Principles and Applications by P.N. Rao, TataMcGraw-Hill
R2. CAD/CAM: Computer Aided design and Manufacturing by Mikell Groover and Zimmer, PearsonEducation

Gaps in the syllabus (to meet Industry/Profession requirements)
Computer graphics
POs met through Gaps in the Syllabus
PO1 TO PO5

Topics beyond syllabus/Advanced topics/Design
Viewing, Clipping

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

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

Mapping of Course Outcomes onto Program Outcomes

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

Mapping Between COs and Course Delivery (CD) methods

CD	Course Delivery methods		Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors		CO1-5	CD1
CD2	Tutorials/Assignments		CO1-5	CD2
CD3	Seminars		-	-
CD4	Mini projects/Projects		-	-
CD5	Laboratory experiments/teaching aids		-	-
CD6	Industrial/guest lectures		-	-
CD7	Industrial visits/in-plant training		-	-
CD8	Self- learning such as use of NPTEL materials and internets		-	-
CD9	Simulation			

COURSE INFORMATION SHEET

Course code:	**ME 503**
Course title:	**Advanced Stress Analysis**
Pre-requisite(s):	**B.Tech 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:	**II/05**
Branch:	**Mechanical Engineering**
Name of Teacher:	

Course Objectives

This course enables the students:

A.	To get familiar with the fundamentals of solid mechanics.
B.	To understand mathematical formulations of several problems.
C.	To develop the ability to formulate the problems and apply appropriate numerical schemes.
D.	To clearly understand the difference as well as suitability to apply the RANS and scale resolving approach.
E.	To be able to implement the concepts using simple CFD codes.

Course Outcomes

After the completion of this course, students will be able to:

CO1.	To understand the fundamentals of CFD.
CO2.	To develop an intuitive understanding of the CFD techniques.
CO3.	To understand the fundamentals of turbulence modelling.
CO4.	To learn fundamentals on the near-wall modelling approach.
CO5.	To apply the CFD concepts on real-world problems.

Syllabus

Module 1: Components of stress at a point; Tensorial character; Cauchy's stress relations; Principal stresses and stress invariants; Octahedral stress components; Homogeneous anddeviatoric stress components; Equilibrium equations; Boundary conditions. (8 L)

Module 2: Components of strain at a point; Tensorial character; Principal strains and strain invariants; Strain-displacement relations; Compatibility conditions; Generalized Hooke's law; Engineering and Lemi's elastic constants; Plane stress and plane strain problems; Biharmonic equation. (8 L)

Module 3: Yield criteria; Stress space; Tresca's and Von-Mises' theories of failure; Yield curves on π-plane; Analysis of fundamental equation of plasticity; The equation of plasticity for a plain strain; The influence of the mean stress on the shear strength; Characteristics and slip lines as a method of determining stresses; Properties of slip lines. (8 L)

Module 4: Principle of superposition; Uniqueness theorem; St. Venant's principle; Stress function; Plane problems in Cartesian coordinates; Solutions by polynomials; Plane problems inpolar coordinates; Complex stress functions. (8 L)

Module 5: Applications – *Torsion of bars*: Saint-Venant's free torsion; Torsion of circular, elliptical and rectangular sections; Membrane analogy. *Bending of plates*: Variation of stresswithin a plate; The governing equation for plate deflection; Strain energy of plates. *Shells*:Symmetrically loaded shells of revolution; Strain energy in bending and stretching of shells;Axisymmetrically loaded circular cylindrical shells. (8 L)

TEXT BOOKS:

T1. L.S. Srinath, *Advanced Mechanics of Solids*, 3rd Ed. Tata McGraw-Hills PublishingCompany Ltd., 2008.

T2. S.P. Timoshenko, J.N. Goodier, *Theory of Elasticity*, 3rd Ed., McGraw-Hill Book Company,1970.

T3. A.C. Ugural, *Stresses in Beams, Plates, and Shells*, 3rd Ed., CRC Press, 2009.

REFERENCE BOOKS:

R1. A.P. Boresi, R.J. Schmidt, *Advanced Mechanics of Materials,* 6th Ed., John Wiley & SonsInc., 2002.

R2. A. Tselikov, *Stress and Strain in Metal Forming*, MIR Publishers, 1967.

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

Solution to more complex problems like propagation of waves in a continuous media, and anisotropicelasticity.

