M.Tech. Degree

PROGRAMME

In

Machine Design Engineering

CURRICULUM

(w.e.f. Session 2019-2020)

DEPARTMENT OF MECHANICAL ENGINEERING
NATIONAL INSTITUTE OF TECHNOLOGY
KURUKSHETRA-136119

VISION OF THE INSTITUTE

- To be a role model in technical education and research, responsive to global challenges.

MISSION OF THE INSTITUTE

- To impart technical education that develops innovative professionals and entrepreneurs.
- To undertake research that generates cutting-edge technologies and futuristic knowledge, focusing on the socio-economic needs.

VISION OF THE DEPARTMENT

To make contribution in the development of nation and evolution of technology by creating highly ethical professionals in Mechanical Engineering who are technically competent and are aware of their social responsibilities.

MISSION OF THE DEPARTMENT

- M1: To produce highly qualified, socially responsible, ethical and motivated students having sound theoretical and practical knowledge of Mechanical Engineering as well as communicative skills who can serve the nation as well as at global level
- M2: To inspire students to be a part of research and development activities.
- M3: To carry out research in order to serve the needs of industries, government and society.
- M4: To encourage students to participate in conferences, workshops, seminars and research activities.
- M5: To develop partnership with government agencies and industries.

PROGRAMME: - MACHINE DESIGN ENGINEERING

Programme Education Objectives (PEOs)

1. To impart education in the domain of Machine Design to have all-round development of students in order to serve the global society.
2. To develop the critical thinking and problem solving ability amongst the students through application of various aspects/fundamentals of Machine Design to understand/ analyze/ solve the critical situations in the area amicably.
3. To develop independent research attitude through projects/dissertations and its administrative & financial management as well as its dissemination to the PG students.
4. To create awareness amongst the students for collaborative and multidisciplinary activities through usage of modern/emerging tools, technologies and research publications
5. To encourage students to be ethically and socially responsible and articulate themselves to be a lifelong learner.

Programme Outcomes (POs)

PO1: An ability to independently carry out research /investigation and development work to solve practical problems.

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

PO3: Students should be able to demonstrate a degree of mastery over the area of Machine Design The mastery should be at a level higher than the requirements in the appropriate bachelor program.

PO4: An ability to develop and apply software and hardware tools / techniques for the analysis of problems related to design, manufacturing and optimization.

PO5: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

MASTER OF TECHNOLOGY SCHEME IN MECHANICAL ENGINEERING (MACHINE DESIGN)

SEMESTER – I

S. No.	Course Code	Course Title	Lecture	Tutorial	Practical	Credits
1	MME1C01	Applied Numerical Methods	3	-	-	3
2	MME1C03	Computer Aided Design	3	-	-	3
3	MME1C05	Design of Mechanisms	3	-	-	3
4	MME1C07	Finite Element Methods	3	-	-	3
5	MME1E__	Elective I	3	-	-	3
6	MME1E__	Elective II	3	-	-	3
7	MME1L01	Test & Optimization Lab I	-	-	3	1
8	MME1L03	CAD& CAE Lab	-	-	3	1
		Total	**18**		**6**	**20**
		Total Contact Hours	**24**			

SEMESTER – II

S. No.	Course Code	Course Title	Lecture	Tutorial	Practical	Credits
1	MME1C02	Industrial Robotics	3	-	-	3
2	MME1C04	Advanced Mechanical Vibrations	3	-	-	3
3	MME1E__	Elective III	3	-	-	3
4	MME1E__	Elective IV	3	-	-	3
5	MME1E__	Elective V	3	-	-	3
6	MME1O__	Open Elective (Non departmental)	3	-	-	3
7	MME1L02	Test & Optimization Lab II	-	-	3	1
8	MME1L04	Robotics Lab	-	-	3	1
		Total	**18**		**6**	**20**
		Total Contact Hours	**24**			

SUMMER VACATION

Course Code	Course Title	P/T	Credits
MME1PW02	Preparatory work for Dissertation/ Project		0

SEMESTER - III

Course Code	Course Title	P/T	Credits
MME1D01/ MME1P01/ MME1I01	Dissertation /Project/Internship Part-I		14

SEMESTER - IV

Course Code	Course Title	P/T	Credits
MME1D02/ MME1P02/ MME1I02	Dissertation /Project /Internship Part-II		14

TOTAL CREDITS: 68

LIST OF ELECTIVES (MACHINE DESIGN)

S. No.	Course Code	Course Title	Credits
1	MME1E31/MME1E32	Advanced Mechanics of Solids	3
2	MME1E33/MME1E34	Measurement and Control	3
3	MME1E35/MME1E36	Experimental Stress Analysis	3
4	MME1E37/MME1E38	Advanced Tribology	3
5	MME1E39/MME1E40	Theory and Analysis of Plates	3
6	MME1E41/MME1E42	Fracture Mechanics	3
7	MME1E43/MME1E44	Mechanics of Composite Materials	3
8	MME1E45/MME1E46	Advanced Engineering Materials	3
9	MME2C02	Soft Computing	3
10	MME2C03	Operations Management	3
11	MME2C05	Computer Aided Manufacturing	3
12	MME2C07	Experimental Designs	3
13	MME2E31/MME2E32	Welding Science & Technology	3
14	MME2E35/MME2E36	Production Planning and Control	3
15	MME2E45/MME2E46	Modeling & Simulation	3
16	MME2E49/MME2E50	Machine Vision & Artificial Intelligence	3
17	MME2E51/MME2E52	Strategic Entrepreneurship	3
18	MME2E53/MME2E54	Total Quality Management	3
19	MME3C01	Advanced Fluid Engineering	3
20	MME3C02	Computational Fluid Dynamics	3
21	MME3E35/MME3E36	Nuclear Engineering	3
22	MME3E39/MME3E40	Renewable Energy & Energy Management	3
23	MME3E45/MME3E46	Solar Energy	3
24	MME3E47/MME3E48	Gas Turbine & Jet Propulsion	3

LIST OF OPEN ELECTIVES FOR OTHER DEPARTMENTS

S. No.	Course Code	Course Title	Credits
1	MME1C01	Applied Numerical Methods	3
2	MME1C02	Industrial Robotics	3
3	MME1C03	Computer Aided Design	3
4	MME1C04	Advanced Mechanical Vibrations	3
5	MME1C05	Design of Mechanisms	3
6	MME1C07	Finite Element Methods	3
7	MME1E33/MME1E34	Measurement and Control	3

MME1C01
APPLIED NUMERICAL METHODS

L	T	P/D	Cr.
3	**-**	**-**	**3.0**

Course Learning Objectives:

1) To introduce the fundamentals of numerical methods used for the solution of engineering problems.
2) To impart the knowledge to the students about solution of simultaneous linear algebraic equations and non-linear simultaneous linear algebraic equations of engineering systems.
3) To review and implement the basic principles of curve fitting, interpolation, spline interpolation and approximation of functions.
4) To use numerical methods for differentiation and integration with engineering applications.
5) To understand the processes of numerical solution of ordinary differential equations and partial differential equations of engineering systems.

Course Contents

1. Approximations and Errors in Computations
Introduction, Numbers and their Accuracy, Errors and their Computation, Error in Series Approximation. **(3 hrs)**

2. Numerical Solution of Ordinary Differential Equations
Introduction, Solution by Taylor's Picard's Method, Euler's Method, Runge-Kutta Methods, Predictor-Corrector Methods, the Cubic Spline Method, Simultaneous and Higher Order Equations, Boundary Value Problems: Finite-Difference Method, The Shooting Method, The Cubic Spline Method. **(9 hrs)**

3. Numerical Solution of Partial Differential Equations
Introduction, Finite-Difference Approximations, Laplace's Equation: Jacobi's Method, Gauss-Seidel Method, SOR Method, ADI Method, Parabolic Equations, Iterative Methods, Hyperbolic Equations. **(9 hrs)**

4. Numerical Differentiation and Integration
Introduction, Numerical Differentiation, Numerical Integration, Euler-Maclaurin Formula, Adaptive Quadrature Methods, Gaussian Integration, Singular Integrals, Fouriers Integrals, Numerical Double Integration. **(6 hrs)**

5. Least- square Curve Fitting and Function Approximation
Introduction, Least-square Curve Fitting, Spline Interpolation, Cubic Splines, Chebyshev Minimax Approximation, Chebyshev Polynomials. **(5 hrs)**

6. Numerical Solution of Nonlinear Systems
Introduction, Picard Iteration, Newton's Method, Perturbed Iterative Scheme. **(2 hrs)**

7. System of Linear Algebraic Equations

Introduction, Methods for Large Linear Systems, Direct Methods, LU- Decomposition Methods, Iterative Methods, III-conditioned Systems. **(6 hrs)**

Course Outcomes:

1) Students will be able to understand the nature and operations of Numerical Analysis, demonstrate familiarity with theories and concepts used in Numerical Analysis.
2) Students will be able to identify the steps required to carry out derivation of the Numerical Methods, studying their convergence rate and performance, applicability of the methods on different test examples.
3) Students will be able to solve simultaneous linear algebraic equations, non-linear simultaneous linear algebraic equationsand select appropriate numerical methods to apply to various types of problems in engineering and science.
4) Students will be able to use standard interpolation methods to estimate intermediate values from a set of discrete values and determine an interpolating function for a set of data points.
5) Students will be able to conduct numerical integration and differentiation.
6) Students will be able to solve ordinary differential equations with initial and boundary values and partial differential equations.

