M. Tech. (Mechanical Engineering)

Course Name: Applied Mathematics and Computational Techniques **Course Code:** ME501
L-T-P scheme: 3-0-0 **Credits: 3**

Prerequisites

- Knowledge of basic calculus and linear algebra.
- Experience with a programming language (e.g., Python, MATLAB, or C).

Objectives

- Develop a strong understanding of applied mathematics concepts.
- Gain proficiency in computational techniques for problem-solving.
- Apply mathematical methods to real-world scenarios.
- Learn to use programming tools for computational applications

Learning Outcomes:

Course Outcome	Description
CO1	Define the basics of Applied Mathematics and Computational Techniques
CO2	Explanation of Applied Mathematics and Computational Techniques in different engineering application
CO3	Apply/execute the numerical methods , Statistical Analysis and Probability and Advanced Topics in Computational Mathematics
CO4	Analysis of Statistical Analysis and Probability and Advanced Topics in Computational Mathematics
CO5	Evaluate/Justify the Advanced Topics in Computational Mathematics for real life and engineering application
CO6	Create mathematical models Probability and Advanced Topics in Computational Mathematics

Unit1: Introduction to Applied Mathematics and Computational Tools

- Overview of applied mathematics and its importance.
- Common computational tools and programming languages.
- Introduction to mathematical modelling.
- Overview of commonly used software (e.g., MATLAB, Python with NumPy/SciPy).
- Implementing computational algorithms in software.

Unit 2: Numerical Methods for Solving Equations

- Root-finding algorithms (e.g., bisection, Newton-Raphson, False Positioning).

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- Systems of linear equations (e.g., Gaussian elimination, LU decomposition, Gauss Seidel).
- Differential Equations, types of differential equations (ODEs, PDEs) and analytical solution methods.
- Numerical methods for solving ODEs (e.g., Euler's method, Runge-Kutta) and PDEs.
- Numerical Integration.
- Curve fitting and Interpolation.
- Linear Algebra in Computational Context
- Review of linear algebra fundamentals and its applications in computational techniques.
- Matrix operations and eigenvalues/eigenvector problems.
- Applications in physics and engineering.

Unit 3: Statistical Analysis and Probability

- Basic statistical concepts (mean, median, variance).
- Probability distributions and their applications.
- Monte Carlo simulations.

Unit 4: Advanced Topics in Computational Mathematics

- Fourier transforms and signal processing.
- Complex numbers and applications in energy engineering.
- Laplace transforms and their applications.

Unit 5: Case studies demonstrating real-world applications.

Course Overview

This course provides an in-depth study of mathematical methods used in applied contexts, focusing on computational techniques for solving real-world problems. Topics include advanced linear algebra, numerical methods, differential equations, optimization, statistical analysis, and applications in various engineering fields.

Exams	Marks	Coverage
Test-1	15 Marks	Syllabus covered upto Test-1
Test-2	25 Marks	Syllabus covered upto Test-2
Test-3	35 Marks	Full Syllabus
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

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Textbooks and Resources

- Primary Textbooks: (a) Advanced Engineering Mathematics,Erwin Kreyszig (Wiley) (b)Numerical Methods for Engineers and Scientists, J.D.Hoffman (Taylor and Francis). (c) Numerical Methods using Python (For scientists and Engineers), Pankaj Dumka (BlueRose).
- Supplementary Resources: Online tutorials, academic papers, and software documentation.

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Course Name: Applied Mathematics and Computational Techniques Lab
Course Code: ME601 **L-T-P scheme: 0-0-2** **Credits: 1**
Prerequisites

- Knowledge of basic calculus and linear algebra.
- Experience with a programming language (e.g., Python, MATLAB, or C).

Objectives

- Develop a strong understanding of applied mathematics concepts.
- Gain proficiency in computational techniques for problem-solving.
- Apply mathematical methods to real-world scenarios.
- Learn to use programming tools for computational applications

Course Outcome	Description
CO1	Define the basics of Applied Mathematics and Computational Techniques
CO2	Explanation of Applied Mathematics and Computational Techniques in different engineering application
CO3	Apply/execute the numerical methods , Statistical Analysis and Probability and Advanced Topics in Computational Mathematics
CO4	Analysis of Statistical Analysis and Probability and Advanced Topics in Computational Mathematics
CO5	Evaluate/Justify the Advanced Topics in Computational Mathematics for real life and engineering application
CO6	Create mathematical models Probability and Advanced Topics in Computational Mathematics

List of Experiments
Experiment 1 (a) and (b):Introduction to Python for Applied Mathematics
Objective: To learn basic operations in Python for mathematical computation.
Description: Implement simple mathematical operations and functions in Python. Write a script to plot a basic graph or function and demonstrate basic data manipulation.
Expected Outcome: Familiarity with Python as computational tools, including basic syntax, data types, and plotting capabilities.

Experiment 2:Mathematical Modelling
Objective: To create a basic mathematical model using differential equations.

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Description: Develop a simple model representing a physical system (e.g., population growth, pendulum motion). Use Python to simulate the system's behaviour over time and validate the results with theoretical predictions.
Expected Outcome: Understanding of mathematical modelling concepts and the ability to create simple models using differential equations.

Experiment 3: Root-Finding Algorithms
Objective: To implement and compare different root-finding algorithms.
Description: Implement bisection, Newton-Raphson, and false positioning methods to find the roots of a given function. Compare their convergence rates and accuracy.
Expected Outcome: Knowledge of different root-finding algorithms and their practical implementation.

Experiment 4: Solving Systems of Linear Equations
Objective: To solve systems of linear equations using various computational methods.
Description: Implement Gaussian elimination, LU decomposition, and Gauss-Seidel iteration to solve systems of linear equations. Evaluate their performance on different types of systems.
Expected Outcome: Understanding of methods to solve systems of linear equations and their computational characteristics.

Experiment 5 (a) and (b): Numerical Methods for ODEs and PDEs
Objective: To solve ordinary and partial differential equations using numerical methods.
Description: Implement Euler's method and Runge-Kutta to solve simple ODEs. For PDEs, use finite difference or finite element methods to solve basic equations like the heat equation. Analyse stability and convergence.
Expected Outcome: Understanding of numerical methods for differential equations and their practical applications.

Experiment 6: Statistical Analysis and Data Visualization
Objective: To perform basic statistical analysis and create data visualizations.
Description: Given a dataset, calculate basic statistics (mean, median, variance) and visualize the data with histograms, scatter plots, and box plots. Discuss the results and identify any patterns or anomalies.
Expected Outcome: Understanding of basic statistical concepts and the ability to visualize data in meaningful ways.

Experiment 7: Monte Carlo Simulations
Objective: To use Monte Carlo simulations for probabilistic analysis.

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Description: Implement a Monte Carlo simulation to estimate the value of Pi or simulate a simple random process. Discuss the concept of convergence and the role of randomness in these simulations.
Expected Outcome: Understanding of Monte Carlo simulations and their applications in probabilistic analysis.

Experiment 8: Fourier Transforms and Signal Processing
Objective: To understand and apply Fourier transforms for signal processing.
Description: Implement the Fast Fourier Transform (FFT) to analyse a signal in the frequency domain. Apply this technique to real-world signals (such as audio or image data) and explore filtering techniques.
Expected Outcome: Knowledge of Fourier transforms and their role in signal processing.

Experiment 9: Complex Numbers and Their Applications
Objective: To explore the use of complex numbers in engineering applications.
Description: Implement complex arithmetic and apply it to electrical engineering problems (like impedance calculations). Analyse circuits using complex numbers and discuss their significance.
Expected Outcome: Understanding of complex numbers and their practical applications in engineering.
Experiment 10: Laplace Transforms and Their Applications
Objective: To use Laplace transforms for solving differential equations and system analysis.
Description: Implement Laplace transforms to solve linear differential equations. Apply these techniques to analyse simple control systems or electrical circuits, and discuss the insights gained from using Laplace transforms.
Expected Outcome: Understanding of Laplace transforms and their applications in solving differential equations and analysing systems.

Experiment 11: Comparing Numerical Integration Methods
Objective: Implement and compare different numerical integration methods to assess accuracy and efficiency.
Description: Implement Numerical Integration techniques likeTrapezoidal Rule, Simpson's Rule, and Gaussian Quadrature to solve some integration problem and compare with the analytical solution.Record errors and analyse the accuracy of each method.
Expected Outcome:Understanding of Numerical Integration methods and their applications in solving integration problems.

Exams	Marks	Coverage
P-1	15 Marks	Syllabus covered upto P-1
P-2	15 Marks	Full Syllabus

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Lab Record	15 Marks	
Punctuality and attendance	15 Marks	
Day to Day Marks	40 Marks	
Total	**100 Marks**	

Course Name: Properties and Selection of Engineering Materials **Course Code:** ME502

L-T-P scheme: 3-0-0 **Credits: 3**

Prerequisite:

Objective:

1. To understand the basic concepts of bonding, crystals, and crystallographic defects in engineering materials.
2. To understand various diffusion, phase diagrams, phase transformations, heat treatment methods and mechanical testing of the materials.
3. To learn various metals, ceramics, polymers, and composite materials and properties of the materials such as mechanical, corrosion, thermal and magnetic, which will help to select the material as per the requirements.

Learning Outcomes:

CO1	Remember the basics of bonding in solids, crystal structure, and defects in crystals
CO2	Understand the concepts of diffusion in solids, phases, phase diagrams, phase transformation, microstructure evaluation, heat treatment processes and mechanical testing of materials.
CO3	Apply the knowledge to distinguish the behaviour of engineering materials as per their properties for specific applications.
CO4	Analyse the material as per requirement to select, process and use in various engineering applications.
CO5	Evaluate the behaviour of the engineering material to defend its use.

Course Content

Unit-1

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Introduction to engineering materials: Types of bonding, Bond force, bond energy, bond length

Crystalline materials: Crystallographic structures, lattice points and space lattice, crystal parameters, crystal symmetries, lattice energy, Bravais space lattices, direction, planes and Miller indices, distribution of atoms in atomic planes, separating between lative planes, allotropy and polymorphism, lattice defects, X-ray diffraction, Bragg's law, Bragg's S-ray spectrometer and correction to Bragg's equation and properties of crystalline solids

<u>Unit-2</u>

Mechanical properties of engineering materials: Diffusion mechanism in solids, steady-state and non-steady-state diffusion, factors affecting diffusion, solubility limit, phase and phase equilibrium, unary phase diagrams, binary phase diagrams, microstructures of isomorphous alloys, mechanical properties of isomorphous alloys, Binary eutectic systems, microstructures of eutectic alloys, eutectoid and peritectic reactions, ceramic and ternary phase diagrams, Gibbs phase rule, iron-iron carbide phase diagram, development of microstructure of Iron-carbon alloys, influence of other alloying elements

Kinetics of phase transformation, isothermal phase transformation diagram, continuous cooling transformation diagrams, mechanical behaviour of Iron-carbon alloys, characteristics of dislocation, slip systems, plastic deformation of polycrystalline materials, strengthening by grain size reduction, solid-solution strengthening, strain hardening, grain recovery and recrystallisation, grain growth, precipitation hardening and heat treatment processes

<u>Unit-3</u>

Failure to engineering materials: fundamentals of fracture, principles of fracture mechanics, tensile, compression, shear, impact, fatigue and creep testing

Ceramics: Glass-ceramics, clay products, refractories, abrasives, cements, ceramic phase diagrams, brittle fracture of ceramics, stress-strain behaviour, mechanism of plastic deformation, heat treatment of glass ceramics

Polymers: Polymer molecules, molecular weight, shape, structure, configuration, thermoplastics and thermosetting plastics, stress-strain behaviour of polymers, macroscopic, viscoelastic deformation and fracture of polymers

<u>Unit-4</u>

Composite materials: particle-reinforced composite, fibre-reinforced composite, polymer-matrix composite, metal-matrix composite, ceramic-matrix composite, carbon-carbon composite, and hybrid composites

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Corrosion of metals: electrochemical considerations, corrosion rate and its prediction, passivity, environmental effects, forms of corrosion, corrosion environment, corrosion prevention

Magnetic properties of engineering materials: diamagnetism, Paramagnetism, ferromagnetism, antiferromagnetism, influence of temperature on magnetic behaviour, domain and hysteresis

Thermal properties of engineering materials: Heat capacity, thermal expansion, thermal conductivity, and thermal stress

Textbooks:

1. William D. Callister, Material Science and Engineering, Willey
2. S. O. Pillai, Solid State Physics, New Age International
3. V. Raghavan, Materials Science and Engineering, PHI

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Course Name: Experimental Methods **Course Code:** ME503

L-T-P scheme: 3-0-0 **Credits: 3**

Prerequisite:

Objective:

1. To understand the basic terminology used for experimentation
2. To analyse the data of the experimentation using statistical methods and regression modelling
3. To learn various methods to experimentally evaluate pressure, flow rate, temperature, force and signal conditioning for data acquisition.

Learning Outcomes:

CO1	Remember the basic terminologies used in experimental work
CO2	Understand the concepts of experimental design, experimentation, data acquisition and modelling.
CO3	Apply the knowledge to distinguish the various errors of experimentations and its compensation
CO4	Analyse the experimental work through signal conditioning, data acquisition, modelling, and prediction.
CO5	Evaluate the experimental work through proper selection of measuring instruments, experimentation with lower order of errors to standardise the process.

Course Content

Unit-1

Introduction: Calibration, standards, dimensions and units, measurement system, dynamic measurement, system response, distortion, impedance matching and experimental planning

Analysis of experimental data: Causes and types of errors, error compensation, uncertainty analysis, statistical analysis of experimental data, probability distribution, Gaussian/normal error distribution, Chi-Square test, methods of least squares, correlation coefficient, multivariable regression, standard deviation and mean, student's t-distribution, graphical analysis, and curve fitting

Unit-2

Design of experiment: Types of experiments, experiments design factors, protocols, factorial designs, Response surface design and Taguchi design

Pressure measurement: Dynamic response considerations, mechanical pressure measurement devices, Bourdon-Tube pressure gage, diaphragm and bellows gages, Bridgman gage, McLeod gage, Pirani Thermal-conductive gage, Knudsen gage, Ionization gage and Alphatron gage

Flow measurement: Positive displacement method, flow-obstruction method, sonic nozzle, flow measurement by drag effects, hot-wire and hot-film anemometers, magnetic flow meters, flow visualization methods, and laser doppler anemometer

Unit-3

Temperature measurement: Temperature measurement by mechanical effects, electrical effects, and radiations, effect of heat transfer on temperature measurement, transient response of thermal systems, and thermocouple compensations, Thermal conductivity measurement, measurement of viscosity, convection heat transfer measurement, humidity measurement and Heat flux meters

Force measurement: Mass balance measurement, elastic elements of force measurement, torque measurement, strain measurement, electrical-resistance strain gage, principles of seismic instruments, sound measurement

Unit-4

Electrical measurement: Potentiometer, linear differential transformer, capacitive transducer, piezoelectric transducer, photoelectric effect, photoconductive transducer, photovoltaic cells, and Hall-effect transducer

Data acquisition and processing: Inverting, noninverting, summing, difference, integrating and logarithmic amplifiers, low pass, high pass, band pass and band stop filters, analogue to digital and digital to analogue converters

Textbooks:

1. J. P. Holman, Experimental Methods for Engineers, Tata McGraw Hill
2. T. W. Armstrong, Introduction to Experimental Methods, CRC Press
3. R. S. Figliola and D. E. Beasley, Theory and Design for Mechanical Measurement, Jhon Wiley & Sons

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Course Name: Experimental Methods Lab **Course Code:** ME602

L-T-P scheme: 0-0-1 **Credits: 1**

Prerequisite:

Objective:

1. To understand the basic experimental techniques
2. To analyse the data of the experimentation and regression modelling
3. To learn various methods to experimentally evaluate the behaviour of the experimental work through pressure, flow rate, temperature, force measurement dealing with signal conditioning for data acquisition.