POs met through Gaps in the Syllabus

PO1 TO PO5

Topics beyond syllabus/Advanced topics/Design

NA

POs met through Topics beyond syllabus/Advanced topics/Design

PO1 TO PO5

	Course Delivery methods
CD1	Lecture by use of boards/LCD projectors
CD2	Tutorials/Assignments
CD3	Seminars
CD4	Mini projects/Projects
CD5	Laboratory experiments/teaching aids
CD6	Industrial/guest lectures
CD7	Industrial visits/in-plant training

CD8	Self- learning such as use of NPTEL materials and internets

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 –

3. Student Feedback on Faculty

4. Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

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

CD	Course Delivery methods	Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1-5	CD1
CD2	Tutorials/Assignments	CO1-5	CD2
CD3	Seminars	-	-
CD4	Mini projects/Projects	-	-
CD5	Laboratory experiments/teaching aids	-	-
CD6	Industrial/guest lectures	-	-
CD7	Industrial visits/in-plant training	-	-
CD8	Self- learning such as use of NPTEL materials and internets	-	-
CD9	Simulation		

COURSE INFORMATION SHEET

Course code: ME 505
Course title: Mechatronics
Pre-requisite(s): B.Tech Mechanical Engineering
Co- requisite(s):
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:

A.	To understand the basics of Mechatronics, sensors and actuators
B.	To analyse various actuation systems, and enable to understand the basic concept of motors
C.	Todevelop system models and control systems for new developed equipments and applications
D.	To analyse and deal with the programmable logic controllers and circuits
E.	To develop new models and concepts, understand the new technology and usage.

Course Outcomes

After the completion of this course, students will be able to:

CO1.	Analyse mechatronic systems and automated systems
CO2.	Apply sensors and controllers in the circuit
CO3.	Apply actuation system and drives to the new developed mechatronic system
CO4.	Analyse various programmable logic controllers and microcontrollers
CO5.	Develop and predict for the performance for various new systems, robotic systems and possible design solutions

Syllabus

Module: 1

Introduction and Overview:
Introduction to Mechatronics, Mechatronics in product design and system control, Sensors and Transducers, displacement, pressure, temperature, optical,piezoelectric, strain guage ,Review of fundamentals of electronics. Data conversion devices, microsensors, signal processing Sevices, Relay (8L)

Module: 2
Actuation systems Drives: stepper motors, servo drives. Ball screws, linear motion bearings, cams, systems controlled by camshafts, electronic cams, indexing mechanisms, tool magazines, transfer systems, hydraulic, pneumatic drives (8L)

Module: 3

System models and controllersMicroprocessors ,Description of PID controllers. CNC machines and part programming , adaptive control. Flexible manufacturing systems (8L)

Module: 4

Programmabe Logic Controllers (PLC)- input and output processing and programming, timers,internal relays and controllers, shift resistor, Ladder programming, converters (8L)

Module: 5

Stages in designing,Mechatronic Systems, Traditonal and Mechatronics design, Case studies of Mechatronics systems, Pick and place robot, Autonomous mobie robot, wireless survellience, balloon engine management, car parking barrier systemsDesign for manufacture and assembly (8L)

Text books:

T1 HMT ltd. Mechatronics, Tata Mcgraw-Hill, New Delhi, 1988.T2

Introduction to Mechatronics and Measurement System by David G. Alciatore, Michael B. Histamd, Mc Graw Hill

T3 Mechatronics by Bolton, Pearson Education

Reference books:

R1 Mechatronics System Design by Devdas and Shetty, Pearson Education

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

Microcontrollers

.**POs met through Gaps in the Syllabus**

PO1 TO PO5

Topics beyond syllabus/Advanced topics/Design

Fuzzy Logic

POs met through Topics beyond syllabus/Advanced topics/Design

PO1 TO PO5

	Course Delivery methods
CD1	Lecture by use of boards/LCD projectors
CD2	Tutorials/Assignments
CD3	Seminars
CD4	Mini projects/Projects
CD5	Laboratory experiments/teaching aids
CD6	Industrial/guest lectures
CD7	Industrial visits/in-plant training
CD8	Self- learning such as use of NPTEL materials and internets

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

Mapping of Course Outcomes onto Program Outcomes

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

Mapping Between COs and Course Delivery (CD) methods				
CD	**Course Delivery methods**		**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors/OHP projectors		CO1-5	CD1
CD2	Tutorials/Assignments		CO1-5	CD2
CD3	Seminars		-	-
CD4	Mini projects/Projects		-	-
CD5	Laboratory experiments/teaching aids		-	-
CD6	Industrial/guest lectures		-	-
CD7	Industrial visits/in-plant training		-	-
CD8	Self- learning such as use of NPTEL materials and internets		-	-
CD9	Simulation			

COURSE INFORMATION SHEET

Course code: ME 506
Course title: Applied Tribology
Pre-requisite(s): B.Tech Machine Design
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 EngineeringName 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 andLubrication,
Second Edition. John Wiley & Sons, Ltd, 2008.