Reference Books:

1. Niyogi, Pradip, “Numerical Analysis and Algorithms”, Tata McGraw –Hill
2. Balagurusamy,E., “Numerical Methods”, Tata McGraw –Hill
3. Sastry, S.S., “Introduction Methods of Numerical Analysis”, PHI
4. Chapra, S.C. and Canale, R.P., “Numerical Methods for Engineers”, Tata McGraw –Hill
5. Gerald, F. Curtis, “Applied Numerical Analysis”, Peason Education

MME1C03
COMPUTER AIDED DESIGN

L	T	P/D	Cr.
3	-	-	3.0

Course Learning Objectives

1) To understand 2D & 3D geometric transformation techniques in CAD.
2) To develop mathematical models to represent curves and surfaces.
3) To understand and generate solid geometries.

Course Contents

1. Introduction

Introduction, Review of vectors & Matrices, Basics of geometric and solid modeling, explicit, implicit, intrinsic and parametric equations, coordinate systems. **(3 Hrs)**

2. Transformations

Introduction, transformation of points and line, 2-D translation, shearing, rotation, reflection, scaling and combined transformation, homogeneous coordinates, 3-D scaling, shearing, rotation, reflection and translation, combined transformations, orthographic, axonometric, oblique and perspective projections. **(8Hrs)**

3. Curves

Geometry and topology, algebraic and geometric forms of straight lines, circles, conics, cubic splines, Ferguson curve, Hermite curve, Bezier curves and B-spline curves, NURBS, composite curves, tangents and normal, blending functions, re-parametrization. **(9 Hrs)**

4. Surfaces

Algebraic and geometric forms, tangents and twist vectors, normal, blending functions, re-parametrization. Plane surface, sixteen-point form, four curve form, ruled surface, surface of revolution, tabulated cylinder, lofted surface, bi-cubic surface, Bezier surface, B-spline surfaces, Coons' patch, blending surface, offset surface, rational surface . **(7Hrs)**

5. Solids

Solid models and representation schemes, their properties, boundary representation, constructive solid geometry, sweep representation, cell decomposition, octree encoding, spatial occupancy enumeration. **(6Hrs)**

6. Analytical properties:

Analytical properties (Intersection & development) of curves and surfaces. **(2 Hrs)**

Course Outcomes:

1) Perform transformations of 2D & 3D objects (such as lines, surfaces and solids).
2) Generate curves and surfaces by developing mathematical models.
3) Model components using solid modeling techniques.

Reference Books:

1. CAD/CAM by Groover and Zimmer, Prentice Hall
2. CAD/CAM: Theory and Practice by I. Zeid, McGraw Hill
3. Geometric Modeling by M.E. Mortenson
4. Computer Aided Engineering Design by AnupamSaxena and Birendra Sahay, Springer

MME1C05
DESIGN OF MECHANISMS

L	T	P/D	Cr.
3	-	-	3.0

Course Learning Objectives

1) To understand the basic concepts of kinematics of different types of mechanisms, velocity and acceleration analysis of mechanisms and the various graphical methods to compute the conjugate point for a specific point.
2) To understand the synthesis of mechanisms using function generation, path generation and motion generation, complex number modeling in kinematic synthesis and dynamics of mechanisms.
3) To understand the concept of balancing of linkages and cam dynamics for rigid and elastic body cam systems.
4) To understand the kinematics of industrial robots, basic terminology in robotics, velocity and acceleration analysis of robotic manipulators.

Course Contents

1. Mechanisms

Reviews of concepts, transmission angle, methods of velocity and acceleration analysis, relative velocity and Instantaneous centre methods, Kennedy's theorem. **(4 Hrs)**

2. Path Curvature

Centrodes or polodes, fixed and moving centrodes, centrode normal and tangent, Euler-Savary equation, conjugate points, Hartmann construction, inflection point, inflection circle, Bobilliar construction, Collineationaxis, Cubic of stationary curveture. **(6 Hrs)**

3. Synthesis of Mechanisms

Introduction, number synthesis, dimensional synthesis, spacing of accuracy points, motion generation, path generation and function generation, graphical and analytical methods, Freudenstein's equation, coupler points. **(4 Hrs)**

4. Complex-number Modeling in Kinematic Synthesis

Complex number notation, the dyad or standard form equation, four-bar motion generation, maximum number of solutions for unknown dyads, path and function generation, triad loops, synthesis of multi-loop linkages, Burmester theory, synthesis of geared mechanisms, Computer program. **(8 Hrs)**

5. Dynamics of mechanisms

Analytical methods for force analysis of mechanisms, complex number methods, Kinetostatic analysis using matrix method, time response of four-bar mechanisms, computer program. **(5 Hrs)**

6. Balancing

Force and shaking moment balancing of linkages, Optimization of shaking moments, Effect of moment balance on input torque, balancing of flexible rotors, field balancing, computer program. **(5 Hrs)**

7. Cam Dynamics

Rigid and elastic-body cam systems, analysis of eccentric plate cam, jump or float, torque-displacement diagram, analysis of an elastic cam system, follower command, spring surge, unbalance and windup. **(4 Hrs)**

8. Kinematics of industrial robots

Absolute and moving reference systems, direction cosines, Eulerian angles, Denavit-Heartenberg parameters, Transformation-matrix position analysis, matrix velocity and acceleration analysis. Computer programs. **(4 Hrs)**

Course outcomes:

1) Understand the basic concepts of kinematics of different types of mechanisms, velocity and acceleration analysis of mechanisms and the various graphical methods to compute the conjugate point for a specific point.
2) Understand the synthesis of mechanisms using function generation, path generation and motion generation, complex number modeling in kinematic synthesis and dynamics of mechanisms.
3) Understand the concept of balancing of linkages and cam dynamics for rigid and elastic body cam systems.
4) Understand the kinematics of industrial robots, basic terminology in robotics, velocity and acceleration analysis of robotic manipulators.

Reference Books:

1. Theory of Machines by Shigley and Uicker Jr., McGraw-Hill
2. Advanced Mechanism Design, by Sandor and Erdman, Prentice Hall of India
3. Theory of machines by S S Rattan, Tata McGraw-Hill Publishing Co. Ltd., New Delhi
4. Theory of mechanisms and Machines by Ghosh and Malik, Affiliated East-West Press, Pvt. Ltd., New Delhi.

MME1C07
FINITE ELEMENT METHODS

L	T	P/D	Cr.
3	-	-	3.0

Course Learning Objectives

1) To understand the basic concepts of finite element method, discretization of the solution domain with one, two and three dimension elements.
2) To understand the weak and strong form of governing equations.
3) To understand the concept weighted residual error over the solution domain.
4) To understand the computer implementation of fem for various engineering problems.

Course Contents

1. Introduction to Finite Element Method
Basic Concept, Historical background, Engineering applications, general description, Comparison with other methods. **(4hrs)**

2. Integral Formulations AndVariational Methods
Need for weighted-integral forms, relevant mathematical concepts and formulae, weak formulation of boundary value problems, variational methods, Rayleigh-Ritz method, and weighted residual approach. **(10 hrs)**

3. Finite Element Techniques
Model boundary value problem, finite element discretization, element shapes, sizes and node locations, interpolation functions, derivation of element equations, connectivity, boundary conditions, FEM solution, post-processing, compatibility and completeness requirements, convergence criteria, higher order and isoparametric elements, natural coordinates, Langrange and Hermite polynomials. **(12 hrs)**

4. Applications To Solid and Structural Mechanics Problems
External and internal equilibrium equations, one-dimensional stress-strain relations, plane stress and strain problems, axis-symmetric and three dimensional stress-strain problems, strain displacement relations, boundary conditions, compatibility equations, Analysis of trusses, frames and solids of revolution, computer programs. **(10 hrs)**

5. Applications To Heat Transfer Problems
Variational approach, Galerkin approach, one-dimensional and two-dimensional steady-state problems for conduction, convection and radiation, transient problems. **(5 hrs)**

6. Applications To Fluid Mechanics Problems
Inviscid incompressible flow, potential function and stream function formulation, incompressible viscous flow, stream function, velocity-pressure and stream function-vorticity formulation, Solution of incompressible and compressible fluid film lubrication problems. **(6 hrs)**

7. Additional Applications

Steady-state and transient field problems. **(10 hrs)**

Course outcomes:

1) Understand the basic concepts of finite element method as applied to solve problems of heat, fluid flow and deformation of solids.
2) Understand the difference between weak and strong form of solutions.
3) Understand the concept of residual error to obtain the solution subjected to various boundary conditions.
4) Understand the basic concepts for programing of fem as applied to various problems arising engineering.