Learning Outcomes:

CO1	Remember the basic principles of experimental work
CO2	Understand the concepts of experimental design, experimentation, data acquisition and modelling.
CO3	Apply the knowledge to distinguish the various errors of experimentations and its compensation to have a better quantization of it.
CO4	Analyse the experimental work through signal conditioning, data acquisition, modelling, and prediction of the output for certain inputs
CO5	Evaluate the experimental work through proper selection of measuring instruments, experimentation with lower order of errors to standardise the process for benchmarking.

Course Content

Experiment 1: To measure the turning force using a turning dynamometer.

Experiment 2: To measure the temperature of the tool at the rake surface during turning operation.

Experiment 3: To measure the vibration generated during the turning operation of a workpiece.

Experiment 4: To measure flow rate using pitot tube and orifice meter.

Experiment 5: To measure the flow velocity with the help of pitot static tube.

Experiment 6: To calibrate burden-tube pressure gage using differential u-tube manometer.

Experiment 7: To measure weight using strain gage setup.

Experiment 8: To measure thermal conductivity of solids and liquids.

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Experiment 9: To measure convective heat transfer in liquids and gases.

Experiment 10: To measure psychrometric parameters for atmospheric air.

Experiment 11: To measure lift and drag on bluff bodies.

Experiment 12:To measure the calorific value of coal using bomb calorimeter.

Experiment 13: To measure the variations of HAZ thickness of EDM drilled holes concerning with the EDM parameters.

Experiment 14: To measure the variation of output of photo voltaic panel with the variation of panel surface temperature.

Textbooks:

1. J. P. Holman, Experimental Methods for Engineers, Tata McGraw Hill
2. T. W. Armstrong, Introduction to Experimental Methods, CRC Press
3. R. S. Figliola and D. E. Beasley, Theory and Design for Mechanical Measurement, Jhon Wiley & Sons

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Course Name: Optimization and Meta heuristic approach **Course Code:** ME504
L-T-P scheme: 3-0-0 **Credits: 3**

Prerequisites:

1. Artificial Intelligence, Numerical Calculus, Programming, Probability and Statistics, Operational Research
2. Knowledge of numerical algorithms, statistics, artificial intelligence, optimization and programming abilities

Objectives:

1. Ability to identify the meta heuristic technique appropriate for a specific problem Ability to implement and validate a computational model based on meta heuristic algorithms Ability to solve a real-world problem using computational intelligence tools
2. Ability to conduct research activity and to prepare reports on a given topic

Learning Outcomes:

Course Outcome	**Description**
CO1	Define the selection, adaptation, prediction and corresponding search spaces, classes of Meta heuristics, the overall structure of a Meta heuristic algorithm, Population-based Meta heuristics, Swarm Intelligence
CO2	Explain the Trajectory-based Meta heuristics, deterministic local search, Random local search
CO3	Application of Population-based Meta heuristics, Swarm Intelligence, Scalability of Meta heuristic Algorithms
CO4	Analysis of Parallel models for population-based Meta heuristics, dynamic optimization hyper-mutation, random immigrants, ageing mechanisms,
CO5	Evaluate the Scalability of Meta heuristic Algorithms, Trajectory-based Meta heuristics etc.
CO6	Develop the model for heuristic algorithms, Population-based Meta heuristics, Swarm Intelligence

Course contents

Unit-I:

Introduction Classes of difficult problems planning, assignment, selection, adaptation, prediction and corresponding search spaces, classes of Meta heuristics, the overall structure of a Meta heuristic algorithm.

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Unit-II:

Trajectory-based Meta heuristics, deterministic local search, Random local search (Matyas and Solis-Wets algorithms). Global search restarted local search, iterated local search, simulated annealing, tabu search, variable neighborhood search etc.

Unit-III:

Population-based Meta heuristics. Overall structure. Main components exploration and exploitation operators, operators for evolutionary algorithms: mutation, crossover, selection. Encoding types. Genetic algorithms, evolution strategies, evolutionary programming, genetic programming.

Unit-IV:

Swarm Intelligence. Ant colony optimization. Particle swarm optimization. Artificial bee colony, Difference-based and Probabilistic Algorithms. Differential Evolution, Population Based Incremental Learning, Estimation of Distribution Algorithms, Bayesian Optimization Algorithms

UnitV:

Scalability of Meta heuristic Algorithms. Cooperative co evolution. Parallel models for population-based Meta heuristics (master-slave, island, cellular, Multi-objective/ multi-modal/ dynamic optimization. Particularities of multi-objective optimization (non-domination, Pareto front etc). Apriori and aposteriori techniques. Quality metrics. Multi-modal optimization and specific approaches (niching, sharing etc). Techniques for dynamic optimization (hyper-mutation, random immigrants, ageing mechanisms, Applications of meta heuristic algorithms for: neural networks design, data mining, scheduling

Exams	**Marks**	**Coverage**
Test-1	15 Marks	Syllabus covered upto Test-1
Test-2	25 Marks	Syllabus covered upto Test-2
Test-3	35 Marks	Full Syllabus
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

References:

1. A. Engelbrecht: Computational Intelligence. An Introduction, Wiley, 2007
2. Z. Michalewicz, D. Fogel: How to Solve It. Modern Heuristics. Springer, 1999
3. Coello C.A., van Veldhuizen D.A., Lamont, G.B.: Evolutionary Algorithms for Solving Multiobjective Problems, Kluwer, 2002
4. D. Zaharie: Metaheuristic algorithms (http://www.info.uvt.ro/~dzaharie/ma2017/lecture)

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Sean Luke: Essentials of Metaheuristics, Lulu, second edition, 2013, available for free at http://cs.gmu.edu/~sean/book/metaheuristics/

Title: Research Methodology and IPR **Course Code:** ME505
L-T-P scheme: 2-0-0 **Credits:** 2(2-0-0)

Course Outcome	Description
CO1	To understand the knowledge on basics of research and its types.
CO2	To learn the concept of literature review, technical reading, attributions and citations.
CO3	Apply the concept of collecting and analyzing the data
CO4	Judge the ethics in research
CO5	To discuss the concepts of Intellectual Property Rights in engineering.

Course Contents:

Unit-1: Introduction, meaning of research, objectives of research, types of research, research approaches, significance of research, research methods versus methodology, research and scientific method, research process, criteria of good research, problems encountered by researchers in India, defining the research problem.

Unit-2: Research design: features of a good design, important concepts relating to research design, use of secondary and exploratory data to answer the research question, qualitative research, observation studies, experiments and surveys. – Case studies

Unit-3: Data Collection and Sources- measurements, measurement scales, questionnaires and instruments, sampling and methods. Data - preparing, exploring, examining and displaying. Data analysis and reporting- overview of multivariate analysis, hypotheses testing and measures of association. Presenting insights and findings using written reports and oral presentation.

Unit-4: Intellectual Property Rights (IPR): Intellectual Property – The concept of IPR, Evolution and development of concept of IPR, IPR development process, Trade secrets, utility Models, IPR & Bio diversity, Role of WIPO and WTO in IPR establishments, Right of Property, Common rules of IPR practices, Types and Features of IPR Agreement, Trademark, Functions of UNESCO in IPR maintenance.

Unit-5: Patents – objectives and benefits of patent, Concept, features of patent, Inventive step, Specification, Types of patent application, process E-filling, Examination of patent, Grant of patent, Revocation, Equitable Assignments, Licenses, Licensing of related patents, patent agents, Registration of patent agents.

References:

1. Research Methodology: A Step-by-Step Guide for Beginners, Ranjit Kumar
2. Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, John W. Creswell
3. The Craft of Research, Wayne C. Booth, Gregory G. Colomb, Joseph M. Williams
4. Intellectual Property: A Very Short Introduction, Siva Vaidhyanathan
5. Intellectual Property: The Law of Trademarks, Copyrights, Patents, and Trade Secrets" Deborah E. Bouchoux
6. Research methodology: an introduction for science & engineering students, Stuart Melville and Wayne Goddard,

Title: Advanced Solid Mechanics **Code:**
L-T-P scheme: 3-0-0 **Credit: 3**

Prerequisite: Students must have already studied courses, “Engineering Mechanics” and “Strength of Materials”

Objective:

1. The primary objective of the course is to introduce students to advanced topics of solid mechanics, e.g., nonlinear elasticity, plasticity, wave propogation, thermodynamic, constitutive modeling etc.
2. Toprovide the fundamental concepts and principles in the analysis of solids in three dimensions
3. Comparison of the 3D elasticity solutions to boundary value problems and frame simplified solutions

Learning Outcomes:

Course	Description

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Outcome	
CO1	**Outline** various concepts, principles and governing equations of mechanics of solid in three dimensions
CO2	**Describe** the ability to interpret complex three dimensional problems
CO3	**Develop** analytical, experimental and computational tools needed to solve the idealized three dimensional problems
CO4	**Identify**the possible solutions to guide a corresponding design, manufacture or failure analysis
CO5	**Apply** the independent judgment required to interpret the results of these solutions

Course Content:

Unit-1:INTRODUCTION

Review of basic concepts and equations in mechanics, Classification of materials, Outline of general techniques to solve boundary value problems.

Unit-2: STRESS AND STRAINS IN 3-D

Cauchy formula, Principal Stress, hydrostatic stress, deviatoric stress, stress transformations, Mohr circle, octahedral shear stress, strain energy densities, etc.

Unit-3:STRAIN ENERGY AND IMPACT LOADING

Definitions, expressions for strain energy stored in a body when load is applied: (i) gradually, (ii) suddenly and (iii) with impact, strain energy of beams in bending, beam deflections, strain energy of shafts in twisting, energy methods in determining spring deflection, Castigliano's& Maxwell's theorems.

Unit-4: UNSYMMETRICAL BENDING

Properties of beam cross section, product of inertia, ellipse of inertia, slope of the neutral axis, stresses and deflections, shear center and the flexural AXIS.

Unit-5:BENDING OF CURVED BARS

Stresses in bars of initial large radius of curvature, bars of initial small radius of curvature, stresses in crane hooks, rings of circular & trapezoidal sections, deflection of curved bars and rings, deflection of rings by Castigliano's theorem stresses in simple chain link, deflection of simple chain links.

Unit-6: THICK PRESSURE VESSELS

Derivation of Lame's equations, radial & hoop stresses and strains in thick and compound cylinders and spherical shells subjected to internal fluid pressure only, wire wound cylinders, hub shrunk on solid shaft.

Unit-7: ROTATING MEMBERS

Stresses in uniform rotating rings and discs, stresses in rotating rims, rotating cylinders, hollow and solids cylinders.

Unit-8: COLUMNS AND STRUTS

Straight and initially curved columns and struts, Rankine's formula.

Teaching Methodology:

This course is introduced to help students in applying their knowledge of Engineering Mechanics and Strength of Materials in order to explore the vast area of applied mechanics and to enhance students' ability to solve problems related to theory of elasticity and plasticity. The entire course is divided into eight separate units: Introduction, Stress and Strains in 3-D, Strain Energy and Impact Loading, Unsymmetrical Bending, Bending of Curved Bars, Thick Pressure Vessels, Rotating Members and Columns and Struts. These sections have been framed to impart a systematic understanding of the basic and advanced principles of mechanics of materials and finally implement these principles to evaluate design, manufacture or failure analysis to satisfy functional and strength requirements. This course is intended to enable the students to apply the knowledge of advanced mechanics of solids in practical engineering problems.

Evaluation Scheme:

Exams	**Marks**	**Coverage**
Test-1	15 Marks	Based on Unit-1 & Unit-2
Test-2	25 Marks	Based on Unit-3, Unit-4, Unit-5 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-6, Unit-7, Unit-8 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Tutorials and lecture slides on Advanced Mechanics of Solids (will be added from time to time): Digital copy will be available on the JUET server.

Text Book:

[1] Advanced Mechanics of Solids by L. S. Srinath, McGraw Hill Education, 2010.
[2] Advanced Mechanics of Materials by Kamal Kumar and R. C. Ghai, 7th Edition, Khanna Publishers

Reference Books/Material:

[1] Advanced Strength of Materials by J. P. Den Hartog Dover Publications, 2014.
[2] Advanced Mechanics of Materials and Applied Elasticity, Saul K. Fenster and Ansel C. Ugural, 5th Edition, Prentice Hall, 2011.

Web References:

[1] https://nptel.ac.in/courses/112101095/
[2]https://ocw.mit.edu/courses/mechanical-engineering/2-002-mechanics-and-materialsii-spring-2004/

Journals References:

[1] Mechanics of Materials, Elsevier
[2] Strength of Materials, Springer
[3] Applied Mechanics and Materials, Scientific.Net
[4] Mechanics of Advanced Materials and Structures, Taylor & Francis
[5] JSME international journal. Ser. 1, Solid mechanics, strength of materials

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Title: Advanced Solid Mechanics Lab **Code:**

L-T-P scheme:0-0-2 **Credit: 1**

List of experiment:

1. To perform uniaxial tension test
2. To perform torsion test
3. To perform compression test
4. To perform Notch impact test
5. To perform Hardness test
6. Locating shear centre of a section
7. Young's modulus – Non Uniform Bending
8. To perform fatigue testing
9. To perform cupping test
10. To perform shear test

Evaluation Scheme:

Exams	Marks	Coverage
P-1	15 Marks	**Based on Lab Exercises: 1-5**
P-2	15 Marks	**Based on Lab Exercises: 6-10**
Day-to-Day Work	40 Marks	**70 Marks**
Lab Record	15 Marks	
Attendance & Discipline	15 Marks	
Total	**100 Marks**	

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Title: Advanced dynamics **Code:**
L-T-P scheme: 3-0-0 **Credit: 3**

Prerequisite: Students must have studied “Kinematics of Machines” and “Dynamics of Machines”.

Objective:

The objective of the course is to introduce basic and advanced topics of vibrations andillustrate significant applications to determine dynamic response of components/structures.