Reference Books

3. B. J. Hamrock, S. R. Schmid, B. O. Jacobson. Fundamental of Fluid FilmLubrication. Second Edition. Marcel Dekker, Inc., 2004.
4. 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 –

3. Student Feedback on Faculty
4. 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 512
Course title: Reverse Engineering and Rapid prototyping
Pre-requisite(s): B.Tech Machine Design
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:

A.	To develop a comprehensive and better designing for an engineering perspective.and change from an older design to newer.
B.	To lay the foundation for subsequent studies in conventional and nonconventional product development phases and to prepare the students to effectively use it in the practice of engineering.
C.	To develop an intuitive understanding of why and how to reverse engineer an older product to new concept and design its improvements.
D.	Understand CAD CAE and RP tools and to redraw a circuit with new amendments

Course Outcomes

After the completion of this course, students will be able to:

CO1.	Explain the Reverse engineering methodology.
CO2.	Examine the disassembled parts with concern to its functionality
CO3.	Choose the different types of RE systems
CO4.	Analyze the basics of RP processes and their advantages.
CO5.	Adapt RE and RP processes in basic design

Syllabus

Module 1:

Basic concepts in reverse engineering: Introduction to RE forward engineering, reverse engineering, value engineering, design thought and process, design step, mechatronics system design The problem what is Reverse Engineering The RE process, Technical Data Development, Benefits of RE, RE as a Quality function, Uses of RE, Value Engineering and RE, Origin of RE, legal issues, Patent Infringement and Theft (8L)

Module 2:

Reverse engineering methodology: RE steps, system level design and examples, product development, product function, product teardown, engineering specification, product architecture visual and Dimensional inspection, comparison to technical data, Disassembly and assembly procedures, material analysis, Technical data generation, Developing engineering drawings, Dimensional accuracy ,technical data package completed, Design verification prototype determination prototype failure and retesting, Inspection criteria, Project Implementation (8L)

Module 3:

Scanning devices: Reverse Engineering and CAD interface, Scanners , Contact type, Non- contact type, Coordinate measuring Devices, 3D scanning white light scanners, Cloud data scanning, Processing, Surface recreation, 3D modeling, Final model development, Digital representation for communication of Product development. **(**8L)

Module 4:

Introduction to Rapid prototyping : Prototyping fundamentals, Historic development, advantages and disadvantages, Limitations of RP, Classification of RP Liquid Based Prototyping, Stereo lithography (SLA), methods, principle, specifications and areas of application, Solid Based RP systems, (SGC), FDM Fused Deposition Modeling, SLS Selective Laser Sintering, 3D Printing **(8L**)

Module 5:

RE in design : Design of new products, R.E. in computer application, Reverse engineering of PLC programmes. Rapid Tooling, aerospace, automotive, Basic design procedures for implementing RE medical and bioengineering, customized implants and prosthetics, forensic science and anthropology. RE and RP interrelation, Case studies. (8L)

Text book:

T1 Reverse Engineering by Kathryn A. Ingle , McGraw Hill 1994.

T2 Rapid prototyping Principles and Application by Rafiq, Nooraani , Wiley and Sons

Reference books:

R1 Rapid Prototyping Principles and Applications, Chua C K Leong K F LMCS World Science Publication.

R2 Rapid Manufacturing , D.T. Pham and S.S Dhmav, Springer, 1997.