Reference Books:

1. The Finite Element Method byZienkiewicz, Tata McGraw Hill
2. The Finite Element Method for Engineers by Huebner, John Wiley
3. An Introduction to the Finite Element Method by J.N.Reddy, McGraw Hill
4. The Finite Element Method in Engineering by S.S. Rao, Pergamon Press

MME1L01
TEST & OPTIMIZATION LAB - I

L	T	P/D	Cr.
-	-	3	1.0

Course Learning Objectives

1) To provide understanding of implementations of basic numerical methods for solving problems viz. system of simultaneous linear and nonlinear equations, spline interpolation,
2) To enable students to develop their own computer programs of the numerical methods for solving different problems.
3) To enable students to understand simulation models

Course Contents

The computer programs to be made in the lab will be based on the theory studied in the course of Applied Numerical Methods (ME-503T). Some of the programs to be made in the lab are:

Numerical solutions of ODE:

1. Program based on Taylor's Picard method,
2. Eulers method
3. RangaKutta Method
4. Predictor-Corrector Method
5. Finite difference method

Numerical solutions of PDE:

1. Finite difference method
2. Jacobi's method
3. Gauss Siedel method
4. SOR method
5. ADI method

Least square and curve fitting:

1. Least square curve fitting
2. Split interpolation

Numerical solutions of nonlinear systems:

1. Picard iteration
2. Newton's method
3. Perturbed iterative schemes

Systems of Linear Algebraic equations

1. Direct method
2. LU-decomposition methods
3. Iterative methods
4. Solutions for ill conditioned systems

The class is supposed to make at least 10 programs evenly distributed from the above list.

1D Simulation

1. Study of simulation and simulation model
2. Types of models
3. Characteristics of models
4. Example of simulation model – Elevator and Power Train
5. Exercise on Hydraulic system simulation
6. Exercise on Hydraulic system simulation
7. Exercise on Mechanisms creation using planar mechanical library

The students are supposed to take at least 10 practical exercises from the above list.

Course Outcomes:

1) Understand different implementation modes of numerical methods.
2) Develop and implement their own computer programs.
3) Solve problems more accurately and efficiently.
4) develop 1D simulation models

Reference Books:

1. Niyogi, Pradip, "Numerical Analysis and Algorithms", Tata McGraw –Hill
2. Balagurusamy,E., "Numerical Methods", Tata McGraw –Hill
3. Sastry, S.S., "Introduction Methods of Numerical Analysis", PHI
4. Chapra, S.C. and Canale, R.P., "Numerical Methods for Engineers", Tata McGraw –Hill
5. Gerald, F. Curtis, "Applied Numerical Analysis", Peason Education

MME1L03
CAD & CAE LAB

L	T	P/D	Cr.
-	-	3	1

Course Learning Objectives

1) To impart knowledge of 2 D sketching, 3 D Modeling for various kind of mechanical parts
2) To provide understanding of editing feature in sketches and 3D models
3) To impart knowledge regarding Assembly feature for multi component geometries
4) To provide knowledge of meshing CAD model
5) To provide knowledge to apply load conditions
6) To provide knowledge to use solver and post processor

Course Contents

List of Experiments

1. Drawing sketches in the sketcher workbench.
2. Constraints sketches and creating base features.
3. Reference elements and sketch-based features.
4. Creating dress-up and hole features.
5. Editing features.
6. Transform features and advanced modeling tools.
7. Working with wireframe and surface design workbench.
8. Assembly modeling.
9. Working with drafting
10. Introduction to CAE & working with advanced simulation and selecting entities
11. Basic mesh techniques and boundary conditions
12. Use of Solver, post processing and generating reports

Course Outcomes:

1) Explain 2 D sketching, 3 D Modeling for various kind of mechanical parts.
2) Use editing feature in sketches and 3D models.
3) Explain and use assembly feature for multi component geometries.
4) Understand drafting and production drawing generation.
5) Use CAE tools for meshing and anaysis
6) Use of post processor for desired results

MME1C02
INDUSTRIAL ROBOTICS

L	T	P/D	Cr.
3	-	-	3.0

Course Learning Objectives

1) To understand the concept of robotics.
2) To understand Direct and Inverse Kinematics of Robot Manipulator.
3) To understand Dynamic Modelling of Robot Arm.
4) To understand control of Manipulators.

Course Contents

1. Introduction to Robotics
Evolution of Robots and Robotics, Laws of Robotics, Progressive advancement in Robots. Robot anatomy, Human Arm Characteristics, Design and Control issue, Manipulation and Control, Programming Robots. **(3 hrs)**

2. Coordinate Frames, Mapping and Transforms
Coordinate Frames, Description of objects in space, Transformation of Vectors, Inverting a Homogeneous Transform, Fundamental Rotation matreies. **(4 hrs)**

3. Direct Kinematic Model
Mechanical structure and notations, Kinematic modeling of the manipulator, DenavitHartenberg Notation, Manipulator Transformation Matrix. **(4 hrs)**

4. The Inverse Kinematies
Manipulator workspace, solvability of Inverse kinematics model, solution techniques, closed form solution. **(4 hrs)**

5. Manipulator Differential Motion and Statics
Linear and angular velocity of a rigid body, relationship between transformation matrix and angular velocity, manipulator Jacobian, Jacobian Inverse, Jacobian Singularities, Static Analysis. **(5 hrs)**

6. Dynamic Modeling
LargrangianMechanies, Two Degree of Freedom manipulator-Dynamic Model, Lagrange-Euler formulation Newton-Euler formulation, Inverse Dynamics. **(4 hrs)**

7. Control of Manipulators
Open and Close loop control, linear control schemes, linear second order SISO model of a manipulator joint. Joint Actuators, Computed Torque Control, force control of Robitics, Manipulators, Hybrid position/force control, Impedance Force/Torque Control. **(4 hrs)**

8. Robotic Sensors

Sensors in Robitcs, classification of Robotic sensors, kinds of sensors used in robotics-Acoustic sensors optic, Pneumatic, force/Torque sensors. **(4 hrs)**

9. Robot Applications

Industrial Applications-Material Handling, Processing Applications, Assembly applications, inspection application, Principles for Robot application and application planning, Robert safety, Non-Industrial Application. **(4 hrs)**

10. Robert Languages and Programming

The Textual Robot Languages, Generations of Robot Programming Languages, Methods of Robot Programming. **(4 hrs)**

Course outcomes:

1) Understand the concept of Industrial Robotics.
2) Understand the Kinematics and Dynamics of Robot Arm.
3) Understand the Robot applications, Robot language and Programming.

Reference Books:

1. Fundamental of Robotics by Robert J. Sehilling Prentice Hall of India.
2. Introduction to Robotics by Saeed B. Niku Pearson Education Asia.
3. Robot Modeling and kinematics by RachidManseur, Luxmi Publications.

MME1C04
ADVANCED MECHANICAL VIBRATIONS

L	T	P/D	Cr.
3	-	-	3.0

Course Learning Objectives:

1) To impart the knowledge about the Multi degree of freedom vibration.
2) To impart the knowledge of Continuous systems.
3) To impart the knowledge of Non-Linear Vibrations.
4) To impart the knowledge of Random Vibrations.

Course Contents

1. Introduction to vibrations
Brief introduction to vibrations, its causes, advantages and disadvantages, classification: un-damped and damped vibrations, single and two degree of freedom models. Introduction to lateral, torsional and bending vibrations. Harmonic and harmonic analysis. Free and harmonically excited vibrations. Vibrations under general forcing conditions. **(6 hrs)**

2. Vibrations of continuous system
Transverse vibrations of a cable, longitudinal and torsional vibrations of a rod, lateral vibrations of a beam, vibrations of membranes. Reyleigh's method. Rayleigh-Ritz method. **(4 hrs)**

3. Vibration Control
Introduction, vibration nomograph and vibration criteria, reduction of vibration at the source, balancing of rotating machines, whirling of rotating shafts, balancing of reciprocating engines, control of vibrations, control of natural frequencies, vibration isolation, vibration absorbers. **(5 hrs)**

4. Vibration measurement and applications
Introduction, transducers, vibration pickups, frequency measuring instruments, vibration exciters, signal analysis, dynamic test of machines an structures, experimental modal analysis, machine condition monitoring and diagnosis. **(5 hrs)**

5. Numerical Integration methods in vibration analysis
Introduction, Finite difference method, central difference method, Runge-Kutta methods for single, multi and continuous systems. Houbolt method, Wilson method, Newmark method. The finite element method. **(6 hrs)**

6. Non linear vibration
Introduction, examples of non-linear vibration problems, exact methods, approximate analysis methods, sumharmonic and superharmonic oscillations, systems with time-dependent coefficients (Mathieu equations), graphical methods, stability of equilibrium states, limit cycles, chaos. **(6 hrs)**

7. Random Vibrations

Random vibrations and random processes, probability distributions, mean value and standard deviation, joint probability distribution of several random variables, correlation function of a random process, Gaussian random process, fourier analysis, power spectral density, wide and narrow band process, response of a single degree of freedom system, response due to stationary random excitations, response of a multidegree system. **(8 hrs)**

Course outcomes:

1) Understand the different types of vibrations – Damped, Undamped, Linear, Angular and Lateral vibrations.
2) Understand the Vibration Measurement and applications and Numerical integration methods.
3) Analyze the problems of Continuous, Non- Linear and Random vibration.