Learning Outcomes:

Course Outcome	Description
CO1	**Outline** different degree of freedom in the vibration system
CO2	**Describe**Multi-degree of freedom systems and continuous system
CO3	**Develop**Response spectrum
CO4	**Identify**Time integration schemes
CO5	**Apply** Lagrange’s equations and Principle of virtual work

Course Content:

Unit-1: Free vibration of single-degree-of –freedom (SDOF) systems,undamped and damped systems

Unit-2:

Forced vibration of single-degree-of –freedom (SDOF) systems, undamped and damped systems, rotating unbalanced mass, whirling of rotating shafts

Unit-3: Harmonic motion of the support, energy dissipation, response to periodic excitation, impulse response, Response to general loading, Duhamel integral

Unit-4:

Energy principles, Lagrange’s equation, Work and energy, principle of virtual work, Alembert’s principle, Lagrange’s equations of motion

Unit-5:Two-degree-of-freedom systems, orthogonality of modes, beatphenomenon

Unit-6: Multi-degree-of-freedom systems, eigenvalue problem, modal analysis, Time integration schemes

Unit-7:

Continuous system, free vibration, bending vibration of rods, bars,beams and plates

Unit-8:

Rayleigh’s energy method, Rayleigh-Ritz method. Symmetric andantisymmetric modes, Kinematics of moving frames & respective applications

M. Tech. (Mechanical Engineering)

Teaching Methodology:

This course is introduced to provideSingle Degrees of Freedom systems, Multi-degree of freedom systems, Responsespectrum, Time integration schemes, Lagrange's equations, Principle of virtual work,continuous system. The entire course is broken down into eight units. Each section helps a student to gain detail knowledge of different types of engineering problems.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1, Unit-2 & Unit-3
Test-2	25 Marks	Based on Unit-4, Unit-5 & Unit-6 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-7 & Unit-8 and around 30% from coverage of Test-1 & Test-2.
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Course-related resources will be provided on JUET server. This can include eBook, lecture material, supplementary course notes.

Text Book:

[1] Rao SS, Mechanical Vibrations, Pearson, Fifth Edition.

Reference Books/Material:

[1] Finite1. Clough RJ and Penzien J, Dynamics of Structures, McGraw-Hill International, Second Edition, 1993.

[2] Mario Paz, Structural Dynamics Theory and Computation, CBS Publishers, Second Edition, New Delhi, 2004.

[3] Wu, JS Analytical and Numerical methods for Vibration analysis, Wiley, 2013

Web References:

[1] https://nptel.ac.in/courses/112105304

Journals References:

[1] Advanced Dynamics: Cambridge University Press

[2] Advanced Dynamics "Analytical and Numerical Calculations with MATLAB": Springer

M. Tech. (Mechanical Engineering)

Title: Advanced dynamics lab **Code:**

L-T-P scheme:0-0-2 **Credit: 1**

List of experiment:

1. Free vibration of single degree of freedom systems
2. Free vibration of damped systems
3. Forced vibration of single degree of freedom systems
4. Forced vibration of damped systems
5. Whirling of rotating shafts
6. Multi degree of freedom system
7. Impact test on cantilever Modal analysis
8. Balancing of multiple mass in single plane
9. Balancing of multiple mass in multiple plane
10. Base Excitation
11. Position, velocity and acceleration analysis of Mechanisms

Evaluation Scheme:

<table>
<tr><th>Exams</th><th>Marks</th><th>Coverage</th></tr>
<tr><td>P-1</td><td>15 Marks</td><td>Based on Lab Exercises: 1-6</td></tr>
<tr><td>P-2</td><td>15 Marks</td><td>Based on Lab Exercises: 7-11</td></tr>
<tr><td>Day-to-Day Work</td><td>40 Marks</td><td rowspan="3">70 Marks</td></tr>
<tr><td>Lab Record</td><td>15 Marks</td></tr>
<tr><td>Attendance & Discipline</td><td>15 Marks</td></tr>
<tr><td>Total</td><td>100 Marks</td><td></td></tr>
</table>

M. Tech. (Mechanical Engineering)

Title: FRACTURE MECHANICS **Code:**

L-T-P scheme: 3-0-0 **Credit: 3**

Prerequisite: Students must have already studied course, "*Strength of material and Material science*".

Objective:

1. The objective of this course is to introduce the mathematical and physical principles of fracture mechanics and their applications to engineering design to develop the ability in students to compute the stress intensity factor, strain energy release rate, and the stress and strain fields around a crack tip for linear and nonlinear materials.
2. It will also expand the students' knowledge on experimental methods to determine the fracture toughness and develop the students understanding on the design principle of materials and structures using fracture mechanics approaches.

Learning Outcomes:

Course Outcome	Description
CO1	**Identify** and describe the basic fracture and fatigue mechanisms. Correctly apply fracture mechanics to predict brittle fracture.
CO2	**Describe** crack resistance and energy release rate for crack criticality.
CO3	**Develop** the Application of Linear Elastic Fracture Mechanics on brittle materials.
CO4	**Identify** the plane stress and plane strain conditions based on the shape and size of plastic zones.
CO5	**Apply** the cause of failure of a material based on fracture surface observations such as the relationship between crack tip opening displacement, SIF and ERR and application of such parameters for ductile and brittle materials.

Course Content:

Unit-1:Introduction to Fracture Mechanics

Stress-Strain Curve, Elements of dislocation theory, Historical perspective, Stress Concentration effect of flaws, Fracture Mechanics approach to design, Effect of material properties on fracture, Cleavage, Brittle and Ductile fracture, ductile brittle transition, modes of fracture failure, Fatigue and stress corrosion cack growth, Damage tolerance.

Unit-2: Linear Elastic Fracture Mechanics

An atomic view of fracture, Griffith Energy Balance, Energy release rate, instability and the R Curves, compliance, tearing modulus, Stress and Displacement field in isotropic elastic materials, Airy stress function, Westergard approach for different modes of fracture, Stress analysis of crack, Stress intensity factor (SIF), relation between K and global behaviour, Effect of finite size.

Unit-3: Elastic-Plastic Fracture Mechanics

Crack tip deformation and plastic zone size, plane stress vs plane strain, effective crack length, Irwin plastic zone correction, Dugdale approach, effect of plate thickness

J Contour Integral: Relevance and scope, J as a path-independent line integral, J as a stress intensity parameter, Stress-Strain relations, J-Controlled fracture, Laboratory measurement of J, Crack Tip Opening Displacement (CTOD), Relationship between CTOD, K and G, Equivalence between CTOD and J, Determination CTOD from strip yield model, HRR Singularity

Unit-4: Fatigue Fracture

Introduction to fatigue, factors affecting fatigue performance, fatigue loading, constant and variable amplitude loading, some characteristics of fatigue crack, Paris Law

Unit-5:**Experimental and Finite Element Estimates of Fracture Mechanics**

Experimental determination of J-Integral, Critical Stress intensity factor and CTOD, Photoelasticity techniques, strain gage measurements, Fatigue crack initiation and propagation testingPreprocessing in Finite Element Method, Element selection and meshing of crack, Load application, constraints, preprocessing checks, processing the model, postprocessing

Teaching Methodology:

Fracture Mechanics is a challenging subject containing a series of new concepts, theories and solution methods, which are linked like a chain. Since the subject is concept and theory intensive, the most effective way to understand the new concepts and theories is to attend the lectures. Lectures comprise of 3 hours contact time per week. The total amount of time needed each week by the student to revise lecture notes and complete the assignments/reports will vary greatly from student to student.

Evaluation Scheme:

Exams	**Marks**	**Coverage**
Test-1	15 Marks	Based on Unit-1& Unit-2
Test-2	25 Marks	Based on Unit-3& Unit-4 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-5 and around 30% from coverage of Test-1 & Test-2.
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	

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Total	**100 Marks**	

Learning Resources:

Course-related resources will be provided on JUET server. This can include eBook, lecture material, supplementary course notes.

Text Book:

Anderson T.L., Fracture Mechanics Fundamentals and Applications, CRC Press, Second edition, 1994

Janssen, M., Zuidema, J., Wanhill, R. Fracture Mechanics.Spon Press.

Reference Books/Material:

1. Kumar Prashant, Elements of Fracture Mechanics, Wheelers Publishing Co. Ltd India, Second edition, 2010

Web References:

[1] https://www.fracturemechanics.org/

[2] https://nptel.ac.in/courses/112106065

Journals References:

https://www.sciencedirect.com/topics/materials-science/fracture-mechanics

M. Tech. (Mechanical Engineering)

Title: Finite Element Method	**Code:**
L-T-P scheme: 3-0-0	**Credit: 3**

Prerequisite: Students must have already studied course, "*Strength of Materials, Dynamics of Machine, Design of Machine Elements and Advanced Mechanics of Solids*".

Objective:

1. Finite element method is an important tool for the approximate analysis ofdifferent engineering problems, for example, solid mechanics, fluid mechanics,heat transfer etc. The purpose of this course is to introduce this approximatetechnique for solution of boundary and initial value problems through domaindiscretization.
2. The main objective of this subject is to provide a practical training in engineering design using finite element methods. When components have complex construction, shape, and general boundary conditions (loading and restraint) the designer will often use finite element methods to determine their structural integrity.
3. The first half of the module aims at introducing the fundamental principles of the modeling for statics and dynamics analyses.
4. In the second half of the module the students will be taught how to use the method in practice, to critically assess and evaluate the results.

Learning Outcomes:

Course Outcome	Description
CO1	**Outline** of this subject is to provide a practical training in engineering design using finite element methods.
CO2	**Describe** the use of finite element methods to determine their structural integrity when components have complex construction, shape, and general boundary conditions (loading and restraint).
CO3	**Develop** the fundamental principles of the modeling for statics and dynamics analyses.
CO4	**Identify** the important stress analysis technique and how it may be used to design components.
CO5	**Apply** the finite element methods for small displacement linear elastic analysis,Non-linear analysis; interpret the numerical results in design.

Course Content:

Unit-1:Fundamental concepts

Introduction, Stresses and equilibrium equations, Boundary conditions, Strain-displacement, Relations, Stress- strain relations, The Rayleigh-Ritz method, Galerkin's method,Application: Axial deformation of bars, Axial spring element, Matrix algebra, Gaussian elimination.

Unit-2: One-dimensional problems
Finite element modeling, Coordinates and a shape functions, Galerkin approach treatment of boundary conditions, Quadratic shape functions, Temperature effects.
Unit-3:Two-dimensional problems
Finite element modeling, Constant strain triangle, Axis symmetric solids subjected to axis symmetric loading, Axis symmetric formulation, Triangular element, Four- node quadrilateral, Numerical integration stress calculations, High order element, Nine-node quadrilateral, Eight-node quadrilateral, Six-node triangle.
Unit-4: Beams, frames & truss element
Introduction, Finite element formulation, Load vector, Boundary considerations, Shear force and bending moment, Beams on elastic supports, Plane frames. 2D & 3D Truss element.
Unit-5:**Three-dimensional problems**
Introduction, Finite element formulation, Stress calculations, Mesh preparation, hexahedral elements and Higher- order elements,
Unit-6: Dynamic considerations
Introduction, Formulation, Element mass matrices: Evaluation of Eigen values and Eigenvectors, Heat transfer Problem, Non-linear problems,Finite element error analysis

Teaching Methodology:
This course is introduced to provide a numerical method for solving problems of engineering and mathematical physics, which include structural analysis, heat transfer analysis, thermal analysis etc. This course is introduced to help students to understand a method which can reduce the degrees of freedom from infinite to finite with the help of discretization or meshing. The entire course is broken down into six units: Fundamental concepts, One-dimensional problems, Two-dimensional problems, Beams, frames & truss element, Three-dimensional problems and Dynamic considerations.
Each section helps a student to gain detail knowledge of the subject to solve different types of engineering problems.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1 & Unit-2
Test-2	25 Marks	Based on Unit-3 & Unit-4 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-5& Unit-6 and around 30% from coverage of Test-1 & Test-2.
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	

Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Course-related resources will be provided on JUET server. This can include eBook, lecture material, supplementary course notes.

Text Book:

[1] Finite Element Analysis by P.Seshu

Reference Books/Material:

[1] Finite Element Method for Engineering by C.V. GirijaVallabhan

[2] T. R. Chandrupatla and A D Belegundu, Introduction to Finite Elements in Engineering, PHI Learning Private Limited, 2011.

[3] J. N. Reddy, An Introduction to the Finite Element Method, Tata McGraw-Hill, 2005

Web References:

[1] https://nptel.ac.in/courses/112/104/112104116/

[2] https://ocw.mit.edu/resources/res-2-002-finite-element-procedures-for-solids-and-structures-spring-2010/

Journals References:

[1] Finite Elements in Analysis and Design: Elsevier

[2] Computer-Aided Engineering: IET

M. Tech. (Mechanical Engineering)

Title: Finite Element Method Lab **Code:**

L-T-P scheme:0-0-2 **Credit: 1**

List of experiment:

1. Introduction to programming
2. Introduction to ABAQUS/ANSYS
3. Development of Bar elements
4. Plane truss problems
5. Beam problems
6. Frame problems
7. Plane stress problems
8. Plane strain and axi-symmetric problems
9. Heat transfer problems
10. Mass matrix, fundamental frequency and mode shape for beams

Evaluation Scheme:

Exams	Marks	Coverage
P-1	15 Marks	**Based on Lab Exercises: 1-5**
P-2	15 Marks	**Based on Lab Exercises: 6-10**
Day-to-Day Work	40 Marks	**70 Marks**
Lab Record	15 Marks	
Attendance & Discipline	15 Marks	
Total	**100 Marks**	

M. Tech. (Mechanical Engineering)

Title: Engineering failure analysis and prevention **Code:**

L-T-P scheme: 3-0-0 **Credit: 3**

Prerequisite: Students must have already studied course, "*Strength of material and Material science*".

Objective:

Analyzing failure is a critical process in determining the physical root causes of problems.The course will assist students in determining causes of failures and eliminating future failure. It will help in enhancing product quality and solving the industrial problems.

Learning Outcomes:

Course Outcome	Description
CO1	**Outline** the Common causes of failure
CO2	**Describe** the principles of failure analysis, fracture mechanicsapproach to failure problems
CO3	**Develop** the techniques of failure analysis, service failuremechanisms, ductile and brittle fracture, fatigue failure, wear failure, hydrogeninduced failure, environment induced failures, high temperature failure, faultyheat treatment and design failures, processing failure (forging, casting,machining etc.)
CO4	**Identify** the failure problems in joints and weldments
CO5	**Apply** the failure analysisof structural components and mechanical system in case studies

Course Content:

Unit-1:Introduction: Common causes of failure

Unit-2: Principles of failure analysis

Unit-3: Fracture mechanics approach to failure problems

Unit-4: Techniques of failure analysis

Unit-5:Service failure mechanisms

Unit-6:Ductile and brittle fracture, fatigue failure, wear failure, hydrogen induced failure, environment induced failures, high temperature failure, faulty heat treatment and design failures, processing failure (forging, casting, machining etc.)