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

Model development

POs met through Gaps in the Syllabus
PO1 TO PO5

Topics beyond syllabus/Advanced topics/Design
NA
POs met through Topics beyond syllabus/Advanced topics/Design
PO1 TO PO5

	Course Delivery Methods
CD1	Lecture by use of boards/LCD projectors

CD2	Tutorials/Assignments
CD3	Seminars
CD4	Mini projects/Projects
CD5	Laboratory experiments/teaching aids
CD6	Industrial/guest lectures
CD7	Industrial visits/in-plant training
CD8	Self- learning such as use of NPTEL materials and internets

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

Mapping of Course Outcomes onto Program Outcomes

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

Mapping Between COs and Course Delivery (CD) methods				
CD	**Course Delivery methods**		**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors/OHP projectors		CO1-5	CD1
CD2	Tutorials/Assignments		CO1-5	CD2
CD3	Seminars		-	-
CD4	Mini projects/Projects		-	-
CD5	Laboratory experiments/teaching aids		-	-
CD6	Industrial/guest lectures		-	-
CD7	Industrial visits/in-plant training		-	-
CD8	Self- learning such as use of NPTEL materials and internets		-	-
CD9	Simulation			

COURSE INFORMATION SHEET

Course code: ME 519
Course title: Computer Graphics
Pre-requisite(s): B. Tech
Co- requisite(s): Nil
Credits: 3
Class schedule per week: 03 L:3, T:0, P:0
Class: M. Tech
Semester / Level: II/05
Branch: Mechanical Engineering
Name of Teacher:

Course Objectives

This course enables the students:

A.	To develop a knowledge of what is computer graphics.
B.	To lay the foundation for subsequent studies in Graphic primitives and attributes of primitives to prepare the students to effectively use it in the practice of engineering.
C.	To develop an intuitive understanding of why and how to incorporate computer graphics and its importance in the real world
D.	To get aware of transformations and analytical & synthetic curve generation.
E	To get them know about viewing and clipping systems and the various applications of it in computer graphics system.

Course Outcomes

After the completion of this course, students will be:

CO1.	Understand the Computer Graphics and its application in real world.
CO2.	To know about the Graphic primitives.
CO3.	Able to understand the Attributes of primitives and Antialiasing.
CO4.	Able to understand the Transformations in computer graphics.
CO5.	Outline the concepts of Viewing and Clipping.

Syllabus

Module 1: Display device: Refresh Cathode ray Tubes, Random Scan and Raster Scan monitors, Colour CRT Monitors, Direct view Storage Tubes, Continuous Refresh and Storage display, LED and LCD Monitors.

Graphic primitives: Points & Lines, Line drawing Algorithm, DDA and Bresenham's Algorithm.
(8 L)

Module 2: Attributes of primitives: Line style, Type, Width, Colour, Character Attributes, Area Filling, Antialiasing. Fill Algorithm: Scan-Line Polygon Fill algorithm, Boundary Fill Algorithm, Flood Fill Algorithm, Seed fill algorithm. (8 L)

Module 3: Analytical & Synthetic curve: C0, C1 & C2 Continuity, Convex hull, Parametric & non- parametric representation of curves.

Analytic curves: Circle, Ellipse, Parabola, Hyperbola, Splines: linear, quadratic, cubic, hermite, Bezier curves, Synthetic Curves: Circle and ellipse drawing, Parametric and Breshenham's algorithm.

(8 L)

Module 4: 2D Transformation: Basic transformation- Translation, Scaling, Rotation, Reflection, Twist,Matrix Representation, Composite Transformations.

3D Transformation: Basic Transformations, 3D Display parallel & perspective projection. (8 L)

Module 5: Viewing: Viewing world co-ordination system, Normalized co-ordinate system, Device/Imageco-ordination system, Window definitions, View port definitions, Viewing transformation.

Clipping: Point clipping, Line clipping, Cohen- Sutherland clipping, Midpoint clipping method,Sutherland and Hodgman Clipping. (8 L)

Text Books:

T1. Computer Graphics-Donald Hearn and M. Pauline Baker - Prentice Hall of India Pvt Ltd.T2.

Introduction to Computer Graphics - N. Krishnamurhy - TMH Publication

Reference Books:

R1. Computer Graphics - Harrington S. - TMH Publication

R2. CAD-CAM Theory and Practice - Ibrahim Zeid - TMH PublicationR3.