Reference Books:

1. Mechanical Vibrations by S.S. Rao, Pear and on Publication.
2. Mechanical Vibration by Thomson, Printice Hall.
3. Mechanical Vibration by Den Hartog, McGraw-Hill

MME1L02
TEST & OPTIMIZATION LAB - II

L	T	P/D	Cr.
-	-	3	1.0

Course Learning Objectives

1) To provide understanding of acoustic and vibration measurementsand their analysis
2) To provide understanding of various sensors
3) To impart knowledge and skills on modal testing & analysis.

Course Contents

Acoustics Measurement and Analysis:

1. Exercise on microphones, probes and calibrators
2. Study of acoustic measurement functions
3. Testing on sound quality
4. Exercise on sound absorption and transmission testing

Vibration Measurement and Analysis:

1. Exercise on vibration measurement and analysis
   i. FFT analyzer
   ii. Order analyzer
   iii. Octave analyzer

Instrumentation fundamentals

1. Study of various sensors and their applications- vibration, noise, force, displacement & velocity
2. Setting up the system analysis setup
3. Setting up the signal analysis setup

Modal testing and analysis

1. Understand the usage of different worksheets for checking structure's dynamic behaviour
2. Define fill mode mapping table, arrange it and how to merge modes
3. Interpret the data collection and selection, time MDOF Op. Polymax, Synthesis and validation
4. Explain geometry creation, predict modes modification, rigid body property calculation and hybrid modelling
5. Understand the modal analysis in LMS test lab and NVH analysis
6. Define modal analysis, modal validation, modal testing and mode shape visualization
7. Calculate FRF function and acquire ability to facilitate FRF selections and deselections
8. Define the physical process with a broad range of processing functions
9. Understand and calculate the structure dynamic behaviour

The students are supposed to take at least 10 practical exercises from the above list.

Course Outcomes:

1) understand and analyze various acoustic problems
2) understand and analyze various vibration problems
3) apply different sensors for various applications and analyze system behaviour
4) perform modal testing and study dynamic behaviour of the structure

MME1L04
ROBOTICS LAB

L	T	P/D	Cr.
-	-	3	1.0

Course Learning Objectives

1) To provide understanding and working of robots for industrial applications
2) To provide understanding of programmingcommands of robots

Course Contents

Spot welding robots:

1. Study of spot welding application
2. Programming commands of spot welding
3. Programming of part with 10 spots and taking the spots

Arc welding robots:

1. Study of arc welding application
2. Programming commands of arc welding
3. Programming ofarc welding operation – butt welding
4. Programming of arc welding operation – Tee joint

Material Handling robots:

1. Basics of robots
2. Study of frames
3. Selection of grippers
4. TCP calculation and configuration
5. Programming commands of robot instructions
6. Defining tool and work object
7. Defining work object
8. Configuring of I/O system
9. Program flow and communication instruction
10. Robot programming- material handling application
11. Robot programming execution-online

The students are supposed to take at least 10 practical exercises from the above list.

Course Outcomes:

1) Understand robot and its coomands
2) Program robots for material handling application
3) Program robots for spot welding application
4) Program robots for arc welding application

MME1E31/MME1E32
ADVANCED MECHANICS OF SOLIDS

L	T	P/D	Cr.
3	-	-	3.0

Course Learning Objectives:

1) To understand how to transform stresses and determine principal stresses so as to predict mechanical failure.
2) To understand the concepts of unsymmetrical bending of beams, shear center and bending of thin plates.
3) To understand the laws governing the deflection of beam-columns and beams on elastic foundations subjected to a variety of loading conditions.
4) To understand how to analyze the contact between elastic bodies and learn the conepts of stress wave propagation.

Course Contents

1. Three Dimensional Stress and Strain:

Theories of failure, Principal stresses and Principal strains, Mohr's circle representation of tri-axial stresses and strains. **(6 hrs)**

2. Unsymmetrical Bending:

Shear centers for sections with one axis of symmetry. Shear center for any unsymmetrical section, stress and deflection of beams subjected to unsymmetrical bending. **(6 hrs)**

3. Bending of Plates:

Basic definitions, Stress, Curvature and Moment relations, Basic Equation of plate deflection. Different boundary conditions, simply supported rectangular plates, axis symmetric loaded circular plates. **(6 hrs)**

4. Contact Stresses:

Due to Two Spherical Surfaces in Contact, Due to Two Parallel Cylindrical Rollers in Contact, Due to Two Curved Surfaces of Different Radii. **(3 hrs)**

5. Buckling of Columns:

Beam columns with single concentrated load, number of concentrated loads, continuous lateral load, end couple, couples at both ends of the column, triangular loads and combined loads. **(5 hrs)**

6. Beam on Elastic Foundations:

General Theory, Infinite, Semi-infinite, and Finite beams, Classification of Beams. Beam supported by equally spaced elastic elements. **(6 hrs)**

7. Elastic Wave Propagation

One-Dimensional Wave Equation and Motions of an Elastic Material, Compressional waves, Shear waves, Reflection and transmission at an interface, Waves in Layered Media, Steady-State One and Two-Dimensional Waves, Plane waves, Rayleigh Waves, Transient Waves, Nonlinear wave propagation, Shock waves **(8 hrs)**

Course Outcomes:

1) The students will be able to transform three-dimensional stress tensor, calculate principal stresses and apply theories of failure in design.
2) The students will be able to determine unsymmetrical bending stresses shear center and deflection of thin plates subjected to general loading.
3) The students will be able to calculate the deflection, slope and shear forces in beam-columns and beams supported on elastic foundations.
4) The students will be able to analyze the contact between elastic non--conformal surfaces.

Reference Books :

1. **'**Advanced Strength and Applied Elasticity' by Ugural & Fenster, Prentice Hall.
2. 'Advanced Mechanics of Solids' by L., Srinath, TMH
3. 'Intermediate Mechanics of Materials' by J. R. Barber, McGraw-Hill
4. 'Introduction to Solid Mechanics' by Shames & Pitarresi, PHI
5. 'Advanced Topics of Strength of Materials' by U.C. Jindal, Galgotia Publication.
6. 'Introduction to Elastic Wave Propagation' by A. Bedford & D. S. Drumheller

MME1E37/MME1E38
ADVANCED TRIBOLOGY

L	T	P/D	Cr.
3	-	-	3.0

Course Learning Objectives

1) To understand the concept of tribology, factors affecting tribological process and the surface measurement techniques.
2) To gain knowledge about the friction process, its types and the friction measurig techniques.
3) To impart the knowledge of wear, its types, wear measurement and the controlling processes, lubrication process and its types.
4) To understand micro and nano tribology and the various types of tools used in nanotribological process.

Course Contents

1. Introduction

Introduction to tribology and its historical background. Industrial importance. Factors influencing tribological phenomena. **(2 hrs)**

2. Engineering Surfaces-Properties and Measurement

Engineering surfaces - surface characterization, computation of surface parameters. Surface measurement techniques. Apparent and real area of contact. Contact of engineering surfaces. **(5 hrs)**

3. Surface Contact

Hertzian and Non-hertzian contact. Contact pressure and deformation in non-conformal contacts. **(6 hrs)**

4. Friction

Genesis of friction, friction in contacting rough surfaces, sliding and rolling friction, Various laws and theory of friction. Stick slip friction behaviour, frictional heating and temperature rise. Friction measurement techniques. **(6 hrs)**

5. Wear

Wear and wear types. Mechanisms of wear -Adhesive, abrasive, corrosive, erosion, fatigue, fretting, etc., wear of metals and non-metals. Wear models – asperity contact, constant and variable wear rate, geometrical influence in wear models, wear damage. Wear in various mechanical components, wear controlling techniques. **(7 hrs)**

6. Lubrication

Introduction to lubrication. Lubrication regimes. Lubricants and their properties. Solid Lubricants. **(6 hrs)**

7. Nanotribology

Introduction to micro and nano tribology. Measurement tools used in nanotribology: SFA, STM, AFM microscale and nanoscale wear Nanofabrication/nanomachining NanohydrodynamicsNanolubricationTribological issues in MEMS. **(8 hrs)**

Course Outcomes:

1) explain the concept of tribology, factors affecting tribological process and the surface measurement techniques.
2) understand the friction process, its types and the friction measurig techniques.
3) explain wear process, its types, wear measurement and the controlling processes, lubrication process and its types.
4) understand micro and nano tribology and the various types of tools used in nanotribological process.

Reference Books :

1. "Engineering Tribology" by PrasantaSahoo, PHI.
2. "Engineering Tribology" by Stachowiak&Batchelor, Elsevier.
3. "Nanotribology and Nanomechanics: An Introduction" by Bharat Bhushan, Springer.
4. "Nanotribology" by Hsu& Ying, Springer.