Unit-7:Failure problems in joints and weldments

Unit-8:Case studies for failure analysis of structural components and mechanical system

M. Tech. (Mechanical Engineering)

Teaching Methodology:

Engineering failure analysis and prevention is a challenging subject containing a series of new concepts, theories and solution methods, which are linked like a chain. Since the subject is concept and theory intensive, the most effective way to understand the new concepts and theories is to attend the lectures. Lectures comprise of 3 hours contact time per week. The total amount of time needed each week by the student to revise lecture notes and complete the assignments/reports will vary greatly from student to student.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1to Unit-4
Test-2	25 Marks	Based on Unit-5 to Unit-7 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-8and around 30% from coverage of Test-1 & Test-2.
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Course-related resources will be provided on JUET server. This can include eBook, lecture material, supplementary course notes.

Text Book:

ASM Handbook, Editor: W.T. Becker and R.J. Shipley, Volume 11: Failure Analysis andPrevention

Reference Books/Material:

[1] James J. Scutti, Introduction to Failure Analysis and Prevention, ASM International.
[2] Fractography, ASM Handbook, Vol. 12.

Web References:

[1] https://nptel.ac.in/courses/112107241

Journals References:

https://link.springer.com/journal/11668
https://www.sciencedirect.com/journal/engineering-failure-analysis

M. Tech. (Mechanical Engineering)

Title: Machine Design and optimisation **Code:**

L-T-P scheme: 3-0-0 **Credit: 3**

Prerequisite: Students must have already studied course, "*Strength of material and Mechanics*".

Objective:

1. Enhance expertise on design of Mechanical Systems with focus on mechanics basedfailure modes.
2. Introduction to tools and principles of optimization appearing in contextof mechanical engineering design.

Learning Outcomes:

Course Outcome	Description
CO1	**Outline** the machine element design based on strength and distortion criterion
CO2	**Describe** the choice of materials and their treatment: Designing for fatigue, creep; Design criterion for fracture.
CO3	**Develop** the application of advanced design criterion to machine elements (like shafts, spur / bevel / worm gears); Design of structures, machines and equipment
CO4	**Identify** the classical methods of unconstrained optimization (single variable and multi variable), classical methods of constrained optimization.
CO5	**Apply**Numerical optimisation techniques including (i) genetic algorithms, (binary and real coded) (ii) simulated annealing. Case studies of Optimum Design (Gear Box, Power Transmission, shape and topology using FE)

Course Content:

Unit-1: Introduction (Failure principles recap, feasible and optimal design)

Unit-2: Design of Mechanical Systems - structures, machines and equipment; formulating system constraints, requirements

Unit-3: Designing for fatigue, creep.

Unit-4: Design for fracture.

Unit-5:Stochastic principles in design

Unit-6: Application of advanced design criterion to machine elements (like shafts, spur / bevel / worm gears)

Unit-7: Classical methods of unconstrained optimization (single variable and multi variable)

Unit-8: Classical methods of constrained optimization (transformational, direct search, linearization methods); Kuhn Tucker Conditions
Unit-9: Advanced optimisation techniques including (i) genetic algorithms, (binary and real coded) (ii)Simulated annealing
Unit-10: Case studies of Optimum Design (Gear Box, Power Transmission, shape and topology using FE)

Teaching Methodology:
Machine Design and optimisation is a challenging subject containing a series of new concepts, theories and solution methods, which are linked like a chain. Since the subject is concept and theory intensive, the most effective way to understand the new concepts and theories is to attend the lectures. Lectures comprise of 3 hours contact time per week. The total amount of time needed each week by the student to revise lecture notes and complete the assignments/reports will vary greatly from student to student.

Evaluation Scheme:

Exams	**Marks**	**Coverage**
Test-1	15 Marks	Based on Unit-1 to Unit-4
Test-2	25 Marks	Based on Unit-5 to Unit-8 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-9 & Unit-10and around 30% from coverage of Test-1 & Test-2.
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:
Course-related resources will be provided on JUET server. This can include eBook, lecture material, supplementary course notes.
Text Book:
[1] Engineering Optimization, S.S.Rao, 3rd enlarged ed, New Age International publishers, 2010 5.
[2] Optimization for engineering design, Kalyanmoy Deb, PHI Learning, 2004
Reference Books/Material:
[1] MechEngg Design, Shigley, Mischke, Budynas, Nisbett, 8th Edn, 2010, McGraw Hill
[2] Machine Design Handbook, Shigley and Mischke, McGraw Hill
[3] Materials selection in Mechanical Design, M.F.Ashby, 3rd Edn, 2005, Elsevier

M. Tech. (Mechanical Engineering)

Web References:
https://archive.nptel.ac.in/courses/112/101/112101298/
Journals References:
https://link.springer.com/book/10.1007/978-1-4471-2748-2

M. Tech. (Mechanical Engineering)

Title: Theory of plates and shells **Code:**
L-T-P scheme: 3-0-0 **Credit: 3**

Prerequisite: Students must have already studied course, "*Strength of material and Engineering mathematics*".

Objective:
The objective of this course is to introduce the students with (a) the two-dimensionaltheories for the analysis of common thin-walled structural elements of engineeringstructures and equipment's, and (b) their solutions by analytical and numerical methodsfor the deformation and stresses of plates, cylindrical shells, spherical domes, conicalshells and pressure vessels.

Learning Outcomes:

Course Outcome	Description
CO1	**Outline** the basic assumptions of two-dimensional theories
CO2	**Describe** the Theory of surfaces, Strain displacement relations in shell coordinates, Stress-resultants, General governingequations of motion, Boundary conditions
CO3	**Develop**Analytical solutions for bending andvibration of rectangular plates and circular plates. Approximate solution techniques.
CO4	**Identify**Membrane theory and its applicability
CO5	**Apply**Membrane and general bending solutionscylindrical, conical and spherical shells, and pressure vessels. Selected problems on thestability. Design considerations.

Course Content:
Unit-1:Introduction: Basic assumptions of two-dimensional theories vis-à-vis threedimensional elasticity
Unit-2: Theory of Surfaces: First and Second Fundamental Forms of Surfaces,Normal to a Surface, Principal Curvatures, Derivatives of Tangent andNormal Vectors, Fundamental Theorems, Classification of Shells.
Unit-3: Fundamental Equations of Theory of Shells: Shells Coordinates, Strain-Displacement Relations, Stress Resultants, General Equations of Motionusing Hamilton's Principle, Boundary Conditions.
Unit-4: Bending and Vibration of Rectangular Plates: Navier Solution, LevySolution, Approximate Solutions Techniques
Unit-5:**Bending and Vibration of Circular Plates**
Unit-6: **Membrane Theory of Shells:** Conditions of Applicability of MembraneTheory, Membrane Shells of Revolution- Cylindrical, Spherical, Conical
Unit-7: **General Bending of Circular Cylindrical Shells**
Unit-8: **Bending Stresses** in Conical and Spherical Shell and Pressure vessels,Cylindrical-to-Hemispherical head junctions.
Unit-9: **Introduction to Stability of Plates and Shells.**
Unit-10: **Special Topics: Presentations by Students**

M. Tech. (Mechanical Engineering)

Teaching Methodology:

Theory of plates and shells is a challenging subject containing a series of new concepts, theories and solution methods, which are linked like a chain. Since the subject is concept and theory intensive, the most effective way to understand the new concepts and theories is to attend the lectures. Lectures comprise of 3 hours contact time per week. The total amount of time needed each week by the student to revise lecture notes and complete the assignments/reports will vary greatly from student to student.

Evaluation Scheme:

Exams	**Marks**	**Coverage**
Test-1	15 Marks	Based on Unit-1 to Unit-3
Test-2	25 Marks	Based on Unit-4 to Unit-7 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-8 to Unit-10and around 30% from coverage of Test-1 & Test-2.
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Course-related resources will be provided on JUET server. This can include eBook, lecture material, supplementary course notes.

Text Book:

J. N. Reddy, *Theory and Analysis of Elastic Plates and Shells*, CRC Press, 2007.

Reference Books/Material:

[1] Harry Kraus, “Thin Elastic Shells”, John Wiley & Sons.

[2] S. Timoshenko, S. Woinowsky-Krieger, *Theory of Plates and Shells*, McGraw-Hill, 1959.

[3] T. K. Varadan and K. Bhaskar, *Analysis of Plates*: Theory *and Problems*, NarrosPublishingHouse, 1999.

[4] Werner Soedel, “*Vibrations of Shells and Plates*” –, Marcel Dekker Inc, 3rd Edition

[5] A. C. Ugural, “*Stresses in Beams, Plates and Shells*” CRC Press, 3rd Ed. 2009

Web References:

https://onlinecourses.nptel.ac.in/noc21_ce59/preview

Journals References:

Analysis of Shells and Plates: Springer

M. Tech. (Mechanical Engineering)

TITLE: Mechanics of Composite Materials **CODE:**

L-T-P scheme: 3-0-0 **Credit: 3**

Course Outcome	Description
CO1	Outline various types of Fiber and Matrix materials.
CO2	Classify the composite materials.
CO3	Apply the concepts to fabricate and testing the composite materials
CO4	Analyze the strengths of Composite material
CO5	Select the appropriate technique to know the mechanics of composites.
CO6	Demonstrate the applications of composite materials in real-world.

COURSE CONTENT

Unit-1: Introduction to Composite Materials-General introduction of composites, Historical development, Constituents of Composite Materials; Types of Fiber and Matrix Materials.

Unit-2: Anisotropic Elasticity; Hooke's Law; Orthotropic Materials, Transverse and Isotropic Stiffness Matrix, Volume Fractions; Longitudinal Strength; Transverse Strengths, In-Plane Poisson's Ratio and Shear Modulus; Out of Plane Shear Modulus.

Unit-3: Halpin Tsai Formulas, Longitudinal Compressive and Tensile Strength; Transverse Tensile Strength, Short Fiber Composites**,** Ply Mechanics, Hooke's Law, Tensors and it's Transformations.

Unit-4: Elastic Potential Theory; Stiffness Matrix, Engineering and Shear Strains; Planes of Symmetries, Rotation Symmetry; Reciprocal Theory, Isotropic and Orthotropic Materials, Plane Stress Condition.

Unit-5: Lamina Orientation; Reduced Stiffness Matrix, Reduced Compliance Matrix; Concept of Mutual Influence, Ply Mechanics: Practice Problems, Laminate Mechanics; Joint Plies, Classical Laminate Theory (CLT), Failure Theories: Maximum Stress and Strain Theories.

TEXT BOOKS-

M. Tech. (Mechanical Engineering)

1. Mallick P. K., Fiber reinforced composites: Materials, manufacturing and design, CRC press, 2007
2. Hull, D. and Clyne, T.W., Introduction to composite materials, Cambridge University press, 1996.
3. Kaw. A. K, Mechanics of Composite materials, CRC Press (Taylor & Francis), 2006.

REFERENCE BOOKS-

1. Bunsell, A, R. and Renard, J., Fundamentals of fiber reinforced composite materials, Institute of Physics Pub, 2005.
2. Gibson, Ronald F**., Principles of composite material mechanics,** CRC Press (Taylor & Francis Group), 2012.
3. Luigi Nicolais., Eva Milella, Michele Meo, Composite materials – A vision for future, Springer, 2011.

M. Tech. (Mechanical Engineering)

Course Name: Advanced Thermodynamics **Course Code:**
L-T-P scheme: 3-0-0 **Credits: 3**

Prerequisites

- Knowledge of Basic Thermodynamics , Heat and Mass Transfer and Fluid Mechanics

Objectives:

1. To present a problem oriented in depth knowledge of Advanced Thermodynamics and heat transfer
2. To address the underlying concepts and methods behind Advanced Thermodynamics and heat transfer

Learning Outcomes:

Course Outcome	Description
CO1	Define/state the Thermodynamic Systems and Laws, Thermodynamic Processes, Combined Heat and Power Systems
CO2	Explain various conditions of Thermodynamic Systems and Laws, Thermodynamic Processes, Combined Heat and Power Systems
CO3	Solve and implement various advanced problems of Thermodynamic Systems and Laws, Thermodynamic Processes, Combined Heat and Power Systems
CO4	Distinguish and do experiment various advanced Thermodynamic problems for different Thermodynamic Processes and Combined Heat and Power Systems
CO5	Justify and defend various Environmental Impact of Thermodynamic Systems
CO6	Investigation of various Environmental Impact of Thermodynamic Systems

Course Description

This course explores advanced concepts in thermodynamics with a focus on renewable energy systems. Topics include entropy, exergy, energy conversion, and efficiency in different renewable energy applications.

Unit 1:

- Thermodynamic Systems and Laws: Overview of basic laws, system boundaries, and thermodynamic cycles.

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- Entropy and Exergy: Concepts of entropy and exergy, and their applications in renewable energy systems.
- Thermodynamic Processes: Adiabatic, isothermal, isobaric, and other processes in renewable energy.

Unit 2:

- Thermodynamics in Energy Conversion: Application of thermodynamics in energy generation from renewable sources.
- Efficiency Analysis: Evaluating energy efficiency in renewable energy systems.
- Thermodynamic Cycles: Review of common cycles (e.g., Rankine, Brayton) and their applications.

Unit 3:

- Combined Heat and Power Systems: Exploring cogeneration and waste heat recovery.
- Environmental Impact of Thermodynamic Systems: Analysing the impact of renewable energy systems on the environment.

Unit 4:

- Thermodynamic Modelling Tools: Introduction to software tools for thermodynamic analysis.

Unit 5:

- Case Studies in Renewable Energy: Analysis of thermodynamic efficiency in real-world renewable energy projects.

Exams	Marks	Coverage
Test-1	15 Marks	Syllabus covered upto Test-1
Test-2	25 Marks	Syllabus covered upto Test-2
Test-3	35 Marks	Full Syllabus
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Course Materials

Textbook: "Advanced Engineering Thermodynamics, by Adrian Bejan

M. Tech. (Mechanical Engineering)

Course Name: Heat Transfer in Renewable Energy Systems **Course Code:**
L-T-P scheme: 3-0-0 **Credits: 3**

Prerequisites: Knowledge of Basic Thermodynamics, Heat and Mass Transfer and Fluid Mechanics

Objectives:

1. To present a problem oriented in depth knowledge of Heat Transfer in Renewable Energy Systems
2. To address the underlying concepts and methods behind Heat Transfer in Renewable Energy Systems

Learning Outcomes:

Course Outcome	**Description**
CO1	Define/state the various modes of heat transfer based on their application
CO2	Explain various Solar Thermal Systems: Application of heat transfer principles in solar thermal collectors, Phase Change Materials
CO3	Solve and implement various Heat Exchange process and Thermal Management in Renewable Systems
CO4	Distinguish and do experiment on Solar Thermal Systems, Phase Change Materials and Case Studies and Applications
CO5	Justify and defend Real-world applications of heat transfer in renewable energy.
CO6	Investigation of Real-world applications of heat transfer in renewable energy.