Computer Graphics - Schaum's Outline - TMH Publication

Gaps in the syllabus (to meet Industry/Profession requirements)
Computer aided Design

POs met through Gaps in the Syllabus
PO1 TO PO5

Topics beyond syllabus/Advanced topics/Design
NA

POs met through Topics beyond syllabus/Advanced topics/Design
PO1 TO PO5

	Course Delivery Methods
CD1	Lecture by use of boards/LCD projectors
CD2	Tutorials/Assignments
CD3	Seminars
CD4	Mini projects/Projects
CD5	Laboratory experiments/teaching aids
CD6	Industrial/guest lectures
CD7	Industrial visits/in-plant training
CD8	Self- learning such as use of NPTEL materials and internets

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

Mapping of Course Outcomes onto Program Outcomes

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

	Mapping Between COs and Course Delivery (CD) methods			
CD	**Course Delivery methods**		**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors/OHP projectors		CO1-5	CD1
CD2	Tutorials/Assignments		CO1-5	CD2
CD3	Seminars		-	-
CD4	Mini projects/Projects		-	-
CD5	Laboratory experiments/teaching aids		-	-
CD6	Industrial/guest lectures		-	-
CD7	Industrial visits/in-plant training		-	-
CD8	Self- learning such as use of NPTEL materials and internets		-	-
CD9	Simulation			

COURSE INFORMATION SHEET

Course code: ME 515R1
Course title: COMPUTER INTEGRATED MANUFACTURING
Pre-requisite(s): B.Tech.
Co- requisite(s): None
Credits: 03 L: 03 T:0 P:0
Class schedule per week: 03
Class: M. Tech
Semester / Level: II/5
Branch: Mechanical Engineering
Name of Teacher:

Course Objectives

This course enables the students:

1.	To acquire knowledge in recent advances in the CIM.
2.	Design and develop CIM systems using the knowledge of mathematics, science, engineering and IT tools
3.	Apply modern computational, analytical, tools and techniques to face the challenges in CIM.
4.	Communicate ideas effectively with diversified groups to become lead professionals in academia and industry in advanced areas of manufacturing.
5.	To inculcate students with professional and ethical attitude, and an ability to relate CIM issues to broader engineering and social context.

Course Outcomes:
After the completion of this course, students will be:

CO1.	Understand the effect of manufacturing automation strategies and know the basics of Computer Integrated Manufacturing (CIM)
CO2.	Analyse automated flow lines and assembly systems and balance the line.
CO3.	Design automated material handling and storage systems for a FMS
CO4.	Design manufacturing cells and apply automatic inspection methods in CIM environment.
CO5.	Analyze the role of OSI model in the design of communication protocols and comprehend the importance of data communications in CIM environment.

Syllabus

MODULE-I

Manufacturing Automation: Automated Manufacturing Systems, Computerized Manufacturing Support Systems, Reasons for Automation and Process Improvement, CIM, Computer based integration between various functions - manufacturing, sales, design, materials, shop floor & computer process monitoring. (8L)

MODULE-II

Manual Assembly Lines: Assembly Workstations and Work Transport Systems

Automated Flow lines: System Configurations, Work part Transfer Mechanisms, Storage Buffers, Control of Production Line, Analysis of Transfer Lines-Transfer Lines with No Internal Parts Storage, Transfer Lines with Internal Storage Buffers. The Line Balancing Problem. (8L)

MODULE-III

Flexible Manufacturing Systems: Flexibility, Types of FMS and its Components. FMS Applications and Benefits, Machine loading problems in FMS, Production scheduling, scheduling rules, Routing and sequencing decisions.

Automatic Material Handling and Storage systems: Design Considerations in Material Handling, Material Transport Equipment- Automated Guided Vehicles, Design of Automated Storage/Retrieval Systems. (8L)

MODULE-IV

Cellular Manufacturing Systems: Part Families, Parts Classification and Coding, Features of Parts Classification and Coding Systems, Opitz of Parts Classification and Coding Systems, Production Flow Analysis, Machine Cell Design, Applications of GT Quantitative analysis of Cellular Manufacturing, Grouping of parts and Machines by Rank Order Clustering, Arranging Machines in a GT Cell.

Automated Inspection systems: Overview of Automated Identification Methods, Bar Code Technology, Radio Frequency Identification. (8L)

MODULE-V

Computer Networks for Manufacturing

Introduction to Data Communications: Data Communications, CIM data Files and report formats for data management.
Networks, The Internet – History, Protocols and Standards. Network Models: Layered Tasks, The OSI model, Layers in the OSI model,
Network Layer: logical addressing and Internet Protocol. MAP/TOP,
Physical Layer and Media: Bandwidth Utilization, Multiplexing, Spread Spectrum, Transmission media
Data Link Layer: Error Detection and Correction, Data Link Control, Multiple Access, Wired LANs: Ethernet, Wireless LANs.
Transport and Application Layer: Process-to-Process Delivery: UDP, TCP and SCTP. Domain Name System, File Transfer. (8L)