MME1E33/MME1E34
MEASUREMENT AND CONTROL

L	T	P/D	Cr.
3	-	-	3.0

Course Learning Objectives

1) To impart the knowledge to the students about significance, applications and types of measurement, identification of functional elements of a measuring system.
2) To study the instrument characteristics, time and frequency response of measuring systems, classification, sources and statistical analysis of errors.
3) To make students understand the construction, working principle and application of various types of transducers.
4) To learn types of control system, represent system by transfer function, block diagrams, signal flow graphs and Mason's formula.
5) To understand the working of different types of controllers, transient and steady state response of control systems.

Course Contents

Part A – Measurement

1. Measurements and Measurement Systems:

Introduction, significance of measurement, methods of measurement, primary secondary and tertiary measurements, mechanical electrical and electronics instruments, applications of measurement system, elements of a generalized measurement system and its functional elements, classifications of standards, primary, secondary and working standards. **(3 hrs)**

2. Instrumentation Characteristics:

Static and dynamic characteristics, first and second order systems response, classification & sources of error, loading facts, mechanical, electrical. **(5 hrs)**

3. Analysis of Experimental Data:

Errors and uncertainties in experiments, role of statistics and variance types of data, presentation of the observations, criteria for rejecting data, specifying result of experiments, confidence level, uncertainty analysis, overall uncertainty. graphical analysis and curve fitting, theory of least squares, application in calibration, goodness of fit, significant figures and rounding off.**(6 hrs)**

4. Transducers:

General criteria for selection, strain gauge, rosettes; types, applications. Variable inductance transducers, capacitive, piezo-electric transducers transducers.Advantages and limitations of digital transducers over analog transducers, digital encoding transducers, classification of encoders, construction of encoders, shaft encoder, optical encoder. **(8 hrs)**

Part B - Control

5. Control systems:

Introduction, types of control systems, performance analysis, mathematical modeling, block diagram representation, representation of systems or processes, comparison elements, transfer function, representation of temperature control systems, signal flow graphs. **(6 hrs)**

6. Types of controllers:

Introduction, types of control action, hydraulic controllers, electronic controllers, controllers.**(6 hrs)**

7. Transient and steady state response:

Time domain representation, laplace transform representation, system with proportional control, proportional cum derivative control, proportional cum integral control, error constants. **(6 hrs)**

Course Outcomes:

1) Identify functional elements in the measuring system.
2) Understand the various instrument characteristics and error measurement.
3) Explain working principles of sensors and transducers.
4) Formulate mathematical model for physical systems and transfer function representation of processes & control elements.
5) Handle any kind of process by framing it in block diagram and different process variables and different types of controller like electronic, pneumatic and hydraulic.

Reference Books :

1. A course in Mechanical Measurement & Instrumentation by A.K. Sawhney, Dhanpat Rai & Sons.
2. Mechanical Measurement by Beckwith & Buck
3. Instrumentation for Measurement in Engineering by S. Gupta
4. Theory and application of Automatic Controls by B.C.Nakra.

MME1E35/MME1E36
EXPERIMENTAL STRESS ANALYSIS

L	T	P/D	Cr.
3	-	-	3.0

Course Learning Objectives

1) To understand the basic principles of stress analysis.
2) To understand the fundamental principles of theory of elasticity.
3) To understand the various types of brittle coatings for stress analysis
4) To understand the principle of operation of strain gauges.
5) To acquaint the students with experimental techniques of stress analysis.

Course Contents

1. Introduction
Introduction to elementary Elasticity, Strain and the Stress-Strain relations, Basic equations of strain, and Plane Elasticity theory. **(4 hrs)**

2. Brittle-Coating Methods
Introduction, Coating Stresses, Brittle-Coating Crack Patterns, Crack Detection, Ceramic-based Brittle Coatings, Resin-based Brittle Coatings, Test Procedures, Calibration. **(6 hrs)**

3. Strain Measurement using Strain Gauges
Introduction, Strain Sensitivity in Metallic Alloys, Gage Construction, Strain-Gauge Adhesive and Mounting Methods, Gauge Sensitivities and Gauge Factor, Piezo-resistive Properties of Semiconductors, Performance Characteristics of Foil Strain Gauges and Semiconductor Gauges. Strain-Gauge Circuits, Analysis of Strain-Gauge Data. **(7 hrs)**

4. Optical Methods
a. Basic Optics- Introduction, Optic Laws, Optical Instruments- the Polariscope, the Interferometer **(3 hrs)**
b. Moire Methods- Introduction, Mechanism of Formation of Moire Fringes, Different approach to Moire Fringe Analysis **(6 hrs)**
c. Theory of Photoelasticity- Introduction, the Stress-optic Law, Effects of a Stressed Model in a Plane and in a Circular Polariscope, Fringe Manipulation, Isochromatic and Isoclinic Fringe Patterns, Compensation Techniques, Separation Method, Calibration Methods, Photoelastic Materials **(6 hrs)**
d. 2-D & 3-D Photoelasticity- Shear Difference Method in 3-D Stress, the Scattered-Light Method, Frozen-Stress Method **(4hrs)**
e. Bi-Refringent Coatings- Coating Stresses and Strains, Coating Sensitivity, Coating Materials, Effects of Coating Thickness **(3 hrs)**

Course Outcomes:

1) Students will be able to understand the theoretical concepts of stress analysis.
2) Students will be able to apply various types of brittle coatings for stress analysis.
3) Students will be able to use various types of strain gauges.
4) Students will be able to understand and use various experimental methods of stress analysis.

Reference Books:

1. Experimental Stress Analysis by Dally, J. W. & Riley, W. F., McGraw Hill
2. The Strain Gage Primer, by CC Perry and HR Lissner, McGraw Hill
3. Experimental stress analysis: Principles and Methods, G S Holister, Cambridge University Press
4. Experimental Stress Analysis by U C Jindal, Pearson
5. Experimental Stress Analysis by Sadhu Singh, Khanna Publishers

MME1E39/MME1E40
THEORY AND ANALYSIS OF PLATES

L	T	P/D	Cr.
3	-	-	3.0

Course Learning Objectives

1) To impart the knowledge to the students about static and dynamic analysis of elastic plates.
2) To study the numerical and approximate methods and their applications in vibrations.
3) To understand the concept of stability analysis of elastic plates.
4) To understand the concept of yield line analysis of elastic plates.

Course Contents

1. Classical methods in Static analysis of elastic plates
Introduction to the theory of elasticity, differential equation of plates in Cartesian coordinate system, boundary condition of the bending theory, solution of the governing differential equation, Fourier series, Navier's solution by double trigonometric series, solutions by single Fourier series. Differential equations of circular plates, solution of circular plates subjected to rotational symmetric loadings, types of circular plates, circular plate loaded by an eccentric concentrated force, continuous plates, plates of various geometrical forms, plates with variable flexural rigidity, plates on elastic foundation, membranes and various analogies, simultaneous bending and stretching. (**10 hrs)**

2. Numerical and approximate methods:
Introduction to practical analysis, finite difference method, solutions of simultaneous linear equations, energy method, other variational methods, techniques to improved energy solutions, finite element method. **(6hrs)**

3. Classical methods in Dynamic analysis of elastic plates:
Introduction to structural dynamics, differential equations of lateral motions, free flexural vibrations of plates, free transverse vibrations of membranes, forced transverse vibrations of rectangular plates. (**6hrs)**

4. Numerical and approximate methods for vibrations:
Energy method for determination of natural frequencies, solution of the differential equation of motion by finite differences, finite element method in dynamic analysis of plates, kinematically consistent mass matrix, damping of discrete systems, natural frequencies obtained from static deflections. **(6 hrs)**

5. Fundamentals of stability analysis:
Basic concepts, equilibrium method, energy method in stability analysis, finite difference solutions of plate buckling, finite elements approach to stability analysis, dynamic buckling, buckling of stiffened plates, post buckling behaviour, inelastic buckling and failure of plates. **(6hrs)**

6. Yield-line analysis of plates:
Introduction to yield-line method, the work method, the equilibrium method, applications of yield-line analysis, yield lines due to concentrated loads. (**6hrs)**

Course Outcomes:

1) Able to explain about static and dynamic analysis of elastic plates.
2) Able to explain about the numerical and approximate methods and their applications in vibrations.
3) Able to explain about the concept of stability analysis of elastic plates.
4) Able to explain about understand the concept of yield line analysis of elastic plates.

Reference Books:

1. Theory and analysis of plates: classical and numerical methods by Rudolph Szilard
2. Theory of plates and shells by Tominshenko.

MME1E41/MME1E42
FRACTURE MECHANICS

L	T	P/D	Cr.
3	-	-	3.0

Course Learning Objectives:

5) To understand the various modes of failure and the underlying physics.
6) To understand the concepts of linear elastic and elastic-plastic fracture mechanics.
7) To understand the importance of crack tip opening displacement in fracture.
8) To understand the various aspects related to fatigue and mixed mode failure.