Course Description

This course explores heat transfer principles (conduction, convection, radiation) with a focus on applications in renewable energy systems like solar thermal, geothermal, and heat exchangers.

Unit 1:

- Introduction to Heat Transfer: Overview of conduction, convection, and radiation.
- Conduction in Renewable Energy Systems: Heat transfer through materials and insulation.
- Convection in Renewable Energy Systems: Natural and forced convection in solar thermal and geothermal systems.

Unit 2:

M. Tech. (Mechanical Engineering)

- Radiation in Renewable Energy: Solar radiation, emissivity, and reflectivity in renewable energy applications.
- Heat Exchangers: Design and operation of heat exchangers for energy systems.

Unit 3:

- Solar Thermal Systems: Application of heat transfer principles in solar thermal collectors.
- Phase Change Materials: Use of phase change materials for energy storage in renewable systems.

Unit 4:

- Thermal Management in Renewable Systems: Strategies for efficient thermal management in renewable energy projects.

Unit 5:

- Case Studies and Applications: Real-world applications of heat transfer in renewable energy.

Exams	Marks	Coverage
Test-1	15 Marks	Syllabus covered upto Test-1
Test-2	25 Marks	Syllabus covered upto Test-2
Test-3	35 Marks	Full Syllabus
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Course Materials

Textbook: Fundamentals and Applications of Renewable Energy, 1st Edition Mehmet Kanoğlu, Yunus A. Çengel, John M. Cimbala

1. Supplementary Resources: Lab equipment, software for heat transfer simulation

M. Tech. (Mechanical Engineering)

Course Name: Viscous Flow Theory **Course Code:**
L-T-P scheme: 3-0-0 **Credits: 3**

Prerequisites: Thermal-Fluids Engineering II *or* 2.06 Fluid Dynamics
Objectives:

1. To present a problem oriented in depth knowledge of Viscous Flow Theory
2. To address the underlying concepts and methods behind Viscous Flow Theory analysis

Course Outcome	Description
CO1	Define/state the basic concepts of fluid dynamics, including fluid properties and fundamental laws, case studies involving simple geometries and boundary conditions
CO2	Explain boundary conditions for viscous flow problems, Properties of these equations, including linearity and nonlinearity
CO3	Solve and implement Navier-Stokes Equations for real life problems
CO4	Distinguish and do experiment for viscous fluid flow for industrial
CO5	Judge the nature of viscous fluid flow for industrial application
CO6	Investigation of Reynolds-averaged approaches to solving turbulent flow

Course Description
This course covers fluid dynamics with a focus on renewable energy systems, including wind turbines, hydro turbines, and geothermal systems. Topics include fluid flow, turbulence, and aerodynamics.

Unit 1:

- Basic concepts of fluid dynamics, including fluid properties and fundamental laws.
- Governing equations for fluid flow (e.g., Navier-Stokes equations).
- Detailed derivation of the Navier-Stokes equations.
- Boundary conditions for viscous flow problems.
- Properties of these equations, including linearity and nonlinearity.

Unit 2:

- Exact Solutions to Navier-Stokes Equations.
- Case studies involving simple geometries and boundary conditions.
- Examples such as plane Couette flow, Poiseuille flow, and Stokes flow around a sphere.

Unit 3:

- Concept of boundary layers in fluid flow.

- Blasius solution for a flat plate boundary layer.
- Displacement, momentum, and energy thickness.

Unit 4:

- Basic concepts of flow instability.
- Reynolds number and its significance.
- Brief overview of transition to turbulence.
- Introduction to turbulence and its characteristics.
- Reynolds-averaged approaches to solving turbulent flow.
- Common turbulence models (e.g., k-ε, k-ω).

Unit 5:

- Discussion of numerical methods for viscous flow analysis.
- Practical examples from engineering applications and research.
- Case Studies and Applications: Real-world examples of fluid dynamics in renewable energy systems.

Exams	**Marks**	**Coverage**
Test-1	15 Marks	Syllabus covered upto Test-1
Test-2	25 Marks	Syllabus covered upto Test-2
Test-3	35 Marks	Full Syllabus
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

References:

- Fluid Mechanics by *Pijush K. Kundu, Ira M. Cohen, David R Dowling (Academic Press)*
- Fluid Mechanics by *Frank M White (McGraw-Hill)*
- Viscous Fluid Flow by *Frank M White (McGraw-Hill)*
- Boundary Layer Theory by *H Sctllichting (McGraw-Hill)*

Course Name: Wind Energy Engineering **Course Code:**
L-T-P scheme: 3-0-0 **Credits: 3**

Prerequisites: Thermal-Fluids Engineering and Fluid Dynamics

Objectives:

1. To present a problem oriented in depth knowledge of wind energy engineering

2. To address the concepts and industrial aspects of Wind Energy Engineering

Course Outcome	Description
CO1	Define/state the basic concepts of Wind Energy Engineering, turbine design, aerodynamics, wind farm layout, and integration into the grid.
CO2	Explain the Principles of wind farm design, including site selection and turbine placemen
CO3	Solve and implement the different techniques for assessing wind turbine performance and efficiency
CO4	Distinguish wind turbine performance and efficiency of offshore wind farm design and construction.
CO5	Judge the environmental impact of wind Energy, impact of wind turbines on wildlife and ecosystems.
CO6	Investigation of energy systems, focusing on turbine design, aerodynamics, wind farm layout

Course Description

This course explores wind energy systems, focusing on turbine design, aerodynamics, wind farm layout, and integration into the grid.

Unit 1:

- Overview of wind energy and its potential as a renewable source.

Unit 2:

- Examination of wind turbine components and their functions.
- In-depth study of aerodynamics and air foil design for wind turbines.

Unit 3:

- Principles of wind farm design, including site selection and turbine placement.
- Wind Farm Grid Integration: Exploring the challenges and solutions for integrating wind farms into power grids.

Unit 4:

- Study of control mechanisms for wind turbine efficiency and stability.
- Techniques for assessing wind turbine performance and efficiency.

Unit 5:

- Specific considerations for offshore wind farm design and construction.
- Environmental Impact of Wind Energy: Exploring the impact of wind turbines on wildlife and ecosystems.
- Analysis of successful wind energy projects and their outcomes.

Exams	Marks	Coverage
Test-1	15 Marks	Syllabus covered upto Test-1
Test-2	25 Marks	Syllabus covered upto Test-2

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Test-3	35 Marks	Full Syllabus
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Course Materials
Textbook: “Wind **Energy Engineering, 2nd Edition by** Pramod Jain
Supplementary Resources: Wind energy simulation software, real-world wind energy case studies

Course Name: Hydro Energy and Fluid Mechanics **Course Code:**
L-T-P scheme: 3-0-0 **Credits: 3**

Prerequisites: Principles of Energy Engineering, Fluid Mechanics in Energy
Objectives:

1. To be acquainted with the problem oriented in depth knowledge of Hydro Energy and Fluid Mechanics
2. To know the concepts and tackle industrial prblems of Hydro Energy and Fluid Mechanics

M. Tech. (Mechanical Engineering)

Course Outcome	Description
CO1	Define/state course explores hydro energy systems, focusing on hydroelectric and hydrokinetic turbines
CO2	Explain the fluid mechanics, turbine design, and environmental considerations, hydroelectric turbine
CO3	Solve the design and layout of hydroelectric plants, environmental impact of hydro energy projects
CO4	Distinguish hydrokinetic turbines and their applications, control mechanisms for hydroelectric plants
CO5	Evaluate the performance of pumped hydro storage and other energy storage
CO6	Investigation of turbine design at different environmental condition

Course Description

This course explores hydro energy systems, focusing on hydroelectric and hydrokinetic turbines. Topics include fluid mechanics, turbine design, and environmental considerations.

Unit 1:
- Overview of hydro energy sources and their potential.
- Principles of fluid mechanics in hydro systems.

Unit 2:
- Study of hydroelectric turbine design and operation.
- Examination of hydrokinetic turbines and their applications.

Unit 3:
- Exploring the design and layout of hydroelectric plants.
- Assessing the environmental impact of hydro energy projects.

Unit 4:
- Study of control mechanisms for hydroelectric plants.
- Examination of pumped hydro storage and other energy storage methods.

Unit 5:
- Analysis of successful hydro energy projects and their outcomes.

Exams	Marks	Coverage
Test-1	15 Marks	Syllabus covered upto Test-1
Test-2	25 Marks	Syllabus covered upto Test-2
Test-3	35 Marks	Full Syllabus
Assignment	10 Marks	
Tutorials	5 Marks	

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Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Course Materials
Textbook: Basic fluid mechanics and hydraulic machines. Hyderabad, India: BS publications.Husain, Z., Mohd. Zulkifly Abdullah and Alimuddin, Z., 2008
Supplementary Resources: Lab equipment for fluid mechanics experiments, CFD software

Course Name: Solar Energy Engineering **Course Code:**
L-T-P scheme: 3-0-0 **Credits: 3**

Prerequisites: Principles of Energy Engineering, Heat and Mass transfer, Fluid Mechanics
Objectives:
1. To be familiar with the problem oriented knowledge of Solar Energy Engineering
2. To carry out the industrial aspects of Solar Energy Engineering application

Course Outcome	Description
CO1	Define/state engineering aspects of solar energy, both solar photovoltaics and solar thermal systems
CO2	Explanation of solar cell technology, solar collectors, and system design
CO3	Application of different the energy storage options for solar energy systems
CO4	Distinguish both solar photovoltaics and solar thermal systems
CO5	Evaluate the factors affecting photovoltaic cell efficiency
CO6	Investigation of impact of solar farms on land use and ecosystems, Cost analysis of solar energy

Course Description:
This course explores the engineering aspects of solar energy, covering both solar photovoltaics and solar thermal systems. Topics include solar cell technology, solar collectors, and system design.

Unit 1:

- Overview of solar energy and its applications.
- Study of photovoltaic cells and their operation.
- Analysing the factors affecting photovoltaic cell efficiency.

Unit 2:
- Examination of solar thermal collectors and their design.
- Principles of solar farm design, including site selection and panel placement.
- Exploring energy storage options for solar energy systems.
- Exploring the impact of solar farms on land use and ecosystems.

Unit 3:
- Study of challenges and solutions for integrating solar energy into the power grid.
- Examination of concentrated solar power technologies and their applications.

Unit 4:
- Types of solar stills.
- Thermodynamics of solar stills.
- Cost analysis of solar stills.

Unit 5: Case Studies in Solar Energy:
- Analysis of successful solar energy projects and their outcomes.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Syllabus covered upto Test-1
Test-2	25 Marks	Syllabus covered upto Test-2
Test-3	35 Marks	Full Syllabus
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Course Materials

Textbook: **Solar Energy Engineering and Applications by Rachid Ahmed, Springer by Rachid Ahmed**
Supplementary Resources: Solar energy simulation software, real-world solar energy case studies

Course Name: Renewable Energy Storage and Conversion **Course Code:**
L-T-P scheme: 3-0-0 **Credits: 3**

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Prerequisites: Principles of Energy Engineering, Heat and Mass transfer, Fluid Mechanics

Objectives:

1. To be familiar with the problem oriented knowledge of Renewable Energy Storage and Conversion
2. To carry out the industrial aspects of Renewable Energy Storage and Conversion

Course Outcome	Description
CO1	Define/state Renewable Energy Storage and Conversion, thermal storage, battery technologies, and pumped hydro storage, as well as the energy conversion processes
CO2	Explanation of Renewable Energy Storage and Conversion, thermal storage, sensible and latent heat storage methods.
CO3	Application of Renewable Energy, conservation strategies in renewable energy systems
CO4	Distinguish various energy storage and conversion techniques used in renewable energy systems
CO5	Evaluate the energy efficiency practices and conservation strategies in renewable energy systems
CO6	Investigation of thermal storage, battery technologies, integrating energy storage into power grids

Course Description

This course explores various energy storage and conversion techniques used in renewable energy systems. Topics include thermal storage, battery technologies, and pumped hydro storage, as well as the energy conversion processes used in renewable energy.

Unit 1:

- Overview of energy storage techniques in renewable energy systems.
- Exploration of energy conversion techniques in renewable energy systems.

Unit 2:

- Exploring sensible and latent heat storage methods.

Unit 3:

- Study of battery storage technologies, including lithium-ion, lead-acid, and emerging battery types.
- Examination of pumped hydro storage systems and their operation.

Unti 4:

- Study of energy storage options for solar energy systems.
- Exploring energy storage solutions for wind energy.

Unit 5:

- Challenges and solutions for integrating energy storage into power grids.
- Exploring energy efficiency practices and conservation strategies in renewable energy systems.

Unit 6:

- Analysis of successful energy storage and conversion projects in renewable energy.

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Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Syllabus covered upto Test-1
Test-2	25 Marks	Syllabus covered upto Test-2
Test-3	35 Marks	Full Syllabus
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Course Materials:

Textbook: " Energy Conversion and Green Energy Storage " by mit Soni, Dharmendra Tripathi, Jagrati Sahariya, Kamal Nayan Sharma

Supplementary Resources: Simulation software, real-world energy storage case studies

M. Tech. (Mechanical Engineering)

Course Name: Computational Fluid Dynamics for Renewable Energy **Course Code:**
L-T-P scheme: 3-0-0 **Credits: 3**
Prerequisites: Principles of Energy Engineering, Heat and Mass transfer, Fluid Mechanics, Numerical Method, Fundamentals of CFD
Objectives:
1. To be capable with the computational problems oriented knowledge of Renewable Energy Storage and Conversion
2. To carry out the CFD simulation for Renewable Energy analysis like wind , tidal flows

Course Outcome	**Description**
CO1	Define/state the basic Fluid Dynamics and Governing Equations Computational Fluid Dynamics and heat transfer analysis in Renewable Energy ,
CO2	Explanation of Fluid Dynamics and Governing Equations Computational Fluid Dynamics and heat transfer analysis in Renewable Energy
CO3	Application of Computational Fluid Dynamics and heat transfer analysis in Renewable Energy at different flow boundary conditions for various flow problems (using FDM,FVM,FEM)
CO4	Distinguish various types of meshes (structured, unstructured) CFD analysis
CO5	Evaluate the CFD simulation accuracy with experiential results of Renewable Energy flow analysis
CO6	Investigation of CFD simulation accuracy with experiential results of Renewable Energy flow

Course Description
This course introduces computational techniques for fluid dynamics and heat transfer analysis in renewable energy systems. Students will learn to use Computational Fluid Dynamics (CFD) software to model and simulate Engineering problems.

Unit 1:
- Overview of CFD and its applications.
- History and evolution of CFD.
- Basic Fluid Dynamics and Governing Equations
- Review of fluid dynamics concepts.
- Conservation laws (mass, momentum, and energy).
- Governing equations (Navier-Stokes equations, Euler equations).