Books:

Text books:

1. Groover, M.P., “Automation, Production Systems and Computer Integrated Manufacturing ",Third Edition, Prentice-Hall, 2007
2. P.N.Rao, "CAD/CAM Principle and Applications", Tata McGraw Hill Publishing Company Limited.
3. Viswanadham N. and Narahari Y., Performance Modelling of Automated Manufacturing Systems, Prentice Hall India, 1994.
4. Kumar Surender, U.Chandra,and S.C.Srivasatava, “Computer Integrated Manufacturing”, Satya Prakshan Pvt. Ltd., New Delhi

Reference books:

1. Kamrani, A.K, Parsaei, H.R and Liles, D.H. (Eds), "Planning, design and analysis of cellular manufacturing systems", Elsevier, 1995.
2. Burbidge, J.L., “Group Technology in Engineering Industry", Mechanical Engineering pub.London, 1979.
3. Rani, S.A., " Hand Book of Cellular Manufacturing Systems", John Wiley & Sons, 1999.
4. Askin R. G. and Standridge C. R., Modelling and Analysis of Manufacturing Systems, John Wiley and Sons, 1994.

5. Ranky P. G., Flexible Manufacturing Cells and Systems in CIM, CIM Ware Ltd., Guildford, Surrey, England, 1990.
6. B. Scholz and Reiter, C.I.M.Interfaces, Chapman Hall, 1992.
7. D. Bedworth et al., Computer Integrated Design and Manufacturing, McGraw Hill, 1991.

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

POs met through Gaps in the Syllabus
N.A

Topics beyond syllabus/Advanced topics/Design
N.A.

POs met through Topics beyond syllabus/Advanced topics/Design

	Course Delivery Methods
CD1	Lecture by use of boards/LCD projectors
CD2	Tutorials/Assignments
CD3	Seminars
CD4	Mini projects/Projects
CD5	Laboratory experiments/teaching aids
CD6	Industrial/guest lectures
CD7	Industrial visits/in-plant training
CD8	Self- learning such as use of NPTEL materials and internets

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

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes				
	PO1	PO2	PO3	PO4	PO5
CO1	2	3	3	2	1
CO2	2	3	3	2	2
CO3	2	3	3	2	2
CO4	3	3	3	2	3
CO5	3	3	3	2	2

Mapping Between COs and Course Delivery (CD) methods			
CD	**Course Delivery methods**	**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors	CO 1-5	CD1
CD2	Tutorials/Assignments	CO 1-5	CD2
CD3	Seminars		
CD4	Mini projects/Projects		
CD5	Laboratory experiments/teaching aids		
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		

COURSE INFORMATION SHEET

Course code: ME 520R1
Course title: ADDITIVE MANUFACTURING
Pre-requisite(s): B.Tech.
Co- requisite(s): None
Credits: 03 L: 03 T:0 P:0
Class schedule per week: 03
Class: M. Tech
Semester / Level: II/5
Branch: Mechanical Engineering
Name of Teacher:

Course Objectives

This course enables the students:

1.	To exploit technology used in additive manufacturing.
2.	To understand importance of additive manufacturing in advance manufacturing process.
3.	To acquire knowledge, techniques and skills to select relevant additive manufacturing process.
4.	To explore the potential of additive manufacturing in different industrial sectors.
5.	To apply 3D printing technology for additive manufacturing.

Course Outcomes:
After the completion of this course, students will be:

CO1.	Apply technique of CAD and reverse engineering for geometry transformation in additive manufacturing.
CO2.	Analyse and select suitable process and materials used in additive manufacturing.
CO3.	Identify, analyse, and solve problems related to additive manufacturing file formats.
CO4.	Apply additive manufacturing processes for direct and indirect tooling
CO5.	Simulate additive manufacturing processes

Syllabus

Module 1
Introduction
Overview, Basic principle need and advantages of additive manufacturing, Procedure of product development in additive manufacturing, Classification of additive manufacturing processes, Materials used in additive manufacturing, Challenges in Additive Manufacturing. [8L]