Course Contents

1. Introduction

Classification of failure and history, Conventional failure criteria, Characteristic brittle failures, Griffith's work, Fracture mechanics, Dilemma of Griffith, Surface energy, Griffith's realization, Griffith's analysis, Mathematical formulation, Critical energy release rate. **(6 hrs)**

2. Stress intensity factor (SIF)

Linear elastic fracture mechanics (LEFM), Stress and displacement fields in isotropic elastic materials, Elementary properties of complex variables SIF of more complex cases: Application of the principle of superposition, Crack in a plate of finite dimensions, Edge cracks, Embedded cracks. **(7hrs)**

3. Anelastic deformation at the crack tip

Investigation at the crack tip, Approximate shape and size of the plastic zone, Effective crack length, Effect of plate thickness. **(5hrs)**

4. Elastic plastic analysis through J-Integral

Relevance and scope, Definition of J-Integral, Path independence, Stress-strain relation. **(5hrs)**

5. Crack tip opening displacement (CTOD)

Relationship between CTOD, K_I and G_I for small scale yielding, Equivalence between CTOD and J; K_{IC} test techniques, Determination of critical CTOD. **(6 hrs)**

6. Fatigue failure

Terminology, S-N curve, Crack initiation, Crack propagation, Effect of an overload, Crack closure, Variable amplitude fatigue load. **(6hrs)**

7. Mixed mode crack initiation and growth

Fracture surface, Mixed mode crack propagation criteria, Crack growth. **(5hrs)**

Course Outcomes:

1) The students will be able to classify failure and apply Griffith's theory to predict brittle failure.
2) The students will be able to apply the concepts of Linear Elastic Fracture Mechanics to determine the stress filed and SIF at the crack tip.
3) The students will be able to estimate the shape and size of plastic zone ahead of crack tip.
4) The students will be able to determine the crack growth rate of fatigue crack.

Reference Books :

1. Prashant Kumar, Elements of Fracture Mechanics, Tata McGraw-Hill Publishing Company Ltd., New Delhi.
2. T .L . Anderson, FractureMechanics - Fundamental s and Applications, 3rdEdition, Taylor and Francis Group.
3. D. Broek, Elementary Engineering Fracture Mechanics, Kluwer Academic, Publishers, Dordrecht.

MME1E43/MME1E44
MECHANICS OF COMPOSITE MATERIALS

L	T	P/D	Cr.
3	-	-	3.0

Course Learning Objectives:

1) To understand the basic concepts and difference between composite materials with conventional materials.
2) To understand role of constituent materials in defining the average properties and response of composite materials on macroscopic level.
3) To apply knowledge for finding failure envelopes and stress-strain plots of laminates.
4) To develop a clear understanding to utilize subject knowledge using computer programs to solve problems at structural level.

Course Contents

1. Introduction

Definition and characteristics, Overview of advantage and limitations of composite materials, Significance and objectives of composite materials, Science and technology, current status and future prospectus.**(6 hrs)**

2. Basic Concepts and Characteristics

Structural performance of conventional material, Geometric and physical definition, Material response, Classification of composite materials, Scale of analysis; Micromechanics, Basic lamina properties, Constituent materials and properties, Properties of typical composite materials. **(6 hrs)**

3. Elastic Behavior of Unidirectional Lamina

Stress-strain relations, Relation between mathematical and engineering constants, transformation of stress, strain and elastic parameters. **(7 hrs)**

4. Strength of Unidirectional Lamina

Micromechanics of failure; failure mechanisms, Macro-mechanical strength parameters, Macromechanical failure theories, Applicability of various failure theories. **(7 hrs)**

5. Elastic Behavior of Laminate

Basic assumptions, Strain-displacement relations, Stress-strain relation of layer within a laminate, Force and moment resultant, General load–deformation relations, Analysis of different types of laminates. **(7 hrs)**

6. Stress and Failure Analysis of Laminates

Types of failures, Stress analysis and safety factors for first ply failure of symmetric laminates, Micromechanics of progressive failure; Progressive and ultimate laminate failure, Design methodology for structural composite materials. **(7 hrs)**

Course Outcomes:

1) Able to understand the basic concepts and difference between composite materials with conventional materials.
2) Able to understand role of constituent materials in defining the average properties and response of composite materials on macroscopic level.
3) Able to apply knowledge for finding failure envelopes and stress-strain plots of laminates.
4) Able to develop a clear understanding to utilize subject knowledge using computer programs to solve problems at structural level.

Reference Books :

1. Isaac M. Daniels, Ori Ishai, "Engineering Mechaincs of Composite Materials", Oxford University Press.
2. Bhagwan D. Agarwal, Lawrence J. Broutman, "Analysis and Performance of fiber composites", John Wiley and Sons, Inc.
3. Mathews, F. L. and Rawlings, R. D., "Composite Materials: Engineering and Science",CRC Press, Boca Raton.
4. Madhujit Mukhopadhyay, "Mechanics of Composite Materials and Structures", University Press.
5. Mazumdar S. K., "Composaite Manufacturing – Materials, Product and Processing Engineering", CRC Press, Boca Raton.
6. Robert M. Jones, "Mechanics of Composite Materials", Taylor and Francis, Inc.

MME1E45/MME1E46
ADVANCED ENGINEERING MATERIALS

L	T	P/D	Cr.
3	-	-	3.0

Course Learning Objectives:

1) To Demonstarte an understanding of mechanics, physical and chemical properties of materials including metals, ceramics, polymers and composites.
2) To Understand existence of imperfections and their effects on mechanical properties of materials and cause of failure.
3) ToDemonstrate understanding of phase diagrams and their use in predicting phase transformation and microstructure.
4) To Understand and predict various types of failures using concept of fracture mechanics, creep and effect of impact.
5) To Know Electrical, Thermal, Optical and Magnetic Properties of metals, ceramics, polymers and composites.
6) To Understand the economic considerations in usage and recycling of materials in humen use.

Course Contents

1. Introduction, Atomic Structure, Interatomic Bonding and Structure of Crystalline Solids:
Historical perspective of Materials Science. Why study properties of materials? Classification of materials. Advanced Materials, Future materials and modern materials, Atomicstructure. Atomic bonding in solids, Crystal structures, Crystalline and noncrystalline materials. Miller indices. Anisotropic elasticity. Elastic behaviour of composites. Structure and properties of polymers. Structure and properties of ceramics. **(6 hrs)**

2. Imperfections in Solids and Mechanical Properties of Metals, Diffusion, Dislocations and Strengthening Mechanisms:
Point defects. Theoretical yield point. Line defects and dislocations. Interfacial defects. Bulk or volume defects. Atomic vibrations; Elastic deformation. Plastic deformation. Interpretation of tensile stress-strain curves Yielding under multiaxial stress. Yield criteria and macroscopic aspects of plastic deformation. Property variability and design factors, Diffusion mechanisms. Steady and non-steady state diffusion. Factors that influence diffusion. Non-equilibrium transformation and microstructure, Dislocation and plastic deformation. Mechanisms of strengthening in metals. Recovery, recrystallization and grain growth. Strengthening by second phase particles. Optimum distribution of particles. Lattice resistance to dislocation motion. **(7 hrs)**

3. Phase Diagrams
Equilibrium phase diagrams. Particle strengthening by precipitation. Precipitation reactions. Kinetics of nucleation and growth. The iron-carbon system. Phase transformations. Transformation rate effects and TTT diagrams. Microstructure and property changes in ironcarbon system. **(6 hrs)**

4. Failure:
Fracture. Ductile and brittle fracture. Fracture mechanics. Impact fracture. Ductile brittle transition. Fatigue. Crack initiation and propagation. Crack propagation rate. Creep. Generalized creep behaviour. Stress and temperature effects. **(7 hrs)**

5. Applications and Processing of Metals and Alloys, Polymers, Ceramics, and composites:
Types of metals and alloys. Fabrication of metals. Thermal processing of metals. Heat treatment. Precipitation hardening. Types and applications of ceramics. Fabrication and processing of ceramics, Mechanicalbehaviour of polymers. Mechanisms of deformation and strengthening of polymers. Crystallization, melting and glass transition. Polymer types. Polymer synthesis and processing, Particle reinforced composites. Fibre reinforced composites. Structural composites. **(7 hrs)**

6. Electrical, Thermal, Optical and Magnetic Properties and economic Considerations:
Electrical conduction. Semi conductivity. Super conductivity. Electrical conduction in ionic ceramics and in polymers. Dielectric behaviour. Ferroelectricity. Piezoelectricity Heat capacity. Thermal expansion. Thermal conductivity. Thermal stresses Diamagnetism and Para magnetism. Ferromagnetism.Antiferromagnetism and ferrimagnetism. Influence of temperature on magnetic behaviour. Domains and Hysteresis, Basic concepts. Optical properties of metals. Optical properties of non-metals. Application of optical phenomena. Economic, Environmental and Social Issues of Material Usage - Economic considerations. Environmental and societal considerations. Recycling issues. Life cycle analysis and its use in design. **(7 hrs)**

Course Outcomes:

1) able to demonstarte an understanding of mechanics, physical and chemical properties of materials including metals, ceramics, polymers and composites.
2) able to understand existence of imperfections and their effects on mechanical properties of materials and cause of failure.
3) able to demonstrate understanding of phase diagrams and their use in predicting phase transformation and microstructure.
4) able to understand and predict various types of failures using concept of fracture mechanics, creep and effect of impact.
5) able to know Electrical, Thermal, Optical and Magnetic Properties of metals, ceramics, polymers and composites.
6) able to understand the economic considerations in usage and recycling of materials in humen use.