Unit 2:
- Finite difference methods.

- Finite volume methods.
- Finite element methods.
- Types of meshes (structured, unstructured).
- Mesh quality and refinement.

Unit 3:

- Specification of boundary conditions for various flow problems.
- Importance of initial conditions in CFD simulations.
- Solvers for linear and nonlinear systems.
- Iterative and direct solvers.

Unit 4:

- Concepts of numerical stability.
- Consistency and convergence of CFD methods.
- Validation and Verification in CFD

Unit 5:

- Solving some fluid flow and Heat transfer problems like Lid Driven Cavity, Flow over Backward facing step, etc.

Evaluation Scheme:

Exams	**Marks**	**Coverage**
Test-1	15 Marks	Syllabus covered upto Test-1
Test-2	25 Marks	Syllabus covered upto Test-2
Test-3	35 Marks	Full Syllabus
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Tutorials, lecture slides and books on mathematics-1 will be available on the JUET server.

Course Materials

Textbook: "Computational Fluid Dynamics the Basics with Applications" by Anderson Jr., John D.

Supplementary Resources: CFD software, real-world CFD case stud

M. Tech. (Mechanical Engineering)

Title: Analysis and Design of Machine Tools   Code:

L-T-P scheme: 3-0-0   **Credit: 3**

Prerequisite: Students must have already studied course, "*Manufacturing Technology*".

Objective:

[1] To provide fundamental knowledge and principles in material removal processes.

[2] To provide the knowledge of different drives and mechanisms used in machine tools, The design of gear boxes & feed boxes, structures, guide ways, spindles and various control systems used in machine tools.

[3] To demonstrate the fundamentals of machining processes. Vibrations induced in machine tools.

[4] To apply knowledge of basic mathematics to calculate the machining parameters for different machining processes.

Learning Outcomes:

Course Outcome	Description
CO1	Outline the machine tools, cutting tool geometry, mechanism of chip formation and mechanics of orthogonal cutting.
CO2	Describe the concepts of design of machine tools and machine tools drives, design and analysis of machine tool structures, columns, beds, spindles, slide ways and bearings.
CO3	Develop newer concepts of designing CNC Machine tool.
CO4	Identify machine tool vibrations, different theories of vibration in machine tools.
CO5	Apply Modal analysis, vibrations induced in machine tools and calculate the values of various forces involved in the machining operations.
CO6	Demonstrate the inter-relationship between cutting parameters and machining performance measures like power requirement, cutting time, tool life and surface finish.

Course Content:

Unit-1: Metal cutting : Mechanics of metal cutting, Geometry of tool and nomenclature, Tool materials, Orthogonal vs oblique cutting. Mechanics of chip formations, types of chips, tools angles, shear angle, Merchant's force circle diagram, Cutting forces, power required, Cutting fluids/lubricants, Tools wear and tool life.

Unit-2: Design and Analysis of Machine Tool Structures, Columns, Beds, Spindles, Slide ways and Bearings.

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Unit-3: Design of Kinematic Schemes of Machine Tools, Design of kinematic schemes used in modern machine tools drives**,** Concepts of design of machine tools, Design of Machine tool drives.
Unit-4:Computer controlled manufacturing process: NC, CNC, DNC, part programming, Introduction to computer aided manufacturing and robotics.
Unit-5: Machine Tool Vibrations, different theories of vibration in machine tools, Modal analysis, Vibration isolation, Static and dynamic testing of machine tools.

Teaching Methodology:
This course is introduced to help students to understand Machine tools,the various parts of machine tools, the forces which act on them. Students will gain advanced knowledge of machining process modeling as well as vibration analysis of machine tools.
Course will equip students to diagnose machining process related issues, and will motivate practical solutions for some industrial problems in the machine tool.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1& Unit-2
Test-2	25 Marks	Based on Unit-3& Unit-4 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-5 and around 30% from coverage of Test-1 & Test-2.
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:
Course-related resources will be provided on JUET server. This can include eBook, lecture material, supplementary course notes.
Text Book:

[1] Manufacturing Automation by Y. Altintas.
[2] Machining Dynamics by T. Schmitz & K. Smith;

Reference Books/Material:

[1] Machine Tool Structures by Koenigsberger & Tlusty

Web References:

[1] https://www.youtube.com/watch?v=orKAv91M0Uo

Journals References:

[1] International Journal of Machine Tools and Manufacture: Elsevier

M. Tech. (Mechanical Engineering)

Title: Metal Machining Code:

L-T-P scheme: 3-0-0 **Credit: 3**

Prerequisite: It is a foundation course of machining

Objectives:

1. To study the basics of metal machining and mechanics of metal machining
2. To study the different cutting tool materials and types & geometry of cutting tools
3. To learn introductory concepts of various advanced machining processes

Learning Outcomes:

CO1	Outline various machining processes such as turning, milling, shaping, drilling, grinding
CO2	Describe various machining processes its mechanism, mechanics
CO3	Develop the knowledge of heat generation in machining and its impact on M-F-T and its regulation
CO4	Identify and use the proper technique required for the machining process of any metallic product
CO5	Apply various advanced machining processes where conventional are not suitable
CO6	Demonstrate the practical exposure of various conventional and nonconventional machining techniques

COURSE CONTENT

Unit 1:

Mechanics of Metal Cutting, Thermal Aspects of Machining

Unit 2:

Cutting fluids, Tool Wear, Tool Life

Machinability, Economics of Machining

Unit 3:

Abrasive Processes, Vibrations in Cutting

Unit 4:

Introduction to Modern Machining Processes

Evaluation Scheme:

Exams	**Marks**	**Coverage**
Test-1	15 Marks	Based on Unit 1
Test-2	25 Marks	Based on Unit 2 & 3 and Unit 1 (20%)
Test-3	35 Marks	Based on Unit 3 & 4, Unit 2 (15%) and Unit 1 (15%)
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Lecture notes on Metal Machining (will be added from time to time): Digital copy will be available on the JUET server.

Text Books:

1. G. K. Lal (2007), Introduction to Machining Science, New Age International Publisher, New Delhi.
2. **A. Ghosh** and A. K. Malik (2010) Manufacturing Science, East West Press Private Limited New Delhi.
3. V.K. Jain (2005), Advanced Machining Processes, Allied Publishers Private Limited, India.

Reference Books:

1. P.C. Pandey and H. S. Shan (1996), Modern Machining Processes, TMH Publishing Limited, New Delhi.
2. R.K Jain (2005), Production Technology, Khanna Publisher, New Delhi.
3. S. Kalpakjian and S. Schemid (2001), Manufacturing, Engineering and Technology, Addison Wesley.

Web References:

1. www.youtube.com/user/nptelhrd

Journals References:

1. *International Journal of Advanced Manufacturing Technology*
2. International Journal of Machine Tools and Manufacture

M. Tech. (Mechanical Engineering)

Title: Metal Machining Lab Code:

L-T-P scheme: 0-0-1 **Credit: 1**

Prerequisite: Basics of workshop

Objectives:

1. To determine the shear plane angle and shear strain during the cutting of single point cutting tool of mild steel sheet
2. To study the different cutting tool materials and types & geometry of cutting tools
3. To learn introductory concepts of roughness during the metal cutting

Learning Outcomes:

CO1	Outline different conventional and nonconventional machining processes
CO2	Describe each process with their practical aspects
CO3	Develop the practical knowledge to manufacture products using machining technology
CO4	Identify the required machining process for a product
CO5	Apply the knowledge to improve the methods
CO6	Demonstrate the skill of metal machining for practical use in the industry

Contents:

S.No.	Name of Experiments
1.	Determine the shear plane angle and shear strain of a work piece on shaper
2.	To determine the roughness in a specimen
3.	Optimization of current to overcome the taper obtains during EDM drilling process
4.	To study the geometry of single point cutting tool
5.	To prepare single point cutting tool as per given tool signature

Evaluation Scheme:

<table>
<tr><th colspan="2">Exams</th><th>Marks</th><th>Coverage</th></tr>
<tr><td colspan="2">P-1</td><td>15 Marks</td><td>Based on Lab Exercises: 1-3</td></tr>
<tr><td colspan="2">P-2</td><td>15 Marks</td><td>Based on Lab Exercises: All</td></tr>
<tr><td rowspan="4">Day-to-Day Work</td><td>Viva</td><td>20 Marks</td><td rowspan="4">70 Marks</td></tr>
<tr><td>Demonstration</td><td>20 Marks</td></tr>
<tr><td>Lab Record</td><td>15 Marks</td></tr>
<tr><td>Attendance & Discipline</td><td>15 Marks</td></tr>
<tr><td colspan="2">Total</td><td colspan="2">100 Marks</td></tr>
</table>

Learning Resources:

Digital copy of study material and videos will be available on the JUET server.

M. Tech. (Mechanical Engineering)

Books:

1. R.K Jain (2005), Production Technology, Khanna Publisher, New Delhi.
2. **A. Ghosh** and A. K. Malik (2010) Manufacturing Science, East West Press Private Limited New Delhi.
3. G. K. Lal (2007), Introduction to Machining Science, New Age International Publisher, New Delhi.

Web References:

1. www.youtube.com/user/nptelhrd

Journals References:

1. *International Journal of Advanced Manufacturing Technology*
2. International Journal of Machine Tools and Manufacture

M. Tech. (Mechanical Engineering)

TITLE	**CODE**	**CREDITS**
Casting and Welding		3

Scope and Objective:

- To understand basic manufacturing processes like casting and welding
- To learn various aspects of different manufacturing techniques such as various casting methods and welding methods
- To have a broad knowledge to design a casting process for a product and design of welded joints

Learning Outcome:

Course Outcome	Description
CO1	Outline scope of various casting and welding processes
CO2	Describe various terminologies used in various casting and welding processes. Designing of the pattern and the gating system. Describe solid solutions, phase diagram, phase transformation, heat treatment processes.
CO3	Develop skills of sand preparation, making pattern,mould, core, gating system, arc welding, resistance welding, gas welding and brazing processes.
CO4	Identify casting and welding processes suitable for different materials. To analyze and compare the processes to choose the appropriate process.
CO5	Identify various defects in casting and welding processes, the causes for their occurrence and the remedies.
CO6	Apply testing and measuring equipments and methods used in casting and welding processes.

COURSE CONTENT

Casting:

Mechanism of Solidification: Design Principles of Gates, Runners and Risers.
Design of Casting, Introduction to ferrous and non-ferrous foundry practice. Iron-Carbon Equilibrium Diagram, TTT Curves, Heat treatment of Metals, Melting Furnaces**(8)**
Recent developments in Casting. Casting defects, Inspection and testing of Castings.

Welding:

Theory of fusion and pressure welding, flow and distribution of heat in welding, Weldability, Welding of various materials, Non conventional welding processes

TEXT BOOKS:

1. Jain P L, Principles Foundry Technology, Tata McGraw Hill
2. Parmar R.S., Welding Process and Technology, Khanna Publishers.

REFERENCES:

1. Pandey P. C. and Singh C. K., Production Engineering Sciences, Standard Publisher.
2. De Garmo, E. P., Black, J. T. and Kohser, R.A., Materials and Processes in Manufacturing, Prentice Hall of India Pvt. Ltd.

3. Ghosh A. and Mallik A. K., Manufacturing Science, EWP Pvt. Ltd.
4. William D. Callister and David G. Rethwisch, Materials Science and Engineering: An Introduction, Wiley

TITLE	**CODE**	**CREDITS**
Casting and Welding Lab		1

Scope and Objective:

1. To study different testing methods for silica sand, moulding sand and design of pattern
2. To study SMAW, GMAW, GTAW, Oxy-acetylene welding and resistance spot welding processes

Learning Outcome:

Course Outcome	**Description**
CO1	Skills to use sand testing equipments used in the foundry viz. GFN test, Moisture content test, Clay content test, Permeability test, Tensile and Compression strength test.
CO2	Skills to use sand testing equipments used in the welding viz. dye penetrant test, ultrasonic test etc.
CO3	Skill to use welding processes viz. SMAW, GMAW, GTAW, Oxy-acetylene welding and Resistance spot welding.
CO4	Skill to prepare edge for making different joints.
CO5	Skill to set the flame in gas welding for welding and cutting operations

CONTENTS

S No	**Name of Experiment**
1	To design a wooden pattern for casting of cast iron
2	Making a wooden pattern designed in Experiment No. 1.
3	Preparing butt joint of two steel plates using manual Metal Arc Welding (MMAW)
4	Preparing lap joint of steel plates using Oxy Acetylene Gas welding.
5	To cut steel sheets of different thicknesses with the help of an oxy-acetylene gas cutting torch
6	To determine the hardness of Heat Affected Zone produced by welding and cut steels using oxy acetylene flame by Rockwell hardness tester.

TEXT BOOKS:

1. Jain P L, Principles Foundry Technology, Tata McGraw Hill
2. Parmar R.S., Welding Process and Technology, Khanna Publishers.

REFERENCES:

1. Rao P. N., Manufacturing Technology I, Tata McGraw Hill.

2. Jain R.K., Production Technology, Khanna Publisher.
3. Kalpakjian S., Schemid S., Manufacturing, Engineering and Technology, Addison Wesley.

Title: Unconventional Manufacturing Processes Code:
L-T-P scheme: 3-0-0 **Credit: 3**

Prerequisite: Students must have already studied courses, "*Conventional Manufacturing Processes and Machining science and Technology*".

Objective:

1. To understand the working principles/mechanisms involved in different unconventional manufacturing processes
2. To learn and know about the applications of hybrid manufacturing processes.
3. To encourage the students for doing their research work in the area of Unconventional Manufacturing Processes

Learning Outcomes:

Course Outcome	Description
CO1	Outline various unconventional manufacturing process based on energy sources and mechanism employed.
CO2	Describe the industrial or real world problems using hybrid manufacturing concepts.
CO3	Develop an idea to fabricate or modify the laboratory setups to find out the solution of industrial problems.
CO4	Identify the most influencing process parameters to manufacture a defect free product.
CO5	Apply most appropriate unconventional technique to manufacture a product economically.
CO6	Demonstrate and deployment the mechanism of unconventional manufacturing processes for solving real-world problems.

Course Content:

Unit-1: Introduction to unconventional manufacturing processes-limitations of conventional manufacturing processes, introduction to hybrid machining process.

Unit-2: Modern machining processes: classification, selection, mechanics, design, economics, accuracy and applications of modern mechanical energy based processes- abrasive jet machining (AJM), water jet machining (WJM), ultrasonic machining (USM).

Unit-3: Thermo-electric processes: Electro discharge machining (EDM), electron beam machining (EBM), laser beam machining (LBM), plasma arc machining (PAM), ion beam machining (IBM).
Unit-4: Chemical Energy based unconventional Machining Processes: chemical machining (CHM), photo chemical machining (PCHM), electrochemical machining (ECM), and electrochemical grinding (ECG).
Unit-5: Electro-discharge grinding (EDG), electro-chemical discharge grinding (ECDG), super finishing processes.
Unit-6: High Velocity Forming Process: Explosive forming processes, Propellant forming, Gas forming, Electro-hydraulic forming, Electromagnetic forming, Pneumatic/mechanical forming, Formability criteria.
Unit-7: Advanced welding processes: ultrasonic welding, laser beam welding, electron beam welding, and plasma arc welding processes.