Module 2
Additive Manufacturing Processes
Liquid-Based Additive Manufacturing Systems I: 3D Systems' Stereolithography Apparatus (SLA), Cubital's Solid Ground Curing (SGC)
Solid-Based Additive Manufacturing Systems: Cubic Technologies' Laminated Object Manufacturing (LOM), Stratasys' Fused Deposition Modeling (FDM);
Powder-Based Additive Manufacturing Systems: 3D Systems' Selective Laser Sintering (SLS), Z Corporation's Three-Dimensional Printing (3DP), Extrude Hone's Prometal 3D Printing Process,
Newer *Additive Manufacturing Systems*: Electron beam free form fabrication (EBFFF), Electron beam melting (EBM), Plasma transferred arc additive manufacturing (PTAAM), Tungsten inert gas additive manufacturing (TIGAM), Metal inert gas additive manufacturing (MIGAM). [8L]

Module 3
Rapid Prototyping Data Formats:
STL Format, STL File Problems, STL File Repair, STL Conversion, STL error diagnostics and other standard file Formats.
Preparation of 3D-CAD model, Reverse engineering, Reconstruction of 3D-CAD model using reverse engineering, Part orientation and support generation, Slicing and Generation of codes for tool path, Surface preparation of materials. [8L]

Module 4
Direct and Indirect Tooling using Additive Manufacturing
Application of various Additive Manufacturing systems in Direct and Indirect Tooling. [8L]

Module 5
Post-Processing in Additive Manufacturing
Support material removal, surface texture improvement, accuracy improvement, aesthetic improvement, preparation for use as a pattern, property enhancements using non-thermal and thermal techniques, Brief information on characterization techniques used in additive manufacturing.
Modelling and Simulation: Thermal model to predict size of deposition such as width and height of deposition, Finite element simulation of additive process. [8L]

Books:

Text books:
1. Gibson, I, Rosen, D W., and Stucker,B., Additive Manufacturing Methodologies: Rapid Prototyping to Direct Digital Manufacturing,Springer, 2010 (T1).
2. Chua C.K., Leong K.F., and Lim C.S., "Rapid prototyping: Principles and applications", Third Edition, World Scientific Publishers, 2010 (T2).
3. Chee Kai Chua, Kah Fai Leong, 3D Printing and Additive Manufacturing: Principles and Applications: Fourth Edition of Rapid Prototyping, World Scientific Publishers, 2014 (T3)
4. Gebhardt A., "Rapid prototyping", Hanser Gardener Publications, 2003 (T4).

Reference books:
1. Liou L.W. and Liou F.W., "Rapid Prototyping and Engineering applications: A tool box for prototype development", CRC Press, 2007 (R1).
2. Kamrani A.K. and Nasr E.A., "Rapid Prototyping: Theory and practice", Springer, 2006 (R2).

Gaps in the syllabus (to meet Industry/Profession requirements)
N.A.

POs met through Gaps in the Syllabus
N.A

Topics beyond syllabus/Advanced topics/Design
N.A.

POs met through Topics beyond syllabus/Advanced topics/Design

	Course Delivery Methods
CD1	Lecture by use of boards/LCD projectors
CD2	Tutorials/Assignments
CD3	Seminars
CD4	Mini projects/Projects

CD5	Laboratory experiments/teaching aids
CD6	Industrial/guest lectures
CD7	Industrial visits/in-plant training
CD8	Self- learning such as use of NPTEL materials and internets

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

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes				
	PO1	PO2	PO3	PO4	PO5
CO1	3	2	3	3	1
CO2	3	2	3	2	2
CO3	3	3	3	3	2
CO4	3	3	3	3	2
CO5	3	3	3	2	2

Mapping Between COs and Course Delivery (CD) methods			
CD	**Course Delivery methods**	**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors	CO 1-5	CD1
CD2	Tutorials/Assignments	CO 1-5	CD2
CD3	Seminars		
CD4	Mini projects/Projects		
CD5	Laboratory experiments/teaching aids		
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		

COURSE INFORMATION SHEET

Course code: ME 525R1
Course title: Robotics Manipulator Design
Pre-requisite(s): B. Tech Kinematics and Dynamics of Machines
Co- requisite(s): NIL
Credits: 3 L: 3 T: 0 P: 0Class
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 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 dynamic parameters of a serial robot by applying the knowledge of general form of dynamic equation of motion.
CO3.	Analyse planar and spatial parallel robots in context to its forward and inverse kinematics, and evaluate its singularity, condition number and manoeuvrability.
CO4.	Design a robotic manipulator and evaluate its primary and secondaryworkspace. Evaluate the performance of an industrial robot based on ISO standards.
CO5.	Determine the trajectory planning of the robot manipulator, and its motion control using various control techniques.