Reference Books :

1. Materials Science and Engineering, William D. Callister, Jr, John Wiley & sons.
2. Modern Physical Metallurgy and Material Engineering, Science, Process, application, Smallman R.E., Bishop R J, Butterworth Heinemann, Sixth Ed.

MME3C01
ADVANCED FLUID ENGINEERING

L	T	P/D	Cr.
3	-	-	3.0

Course Learning Objectives

1. To provide the students the necessary analytical skills to solve and analyse phenomena involving fluids in various engineering applications.
2. To understand the concept of boundary layer and its importance in fluid engineering.
3. To study the compressible flow and implications of shock wave formation
4. To acquaint the students with important concepts of aerodynamics.

Course Contents

1. **Introduction and basic laws**
   Review of basic concepts of fluid mechanics, Non Newtonian fluids, Stress at a point, derivation of Navier Stokes equation, Basic laws in integral form, Reynolds transport theorem, continuity, momentum and energy equations in integral form and their applications. **(7hrs)**

2. **Ideal fluid flow**
   Kinematics of fluid flow, potential flow, source, sink, doublet and vortices; superimposition of uniform stream with above; flow around comers; Rankine ovals, flow around uniform cylinders with and without circulation, pressure distribution on the surface of these bodies **(6 hrs)**

3. **Viscous flow**
   Exact solution; plane Poiselle and Coutte flows; Hagon-Poiselle flow through pipes; flows with very small Reynold's numbers; Stokes flow around a sphere, Elements of hydrodynamic theory of lubrication**.** **(4 hrs)**

4. **Laminar and Turbulent boundary layer flows**
   Elements of two dimensional boundary layer theory; displacement thickness, momentum thickness, energy thickness; Von Karman Momentum Integral Equation Laminar boundary layer, Turbulent boundary layer, Boundary layer separation. **(6 hrs)**

5. **Compressible flow**
   Wave propagation and sound velocity, Mach number and compressible flow regimes, basic equations for one dimensional compressible flow, isentropic flow relations, variation of velocity with area, normal shock wave, oblique shock wave, Fanno and Rayleigh lines, flow in a converging diverging nozzle **(6 hrs)**

6. **Vortex motion**
   Definitions; vortex lines, surfaces and tubes; vorticity, circulation, Kelvins circulation theorem, Helmholtzs vorticity theorem, Biot-savart law for induced vorticity, system of vortex filaments, horse-shoe vortex filaments, ring vortices, vortex street **(6 hrs)**

Course Outcomes:

1. Students will be able to understand and apply standard equations for fluid problems.
2. Students will be able to understand and analyse the flow around various bodies.
3. Students will be able to calculate pressure in hydrodynamic bearings using Coutte flow.
4. Students will be able to understand the concept of boundary layer and skin friction drag.
5. Students will be able to understand the basics of aerodynamics, concepts of compressible flow, supersonic flow and consequences shock waves generation.

Recommended Books:

1. Fundamentals of Mechanics of Fluid by Curriec, McGraw-Hill
2. Foundation of Fluid Mechanics, Yuan, Prentice Hall
3. Engineering Fluid Mechanics, K.L.Kumar, Eurasia
4. Fluid Mechanics and its applications, Gupta and Gupta, Willey Eastern
5. Introduction to Fluid mechanics and Machines, Som& Biswas, TMH
6. Fundamental of Compressible Flow, S M Yahya, New Age
7. Fluid Mechanics, Frank M White, TMH

MME3C02
COMPUTATIONAL FLUID DYNAMICS

L	T	P/D	Cr.
3	-	-	3.0

Course Learning Objectives

1. To be able to apply PDEs to CFD problems.
2. To be able to understand fundamentals of discretization and apply them to CFD problems.
3. To be able to formulate and solve problems related to heat transfer and fluid flow using Finite Difference and Finite Volume Methods.
4. To be able to understand the limitations and errors involved in solution to CFD problems.

Course Contents

1. **Introduction**
   Introduction to C.F.D., models of flow, governing differential equations – continuity equation, momentum equation, energy equation, Navier- Stokes equation, physical boundary conditions. **(5 hrs)**

2. **Mathematical behaviour of governing equation**
   Classification of quasi linear partial differential equation, General method of determining the Classification of partial differential equation, hyperbolic, parabolic, elliptic equations. **(5 hrs)**

3. **Discretization methods**
   Finite difference methods, difference equations, explicit & implicit approach, errors & analysis of stability. Basics of finite control volume method **(5 hrs)**

4. **Heat conduction problem**
   Solution of One dimensional heat conduction through a fin, solution of two dimensional steady state and transient heat conduction problems, heat conduction problems in cylindrical coordinates: axisymmetric and non-axisymmetric problems. **(7 hrs)**

5. **Heat conduction with convection & diffusion**
   Steady state one dimensional convection and diffusion, upwinding, exact solution, exponential scheme, hybrid scheme, power law scheme, Discretization equation for two dimensions & three dimensions, false diffusion **(8 hrs)**

6. **Fluid flow problem**
   Viscous incompressible flow, solution of the couette flow problem by F.D.M., calculation of the flow field using stream function – vorticity method, numerical algorithms for solving complete Navier-Stokes equation – MAC method; SIMPLE method. **(10 hrs)**

Course outcomes:

1. Understand the concepts of PDEs and apply them to CFD problems.
2. Understand discretization and its application to problems.
3. Solve problems related to heat transfer and fluid flow using Finite Difference and Finite Volume Methods.
4. To understand the limitations and errors involved in solution to CFD problems.

Recommended Books:

1. Suhas. V. Patankar, Numerical heat transfer and fluid flow, Hemisphere.
2. John. D. Anderson, Jr, Computational fluid dynamics, McGraw Hill.
3. Vesrteeg and Malalsekera, An Introduction to Computational fluid dynamics- The Finite Volume Method, Longman Scientific and Technical.
4. Anil .W. Date, Introduction to Computational fluid dynamics, Cambridge University Press.
5. Niyogi, Chakraborty and Laha, Introduction to Computational fluid dynamics, Pearson Education.

MME3E39/MME3E40
RENEWABLE ENERGY & ENERGY MANAGEMENT

L	T	P/D	Cr.
3	0	-	3

Course Learning Objectives

1. To understand the basic concepts of Renewable Energy and apply them to address the practical applications.
2. To understand the basic concepts and applications of sources of renewable energy.
3. To impart the knowledge to the students about various contemporary methods to utilize different sources of renewable energy.
4. To impart the knowledge to the students about energy conservation management.

Course Contents

1. **Solar Energy**
   The sun as a perennial source of energy, direct solar energy utilization; solar thermal applications – water heating systems, space heating and cooling of buildings, solar cooking, solar ponds, solar green houses, solar thermal electric systems; solar photovoltaic power generation; solar production of hydrogen. **(6 hrs)**

2. **Energy from Oceans**
   Wave energy generation – energy from waves; wave energy conversion devices; advantages and disadvantages of wave energy; Tidal energy – basic principles; tidal power generation systems; estimation of energy and power; advantages and limitations of tidal power generation; ocean thermal energy conversion (OTEC); methods of ocean thermal electric power generation. **(6 hrs)**

3. **Wind energy**
   Basic principles of wind energy conversion; design of windmills; wind data and energy estimation; site selection considerations. **(4 hrs)**

4. **Hydro power**
   Classification of small hydro power (SHP) stations; description of basic civil works design considerations; turbines and generators for SHP; advantages and limitations. **(5 hrs)**

5. **Biomass and bio-fuels**
   Energy plantation; biogas generation; types of biogas plants; applications of biogas; energy from wastes. **(5 hrs)**

6. **Geothermal energy**
   Origin and nature of geothermal energy; classification of geothermal resources; schematic of geothermal power plants; operational and environments problems. **(5 hrs)**

7. **Energy conservation management**
   The relevance of energy management profession; general principles of energy management and energy management planning; application of Pareto's model for energy management; obtaining management support; establishing energy data base; conducting energy audit; identifying, evaluating and implementing feasible energy conservation opportunities; energy audit report; monitoring, evaluating and following up energy saving measures/projects.

   (10hrs)

Course Outcomes:

1. The students will be able to understand importance of Renewable Energy Sources.
2. The students will be able to utilize different sources of renewable energy in engineering applications.
3. The students will be able to work on different methods to utilize renewable sources.
4. The students will be able to understand and make energy audit report.

Recommended Books:

1. 'Renewable energy resources'. John W Twidell and Anthony D Weir.
2. 'Renewable energy – power for sustainable future'. Edited by Godfrey Boyle. Oxford University Press in association with the Open University.
3. 'Renewable energy sources and their environmental impact'. S.A. Abbasi and Naseema Abbasi. Prentice-Hall of India.
4. 'Non-conventional sources of energy'. G.D. Rai. Khanna Publishers.
5. 'Solar energy utilization'. G.D. Rai. Khanna Publishers.
6. 'Renewable and novel energy sources'. S.L.Sah. M.I. Publications.
7. 'Energy Technology'. S.Rao and B.B. Parulekar. Khanna Publishers.