Teaching Methodology:

This course is introduced to help students to understand the various unconventional manufacturing processes with their industrial applications. The entire course is broken down into six separate units: Introduction, Unconventional machining processes, Hybrid machining processes, unconventional finishing processes, unconventional welding processes, unconventional forming processes, and powder metallurgy. Students are motivated to do their research work in the domain of unconventional manufacturing processes.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1 & Unit-2
Test-2	25 Marks	Based on Unit-3 & Unit-4 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-5 to Unit-7 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Referred video lectures and lecture notes on Unconventional Manufacturing Processes are available on JUET server.

Text Book:

[1] Ghosh and Mallik, Manufacturing Science, EWP Private Ltd.
[2] Jain V. K., Advance Machining Processes, Allied Publisher.
[3] Pandey P. C., Modern Machining Processes, TMH Publication.
[4] Benedict G.F., Non Traditional Manufacturing Processes, Marcel Dekker.

Reference Books/Material:

[1] El-Hofy, H., Advanced Machining Processes-Non-traditional and Hybrid Machining Processes, McGraw-Hill, NewYork.
[2] McGough J. A., Advanced Methods of Machining, Chapman and Hall Ltd., London.
[3] Kochan D., Solid Freeform Manufacturing, Elsevier Science.
[4] Groover M.P., Fundamentals of Modern Manufacturing Processes, Prentice Hall.
[5] Chryssolouris, G., Laser Machining - Theory and Practice (Mechanical Engineering Series), Springer - Verlag, NewYork.

Web References:

[3] www.nptel.com
[4] https://nptel.ac.in/courses/112/107/112107077/

Journals References:

[1] Journal of Manufacturing Processes: Elsevier
[2] Materials and Manufacturing Processes: Taylor & Francis
[3] Journal of Materials Processing Technology: Elsevier
[4] Advances in Manufacturing: Springer

M. Tech. (Mechanical Engineering)

TITLE	CODE	CREDITS
COMPUTER INTEGRATED MANUFACTURING		3

Objectives:

- This course introduces students with computer assisted modern manufacturing technologies.
- The topics covered in this course include basics of automation, NC programming (manual and APT), concepts of group technology, Flexible Manufacturing system, CIM and robotics.
- The objective of this course is to make students learn the important theoretical concepts, and the state-of-the-art technological developments in the area of modern manufacturing.

Learning Outcome:

Course Outcome	Description
CO1	Outline basic concepts related to CIM like types of production, plant layout, sequencing and scheduling, group technology, types of automation and FMS.
CO2	Describe NC, CNC and DNC, computer aided process planning (CAPP) and Automated inspection.
CO3	Develop ability to classify parts into families via GT concepts, classification and coding schemes, PFA etc.
CO4	Identify the sequence of operation, generate process plan and simulate and write part programs for CNC milling and lathe; FMS introduction, component and layouts.
CO5	Apply acquired knowledge to perform machining, inspection and assembly operations on Flexible manufacturing system available in CIM lab of the department.
CO6	Demonstrate ability to work in a flexible manufacturing system in an organization.

COURSE CONTENT

Introduction: Automation, Need for Automation, Types of automation systems, Automation strategies, levels of automation, Introduction to NC, CNC and DNC and Computer integrated manufacturing, CIM wheel, components of CIM

Part programming: Introduction, NC coordinate system, fixed and floating zero machines, NC motion control systems, part programming methods, Manual part programming for milling and lathe using G and M codes, various canned cycles

Group Technology: part families, part classification and coding, production flow analysis, composite part concept, benefits of GT.

M. Tech. (Mechanical Engineering)

Flexible Manufacturing System: Definition of FMS, components of FMS, types of flexibilities, classification of FMS, primary and secondary material handling systems, FMS layout configurations, computer control system, FMS applications and benefits.
Automated Material Handling and AS/RS: Introduction, types of material handling equipment, automated guided vehicle system (AGVs), applications, vehicle guidance and routing, traffic control and safety system management, Basic components of AS/RS, types of AS/RS, AS/RS controls, special features.
Robotics: Definition, robot anatomy and related attributes, robot configuration, work volume, types of control systems, end effectors, industrial applications of robot, introduction to robot programming.

Automated Inspection & Testing: Automated inspection principles, off-line and on-line inspection, contact and noncontact inspection techniques, Co-ordinate measuring machine (CMM): Introduction and types of CMM.
Manufacturing Support System: Product design and CAD, concurrent engineering and Computer aided process planning (CAPP).

TEXT BOOK:

1. Groover M. P., Automation, Production Systems And Computer-integrated Manufacturing, PHI.
2. Miller R. K., FMS/CIM Systems Integrated Handbook, Prentice Hall

REFERENCES:

1. Parrish D. J, “Flexible manufacturing”, Butterworth – Heinemann Ltd, 1990
2. Rao, P.N., CAD / CAM Principles and Applications, McGraw Hill Publishers, New Delhi
3. Jha, N. K., Handbook of Flexible Manufacturing Systems, Academic Press Inc.

M. Tech. (Mechanical Engineering)

Title: Mechanics of Metal Forming — Code:

L-T-P scheme: 3-0-0 — **Credit: 3**

Prerequisite: Students must have already studied courses, “Material science”, and “Manufacturing process”.

Objective:

1. To learn the importance metal forming processing routes fordifferent materials and its importance for advanced materials manufacturing
2. To learn and be able to perform engineering work in accordance with ethical and economic constraints related to metal forming processes.

Learning Outcomes:

Course Outcome	Description
CO1	Understands the stress and strain at an inclined plane from the given three dimensional stresses
CO2	Determine the forming load estimation during different metal forming processes
CO3	Apply knowledge of types of modelling technique
CO4	Undertake problem identification and identify different forms of metal forming techniques
CO5	Evaluate the properties of different forming operation
CO6	Analyze design and processing in metal forming like strain, strain rate and thermal effects in metal forming

Course Content:

Unit-1: Elasticity - Analysis of Stress and Strain, General Equations of Elasticity,

Unit-2: Plasticity - Plastic deformations, Theories ofPlasticity.

Unit-3: Modeling Techniques: slip line slab, Upper Bound and FEM.

Unit-4: Mechanics of Manufacturing Processes: Rolling, Forging, Wire Drawing, Extrusion, Deep Drawing, Bending and other miscellaneous forming operations.

Unit-5: Analysis of Manufacturing Processes: Rolling, Forging, Wire Drawing, Extrusion, Deep Drawing, Bending and other miscellaneous forming operations.

Unit-6: Analysis of Die failure: in Metal Forming, Strain, Strain rates and thermal effects in metal forming.

Teaching methodology:

This course covers the design aspects of the different metal forming operation such as rolling, drawing, extrusion, and many more. The load calculations in actual and ideal condition are also emphasized for each and every metal forming processes.

Evaluation Scheme:

Exams	**Marks**	**Coverage**
Test-1	15 Marks	Based on Unit-1
Test-2	25 Marks	Based on Unit-2, Unit-3 and around 30% from

		coverage of Test-1
Test-3	35 Marks	Based on Unit-4 to Unit-5 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Tutorials and referred video lecture on Advanced Materials Technologyis available on JUET server.

Text Book:

1. Dieter George E.,Mechanical Metallurgy, McGraw-Hill, 1988.
2. Timoshenko S.P., Strength of Materials. Advanced Theory and Problems, CBS Publishers andDistributors, New Delhi.

Reference Books:

1. Hearn E. J., Mechanics of Material Vol. I & II, Butterworth-Heinemann Publication.
2. Gere J. M., Mechanics of Materials, Thomson Press.
3. Pytel A. and kiusalaas J., Mechanics of Materials, Thomson Press.

M. Tech. (Mechanical Engineering)

TITLE	**CODE**	**CREDITS**
ADDITIVE MANUFACTURING PROCESS		3

SCOPE AND OBJECTIVES

LEARNING OUTCOME

1. The student will be able to select between a subtractive and an AM process for a particular application. He or she will be able to select a particular AM process.
2. The student will be able to take a career in research or in advanced manufacturing, the AM being a rapidly evolving area and with wide applications.
3. It is aimed at making the students ready for product development of engineering components and for entrepreneurship. He will be able to employ RE for value addition and reproduction of parts.

Objectives:

1. The objective of this first course on additive manufacturing (AM) to the PG students of Manufacturing Technology stream is to make the students aware of rapidly evolving and widely used technology.
2. It is aimed to make the students aware of the technology for conceptual modeling, prototyping and rapid manufacturing. It is also aimed to introduce reverse engineering (RE).
3. It is aimed to impart detailed knowledge of wide applications of AM in industry and society; and in particular, key applications of AM such as rapid tooling, medical AM and rapid manufacturing.

Learning Outcome:

Course Outcome	Description
CO1	Outline the additive manufacturing process. Introduction, definition, Process chain
CO2	Describe classification and detail descriptions of various rapid prototyping, matrials, comparison with subtractive mfg. processes
CO3	Develop understanding of various processes in different circumstances, various file formats for additive manufacturing
CO4	Identify differences among rapid prototyping, manufacturing and rapid tooling. STL file conversion, errors and repair.
CO5	Apply acquired knowledge in new product development and mass customization of products in various industries such as automobile, aerospace, medical, construction, fashion, electronics etc.
CO6	Demonstrate skill to build AM part by preparing CAD model directly or through reverse engineering, pre processing, part building and post processing the part.

COURSE CONTENT

1. INTRODUCTION

Prototyping, rapid prototyping, Additive Manufacturing (AM), Process chain of additive manufacturing, Advantages of AM.

2. CLASSIFICATION OF AM PROCESSES

Liquid based, solid based, and powder based AM processes; Stereolithography and other liquid based systems, Fused Deposition processes for polymers, ceramics and metals, Laminated Object Manufacturing , Shape Deposition Manufacturing, Laser sintering based technologies, 3D printing, Direct Metal Deposition, LENS, Electron beam melting based process.

3. APPLICATIONS OF AM

Introduction, applications of AM in different categories such as conceptual design, rapid manufacturing, rapid tooling, terrain modeling, medical AM and mass customization (most of things to be discussed in detail in the chapters on Rapid Manufacturing, Medical AM and Rapid Tooling).

4. RAPID MANUFACTURING

Different applications of AM for directly making end-use parts – industrial applications, utilizing porous property, medical applications such as dental, hearing aid and medical devices, terrain modeling, transport, military, architectural, electronics, etc. Mass customization – production of customized products in mass scale.

5. MEDICAL AM

Medical applications of AM for prosthesis and implant; tissue engineering; complex surgical planning and visualization of bio-molecules with several case studies in each category.

6. DATA EXCHANGE FORMATS

Data formats for AM and associated details, Data conversion for AM and associated difficulties, Data validity checks for AM, Data repair procedures for AM, Slicing algorithms and related details, Direct slicing, Standard data formats for translation, Relevant AM file formats, STEP data format and its details.

7. RAPID TOOLING (RT)

Soft tooling and hard tooling, Direct methods of rapid tooling, Indirect methods of rapid tooling processes.

8. INTRODUCTION TO REVERSE ENGINEERING

Definition of Reverse Engineering (RE), Need for RE, Three phases in the generic RE process – scanning (contact and non-contact scanners), point processing and geometric modeling.

TEXT BOOKS:

1. Chua, C K, Leong, K F and Lim CS, Rapid Prototyping: Principles and Applications in Manufacturing, World Scientific, 2003.
2. Gibson, I., Rosen, D.W. and Stucker, B., Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, Springer, New York, 2010.

REFERENCES:

1. Prasad, Hari and Badrinarayan, K.S., *Rapid Prototyping and Tooling*, ISBN: 978-81-923-2065-6, 1st edition, SIP-Page Turners Publications, Surya Infotainment Products Pvt. Ltd., Bangalore, 2013.
2. Hopkinson, N, Hague, R, and Dickens, P, *Rapid Manufacturing: An Industrial Revolution for a Digital Age: An Industrial Revolution for the Digital Age*, Wiley, Jan 2006.
3. Castle Island Co., *Worldwide Guide to RP*, available at: www.additive3d.com.

4. Hilton, P.D. and Jacobs, P.F., *Rapid Tooling – Technologies and Industrial Applications*, Marcel Dekker AG, Basel, Switzerland, 2000.
5. Gibson, Ian, *Advanced Manufacturing Technologies for Medical Application – Reverse Engineering, Software Conversion and Rapid Prototyping*, John Wiley and Sons Ltd, West Sussex, England, 2005

Title: Advanced Materials Technology Code:
L-T-P scheme: 3-0-0 **Credit: 3**

Prerequisite: Students must have already studied courses, "Material science", "Manufacturing process".

Objective:

3. To learn the importance non-conventional processing routes fordifferent materials and its importance for advanced materials manufacturing
4. To learn and be able to perform engineering work in accordance with ethical and economic constraints related to the design of metallurgicalstructures.

Learning Outcomes:

Course Outcome	Description
CO1	Understands the working principles of different advanced processes
CO2	Determine and select the Type of Deposition and Spraying technique with respect to the application
CO3	Apply knowledge of types of Pre-treatment methods to be given to surface engineering
CO4	Undertake problem identificationand identifydifferent forms of processing techniques of surface engineering materials.
CO5	Evaluate the properties of surface degradation of materials.
CO6	Analyze design and processing new types of surface testing methods and Comprehend the degradation properties

Course Content:

Unit-1: Review of Mechanical Behavior of Materials: Plastic deformation in poly phase alloys - Strengthening mechanisms - Griffith's theory of failure modes – Brittle and ductile fractures - Damping properties of materials - fracture toughness - Initiation and propagation of fatigue cracks - Creep mechanisms - Hydrogen embrittlement of metals.

Unit-2: Surface Modification of Materials: Mechanical surface treatment and coating - Case hardening and hard facing - thermal spraying – vapour deposition-ion implantation - Diffusion coating - Electroplating and Electroforming - Conversion coating - Ceramic and organic coatings – Diamond coating - Advanced surface modification of steels.

Unit-3: Advanced Heat Treatment of Materials: Unconventional surface hardening techniques-Heat treatment of critical mechanical elements like gears, tools, dies, springs, shafts-Heat treatment of Al, Cu, Ni and Ti alloys-Polymerquenchants.

Unit-4: Modern Materials and Alloys: Super alloys-Refractory materials-Ceramics and their applications-Low melting alloys-shape memory alloys-Metal matrix and ceramic matrix composites.

Unit-5: Applications of Advanced Materials: Ti and Ni based alloys for gas turbine applications-Maraging and Cryogenic steels-Newer materials and their treatment for automobile applications-Materials for Naval and nuclear systems.