SYLLABUS

Module 1:

Introduction to serial and parallel robot structure, standard kinematic notations, transformation matrices, link and joint parameters, forward and inverse kinematics, Euler angles, The Jacobian matrix, Link velocities, Jacobian computation, Acceleration analysis, Singularity and Redundant robots. (8L)

Module 2:

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. Identificationof dynamic parameters, choice of identification trajectories, Evaluation of joint coordinates and torques, Practical considerations. (8L)

Module 3:

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 4:

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)

Module 5:

Trajectory planning: Cartesian and Joint space trajectories, Cubic, Quintic polynomial, Point to Point and Continuous path planning. Introduction to various control techniques, open-loop and closed-loop control, proportional (P) control, Integral (I) control, Derivative (D) control, PI control, PD control, PID control, State space representation. (8L)

Text Books

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

Reference Books

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

6. 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	3
CO4	3	3	3	3	3
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): B.Tech Engineering Mathematics, Engineering Mechanics
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	50
Semester End Examination	50

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

Semester End Examination	% Distribution
Examination Experiment Performance	30
Quiz	20

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 COURSEDELIVERY 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: ME 516
Course title: Advanced CAD and Reverse Engineering Lab
Pre-requisite(s): B.Tech
Co- requisite(s):
Credits:2 L:0, T: 0, P4
Class schedule per week: 04
Class: MCD
Semester / Level: II/05
Branch: Mechanical Engineering
Name of Teacher:

Course Objectives

This course enables the students:

A.	To learn various 2D and 3D Modeling techniques
B	To be conversant with reverse engineering and design attributes
C	To know various softwares for curve fitting
D	To be able to generate prototypes with various RP techniques

Course Outcomes

After the completion of this course, students will be able to:

1.	Create 3D models and prepare a new design
2.	Analyse the cloud data points and to further process it
3.	Generate usable data after curve fitting and segmentation
4.	Produce rapid prototyped parts out of scanned data
5.	Generate new ideas and products for varied uses

List of Experiments

- Review of 2-Dimensional drawing.
- Introduction to 3-Dimensional modelling (Part modelling)
- Introduction to assembly modelling and assembly of mechanical engineering components
- Writing program for 2-D and 3-D transformation for Translation, Scaling, Rotation, Shearing and Reflection
- To scan and gather the cloud data from the digitizer/ scanner
- To convert the point cloud to a polygonal mode (Clean, smoothen and sculpt the required shape and memory)
- To draw or create curves on the mesh using automated tools such as feature detection
- Fit the B Spline surfaces using surface fitting and editing tools
- Export the final fitted curves to a CAD package and generate tool paths for machining.
- Analysis and measurement of the dimensions of each component for a new design

- Convert finally to .stl and pass the drawing to the Rapid Prototyping Machine
- Analyse the final prototype with the initial prototype.

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
Day to day performance & Lab files	10
Quiz (es)	20
Viva	20

Semester End Examination	% Distribution
Examination Experiment Performance	30
Quiz	20

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 of Course Outcomes onto Program Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	3	2
CO2	3	3	3	1	1

CO3	3	2	2	1	2
CO4	3		3	1	1
CO5	2	2	3	3	3

MAPPING BETWEEN COURSE OUTCOMES AND COURSEDELIVERY 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

Open Electives

COURSE INFORMATION SHEET

Course code: ME 682
Course title: Design Methodology
Pre-requisite(s): B.Tech
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.	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, EmrahYayici.
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> :
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: ME 683
Course title: Renewable Sources of Energy
Pre-requisite(s): B.Tech
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: III/06
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

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 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 , Biomassprograms 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 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: ME 684
Course title: Energy Management and Auditing
Pre-requisite(s): B.Tech
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: III/06
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 energy equipment and to prepare energy flow diagrams andenergy 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 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: ME 685
Course title: Industrial Robotics
Pre-requisite(s): B. Tech
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 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, Theory (Quiz and End semester) examinations

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

Cost effective performance analysis of robots.

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

<u>Topics beyond syllabus/Advanced topics/Design:</u>

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: ME 686
Course title: Reliability in Design
Pre-requisite(s): B.Tech
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 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 ofReliability 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) andTaguchi 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 VasiliyKrivtsov. 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) :
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