Teaching methodology:

This course covers the metallurgical aspects of the welding of common engineering metals such as plain carbon, alloy and stainless steels, aluminum and cast iron. The selection of filler metals, transfer and recovery of alloying elements and design of preheating and post heating cycles is also emphasized.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1
Test-2	25 Marks	Based on Unit-2, Unit-3 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-4 to Unit-5 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Tutorials and referred video lecture on Advanced Materials Technologyis available on JUET server.

Text Book:

1. E Paul Degarmo, J T Black, Ronald A Kohser., Materials and Processing in Manufacturing, Willey Publication, 2006
2. Composite Materials Hand book – M M Schwartz, McGraw Hill.
3. G.E. Totten., Steal heat treatment handbook- Metallurgy and Technologies, CrC press, Taylor and Francis group, second edition.

Reference Books:

1. P K Mallick., Fiber Reinforced Composites- Materials, Manufacturing and Design, CRC press, Taylor and Francis group.
2. Metal Matrix Composites – Minoru Taya, Richard J Arsenault

M. Tech. (Mechanical Engineering)

TITLE: Industrial Inspection and Quality Control CODE:

L-T-P scheme: 3-0-0 **Credit: 3**

SCOPE AND OBJECTIVE:

Induatrial inspection and quality control is a collection of tools that when used together can result in process stability and variance reduction. Objective of course is

1. Satisfactory level of quality must be achieved with a minimum cost
2. Eliminating assignable (special) sources of variation product outcome, so that the process is stable.
3. Monitoring the ongoing production process, assisted by the use of control charts, to detect significant changes of mean or variation.

Learning Objectives:

CO1	Understand the role of statistical tools in quality improvement and inspection of industrial process & products
CO2	Able to interpret and implement Inspection Planning, Inspection & Quality Control, Quality Assurance and Evaluation
CO3	Understand the different types of variability, rational subgroups, and how a control chart is used to detect assignable causes
CO4	Construct and interpret control charts for variables and numbers
CO5	Able to find the process capabilities and interpreting different indexes of process capability
CO6	Able to demonstrate the applications and implementation of TQM, ISO 9000

COURSE CONTENT

Quality

Concept of Quality, Quality Function, Quality Traits, Quality Characteristics, Quality Management, Quality Principles, Quality Policy, Quality System, Quality Planning, Organizing for Quality, Quality of Design, Quality Circles.

Inspection

M. Tech. (Mechanical Engineering)

Definition of Inspection, Inspection Planning, Measurement Errors, Objectives of Inspection, Floor / Patrol Inspection, Centralized Inspection, Process Inspection, Final Inspection, Difference between Inspection & Quality Control. Quality Assurance Importance, Total Quality Assurance, Management Principles in Quality Assurance, Forms of Quality Assurance, Evaluation of Quality Assurance, Quality Assurance Programme, Quality Assurance Aspects, Quality Assurance Departments.

Quality Control

Total Quality Control, Objectives of Quality Control, Principles of Quality Control, Quality Control Tools, Statistical Quality Control, Control Charts, Construction of Control Charts for Variables (R, X - bar Chart) and Attributes (p, np, C, U Charts), Acceptance Sampling by Attributes, AOQ & OC Curves, Types of Sampling Plans, Analysis of Process Capability, Use of Dodge Roming and Military Standards Sampling Tables.

Quality Management System

Quality Management systems- origin of ISO 9000 series (ISO 9001,9002,9003,9004) ISO 9001:2000, clauses of ISO 9001:2000, overview of QS 9000 series.

Text Book

1. D.C. Montgomery, Introduction to Statically quality control, John Wiley & Sons, Inc.
2. A.M. Badhade, Metrology and Quality control

Reference Books

1. Suganthi, L and Samuel, A Anand , TOTAL QUALITY MANAGEMENT , Phi Learning Pvt. Ltd.
2. R. P. Mohanty, TOTAL QUALITY MANAGEMENT, Jaico

M. Tech. (Mechanical Engineering)

Title: Operations and Supply Chain Management Course Code:
L-T Scheme: 3-0 **Course Credits: 3**

Scope and Objectives:
Operation and Supply Chain Management applied successfully in many different areas of engineering, production and business activities for better & scientific decision making.
Role of Operations and Supply Chain Management

1. Better control on operations and supply chain system
2. Better coordination among the organizations departments
3. Better decisions and quantitative decision.

Learning Outcome:

Course Outcome	Description
CO1	Outline scope, importance and evolution of Operations and supply chain management. Describe various mrhods of forecasting and their applications.
CO2	Describe various concepts related to facilities, inventory, facility layout, capacity planning etc. in detail
CO3	Develop understanding on sequencing and scheduling and their applications in industries.
CO4	Identify scope of supply chain and study about various concepts of supply chain management.
CO5	Apply the various concepts of operations and supply chain management in practices and concepts utilizing case problems and problem-based learning situations.
CO6	Demonstrate the use of and use of IT, effective written and oral communications, critical thinking, team building and presentation skills as applied to business problems.

CONTENTS
FORECASTING: Introduction, different methods of forecasting, errors in forecasting
FACILITY LAYOUT AND LOCATION: Introduction, different models of layout, decision making
CAPACITY AND AGGREGATE PLANNING:Capacity measurement, long-term and short term strategies, aggregate planning
INVENTORY MANAGEMENT: Various costs in inventory management and need, deterministic models and discounts, probabilistic inventory management
SCHEDULING MODELS AND APPLICATIONS: Scheduling in MRP system, sequencing rules and applications, batch production sequencing and scheduling .

M. Tech. (Mechanical Engineering)

INTRODUCTION TO SUPPLY CHAIN: Definition, complexity, key issues, centralized vs. decentralized systems, bullwhip effect, push-based, pull based systems
OUTSOURCING AND TRANSPORTATION: Make or buy decisions, drivers of the decisions, network design decisions, cross-docking, and transshipment.
DISTRIBUTION AND LOGISTICS IN SUPPLY CHAINS: Direct shipment/intermediate storage policies, vehicle routing models, third-party logistics.
INFORMATION TECHNOLOGY IN SUPPLY CHAIN: Enabling supply chain through IT, ERP vendor platforms, Service oriented architecture (SOA), RFID

Text Book

1. Supply Chain Management by *Chopra and Meindl*
2. Operations research by Sharma J.K., Trinity press

References:

1. Operations Management by *Evans and Collier*
2. Operations Management by *Heizer and Render*

M. Tech. (Mechanical Engineering)

Title of Course: Robotics and Automation Course Code:
L-T-P: 3:0:0 **Course Credits: 3**

Course Outcome	Description
CO1	Outline the terminology, components and subsystems of Automation
CO2	Describe the working principles of drive system, end effectors, sensor, and machine vision systems of robots.
CO3	Apply the concepts of dynamics for a typical Pick and Place robot.
CO4	To choose the appropriate Sensor and Machine vision system for a given application
CO5	Apply appropriate technique to analyze the robot kinematics.
CO6	Demonstrate and deployment the skills to write the program for real world applications of robot.

COURSE CONTENT

Fundamentals of Automation: Strategies and economics, Principles of automation applied to loading feeding, measuring, material handling, storage, assembly, process control and quality control.

Industrial Robots: Technology, programming and applications, Manufacturing systems: Transfer machines, conventional machine layout systems, flow line systems, machining centres, NC, DNC and CNC systems.

Flexible Manufacturing Systems, Introduction, Production, materials handling and management sytems in FMS.

Group Technology: Classification procedures and coding systems, Layout planning model for GT, materials requirement planning and computer aided process planning. Introduction to Computer - Integrated Manufacturing systems, Factories of the future and Social impacts.

Robot Technology:- Physical configuration, Drives (Hydraulic, Pneumatic, Electrical), Basic motors, Sensors including vision, Technical features, Programming languages, Work cell control Robot sensors, Robot applications**.**

TEXT BOOKS:

1. Deb S. R. and Deb S., “Robotics Technology and Flexible Automation”, Tata McGraw Hill Education Pvt. Ltd, 2010.
2. John J.Craig , “Introduction to Robotics”, Pearson, 2009.
3. Mikell P. Grooveret. al., "Industrial Robots - Technology, Programming and Applications", McGraw Hill, New York, 2008.
4. Kuo B C, "Automatic Control Systems", Prentice-Hall of India Pvt. Ltd, New Delhi, 2004.

REFERENCES BOOKS:

1. Richard D Klafter, Thomas A Chmielewski, Michael Negin, "Robotics Engineering – An Integrated Approach", Eastern Economy Edition, Prentice Hall of India Pvt. Ltd., 2006.
2. Fu K S, Gonzalez R C, Lee C.S.G, "Robotics : Control, Sensing, Vision and Intelligence", McGraw Hill, 198
3. Handbook of Industrial Robotics edited by Shimon Y.
4. Robotics: Designing the Mechanisms for Automated Machinery by Ben-Zion Sandler.

M. Tech. (Mechanical Engineering)

Title of Course: Dissertation Part-I Course Code:

Prerequisite: Students must have already studied the courses like, "*Advanced Manufacturing Processes*", "*Materials Science and Composites*" etc.

Objective:

To study of literature survey, formulate the research problem and develop necessary methodology related to research problem. The first part of the Dissertation should be to determine the interest of students and broadly identify the area of work, finalize the research problem based on literature survey. The students should have familiarity with the concepts, tools, techniques required to carry out the Dissertation work. Student is expected to start the research work

Learning Outcomes:

Course Outcome	Description
CO1	Outline the dissertation topics with respect to their needs for the society.
CO2	Description of usefulness of the work in the context of present application
CO3	Development of the literature survey in chronological order
CO4	Identification of the problem in current areas of manufacturing technology
CO5	Application and usefulness to the society.
CO6	Demonstration and deployment of manufacturing techniques requires to complete the work

Course Content:

Unit 1: Motivation about dissertation Topic

Unit 2: Usefulness of the work in the context of present application

Unit 3: Literature survey in chronological order.

Unit 4: Problem formulation.

Unit 5: Study / Analysis of different existing methods based on adequate performance parameters.

Unit 6: Mathematical formulation of the proposed method.

Teaching Methodology/Guidelines:

Each student will decide his Dissertation topic in consultation with his/her supervisor on which he/she will work towards the fulfillment of Master's Dissertation. In the first mid-term seminar, the researcher will present a literature review and define the problem. In the final viva-voce, the researcher is expected to give the problem formulation in detail. By the end of the first semester of the dissertation, the experimental techniques, analysis and/or synthesis procedure should come out clearly. Progress of the work should also be presented. The viva-voce will be based on your work, thesis report and presentation. Finally a report will be submitted towards the end of the semester.

M. Tech. (Mechanical Engineering)

Evaluation Scheme:

<table>
<tr><th colspan="2">Exams</th><th>Marks</th><th>Coverage</th></tr>
<tr><td colspan="2">Presentation-1</td><td>15 Marks</td><td>Unit 1-Unit 2</td></tr>
<tr><td colspan="2">Presentation-2</td><td>15 Marks</td><td>Unit 3-Unit 4</td></tr>
<tr><td colspan="2">Presentation-3</td><td>20 Marks</td><td>Unit 5-Unit 6</td></tr>
<tr><td rowspan="4">Day to day work</td><td>Attendance</td><td>10 Marks</td><td rowspan="4">50 Marks</td></tr>
<tr><td>Sincerity</td><td>10 Marks</td></tr>
<tr><td>Report</td><td>15 Marks</td></tr>
<tr><td>Performance</td><td>15 Marks</td></tr>
<tr><td colspan="2">Total</td><td colspan="2">100 Marks</td></tr>
</table>

Learning Resources:
After discussion with the concerned faculty members, Student will develop some new areas in the field of Manufacturing technology (Mechanical Engineering) and related information.

Text Books & Reference Books/Material: Related to Area of Research work

Web References:
[1] https://www.sciencedirect.com
[2] https://www.springer.com
[3]] https://www.taylorandfrancis.com

M. Tech. (Mechanical Engineering)

Title of Course: Dissertation Part-II   Course Code:

Prerequisite: Students must have already studied the courses like, "*Advanced Manufacturing Processes*", "*Materials Science and Composites*" and "Programming and/ or *Simulation Tools"* etc.

Objective:
The objective of Dissertation Part-I is to promote a systematic understanding of the knowledge, critical awareness of current problems, originality in the application of knowledge and the quality of work. The ideal work may be characterized by a new result in design, development and implementation. It should have the potential of industrial/scientific acceptance. Dissertation Part-II should be seen in continuation with Dissertation Part-I. The researcher should continue the research work in the two parts.

Learning Outcomes:

Course Outcome	**Description**
CO1	Outline the dissertation topics with respect to their needs for the society.
CO2	Description of usefulness of the work in the context of present application
CO3	Development of the literature survey in chronological order
CO4	Identification of the problem in current areas of manufacturing technology
CO5	Application and usefulness to the society.
CO6	Demonstration and deployment of advanced manufacturing techniques requires to complete the work

Course Content:
Unit 1: Motivation about dissertation Topic
Unit 2: Usefulness of the work in the context of present application
Unit 3: Literature survey in chronological order.
Unit 4: Problem formulation.
Unit 5: Study / Analysis of different existing methods based on adequate performance parameters.
Unit 6: Mathematical formulation of the proposed method.
Unit 7: Applications of the proposed work in real world problems for finding the solutions
Teaching Methodology/Guidelines:
Each researcher should present analytical and/or experimental works in consultation with his/her supervisor towards the fulfillment of Master's degree. The researcher will present the progress of his work in the mid-semester evaluation. He/she will present his/her complete work including literature review and introduction. The evaluation will be done based on the work done in both the semesters. In the end-semester evaluation of 4th

semester, the researcher will present his/her research work and defend his/her dissertation. Finally a dissertation has to be submitted to the University for Partial Fulfillment of M. Tech. program according to university rules. The students have to submit one copy of the dissertation soft bound/spiral bound before the end-semester evaluation for external examiner to facilitate modification. They should submit three bound copies of the dissertation after the end-semester evaluation, one of which will go to the supervisor. Therefore, a student will get four copies bound (one copy for himself), if he/she has one supervisor. The no. of copies may increase, in case he/she has more than one supervisor.

Evaluation Scheme:

Exams		Marks	Coverage
Presentation-1		15 Marks	**Unit 1-Unit 2**
Presentation-2		15 Marks	**Unit 3-Unit 4**
Presentation-3		20 Marks	**Unit 5-Unit 6**
Day to day work	Attendance	10 Marks	**50 Marks**
	Sincerity	10 Marks	
	Report	15 Marks	
	Performance	15 Marks	
Total		**100 Marks**	

Learning Resources:
After discussion with the concerned faculty members, Student will develop some new areas in the field of Manufacturing technology (Mechanical Engineering) and related information.

Text Books & Reference Books/Material: Related to Area of Research work

Web References:

[1] https://www.sciencedirect.com
[2] https://www.springer.com
[3]] https://www.taylorandfrancis.com