MME3E47/MME3E48
GAS TURBINE AND JET PROPULSION

L	T	P/D	Cr.
3	0	-	3

Course Learning Objectives

1. Basic knowledge of physical principles of Aerodynamics
2. To create awareness on various gas turbine technology.
3. To make understand on jet propulsion like ramjet and its technology.
4. General understanding of how the design of a hypersonic influences performance.

Course Contents

1. **Introduction**
   Fundamentals of Aerodynamics quantities & equations, Bernoullli's principle, Compressibility, Thermodynamics laws & Process, isentropic flows, speed of sound, Shock Waves Normal & Oblique shock Waves. **(10hrs)**

2. **Gas Turbine**
   Principle of Gas Turbines &Components of the Gas Turbine Engine, air breathing engines like Turbojet, Turboprop, Turbofan, Turbojet and Ramjet & Scramjet Engine working, Compressors, Turbines, Nozzles and Diffusers, combustor & its thermal coating,. Efficiencies of air breathing, Cycle analysis of air breathing systems, Calculations for Thrust and Fuel Consumption, Thermodynamic Analysis of the Engine and Numerical.
   (10 hrs)

3. **Ramjets**
   Thermodynamics cycle, Engines Component analysis, Supersonic Intake, full size supersonic combustor, injection and flame holding strategies, performance Thrust Calculations, Specific thrust, fuel consumption, efficiency, design, energy equations and gas laws fundamental issues in supersonic combustion, issues in developing a supersonic combustor Turbo ramjets and Numerical. **(10 hrs)**

4. **Hypersonic**
   Introduction, Mach number, Need, Scramjets propulsion fuels, Combustors, HyperMat Materials, Zirconium boride, ultra-high temperature ceramics, c-sic composite Hypersonic vehicle shapes, Flow with heat addition, Stoichiometry, hypersonic facilities, Design of a supersonic wind tunnel, control volume analysis, overall engine analysis, Future challenges and Numerical. **(10 hrs)**

Course Outcomes:

1. Understand the aerodynamics laws and its concepts.
2. Understanding the components of gas turbine.
3. Analysis of Ramjets engine and its operation.
4. Understand how scramjet propulsion fits within context of aerospace propulsion and modeling the performance of a 2D simple scramjet engine.

Reference Books:

1. Fundamentals of Gas Dynamics by V.Babu, ANE Student Edition.
2. Fundamentals of Propulsion by V.BabuANE Student Edition.
3. Mechanics and Thermodynamics of Propulsion-Philip Hill and Carl Peterson,Addison Wesley.
4. Elements of Gas Turbine Propulsion-J D Mattingly, McGraw-Hill.
5. Introduction to Aeronautical Engineering online course edx by TuDelftuniversity. (https://courses.edx.org/courses/course-v1:DelftX+AE1110x+2T2018/course/)
6. Gas Dynamics and Propulsion - Video course by Prof. V. BabuDepartment of Mechanical Engineering IIT Madras (https://nptel.ac.in/courses/112106166/).
7. Hypersonics – from Shock Waves to Scramjets online course Edx by University of Queensland .(https://courses.edx.org/courses/coursev1:UQx+Hypers301x+1T2018/course/)
8. Jet Aircraft Propulsion (Video) by Prof. Bhaskar RoyIIT Bombay(https://nptel.ac.in/courses/101101002/37).
9. Aerospace Propulsion by Dr. P.A. RamakrishnaIIT Madras(https://nptel.ac.in/courses/101106033/4).

MME3E45/MME3E46
SOLAR ENERGY

L	T	P/D	Cr.
3	0	-	3

Course Learning Objectives

1. To understand the basic concepts of Renewable Energy, specifically solar energy and apply them to address the practical applications.
2. To understand the basic concepts and applications of solar energy.
3. To impart the knowledge to the students about various contemporary methods to utilize solar energy.
4. To impart the knowledge to the students about solar thermal power generation.

Course Contents

1. **Solar Radiation**
   Characteristics, Earth-sun relations, Estimation on horizontal and tilted surfaces, Radiation characteristics of opaque and transparent material. **(5 hrs)**

2. **Flat Plate Collectors**
   Description, theory, Heat capacity effects, Time constant, Measurement of thermal performance, Air heaters. **(6 hrs)**

3. **Evacuated Tubular Collectors**
   One axis, Two axis, Solar tracking, Cylindrical, Spherical and Parabolic and Paraboloid concentrators. Composite collectors, Central receiver collectors. **(6 hrs)**

4. **Heat Storage**
   Sensible and latent heat storage, Chemical energy system, performance calculations. **(5 hrs)**

5. **Flow Systems**
   Natural and forced flow systems, Water heating systems for domestic, industrial and space heating requirements, Solar distillation. **(5 hrs)**

6. **Solar Heating and Cooling**
   Direct, indirect and isolated heating concepts, Cooling concepts, Load calculation methods, Performance evaluation methods. **(4 hrs)**

7. **Solar Thermal Power Generation**
   Introduction, Paraboloidal concentrating systems, Cylinderical concentrating systems, Central receiver system. **(5 hrs)**

8. **Solar Refrigeration and Air Conditioning Systems**
   Introduction, Solar refrigeration and air conditioning systems, Solar desiccant cooling.
   (4 hrs)

Course Outcomes:

1. The students will be able to understand importance of Solar Energy amongst Renewable Energy Sources.
2. The students will be able to utilize different sources of renewable energy in engineering applications.
3. The students will be able to work on different contemporary methods to utilize solar energy, especially solar thermal power generation.

Reference Books:

1. Solar Thermal Engineering Process by Duffie and Beckman.
2. Advanced Solar Energy Technology by H.P. Garg.
3. Solar Energy by S.P. Sukhatme.
4. Solar Energy by J.S. Hsieh.
5. Solar Thermal Engineering by P.J. Lunde.

MME3E35/MME3E36
NUCLEAR ENGINEERING

L	T	P/D	Cr.
3	-	-	3.0

Course Learning Objectives

1. To be able to understand the concepts of neutron physics and various nuclear Processes involved in Nuclear Power Plants.
2. To be able to calculate heat generation from nuclear reaction.
3. To be able to design and analyze the performance of nuclear power plants.
4. To get acquainted with applications of radioactivity.
5. To be able to appreciate the hazards associated with radioactivity and the necessity of waste disposal.

Course Contents

1. **Concepts of Nuclear Physics**
   The atom, structure, the nucleus, nuclear structure, atomic transmutation of elements, detection of radio-activity, particle accelerator, decay, natural of elements, nucleus interactions, decay rates, half-life, transuranic elements. **(6hrs)**
2. **Neutorn Interaction**
   Advantages of using neutron, neutron moderation, fission chain reaction, thermalisation of neutrons, fast neutrons, prompt and delayed neutrons, fission products. **(4hrs)**
3. **Energy Release**
   Mass energy equivalence, mass defect, binding energy, energy release in fission & fusion, thermonuclear reaction, fusion bomb. **(4hrs)**
4. **Reactor Materials**
   Fissile & fertile materials, cladding & shielding materials, moderators, coolants. **(4hrs)**
5. **Reactor Technology**
   Basic principles, fuel assembly, neutron balance, reactor kinetics, reactor coefficients, reactor stability, excess reactivity, Xenon poisoning, burnable absorbers, reactivity control, heat balance, production& transfer of heat to the coolant, structural considerations. **(10 hrs)**
6. **Nuclear Reactors**
   Types of nuclear reactors, pressurized water reactors, boiling water reactors, CANDU type reactors, gas cooled & liquid metal cooled reactors, fast breeder reactors. **(6hrs)**
7. **Safety Considerations & Waste Disposal**
   Hazards, plant site selection, safety measures incorporated in; plant design, accident control, disposal of nuclear waste. **(4hrs)**
8. **Health Physics & Radio-isotopes**
   Radiation: units, hazards, prevention, preparation of radio-isotopes& their use in medicine, agriculture & industry. **(2hrs)**

Course outcomes:

1. Understand the concepts of neutron physics and various nuclear Processes involved in Nuclear Power Plants.
2. Calculate heat generation from nuclear reaction.
3. Design and analyze the performance of nuclear power plants.
4. Get acquainted with applications of radioactivity.
5. Appreciate the hazards associated with radioactivity and the necessity of waste disposal.

Reference Books:

1. M. M. El-Wakel, Nuclear Power Engineering, McGraw Hill
2. Shultis and Faw, Fundamentals of Nuclear Science and Engineering, CRC Press
3. Stephenson, Introduction to Nuclear Engineering, McGraw Hill
4. Murray, Nuclear Energy, Butterworth-Heinemann

MME2C07
EXPERIMENTAL DESIGNS

L	T	P/D	Cr
3	0	-	3

Course Learning Objectives

1) To introduce the concept of experimentation
2) To expose students to different types of experimental designs like Latin Square Design and Graeco Latin Square Design
3) To understand the nature of full factorial designs with two levels
4) To understand the concept of fractional factorial designs with two levels
5) To understand Taguchi's DOE Approach and Response Surface Methodology

Course Contents

1. **Introduction**
   Introduction, Objectives for experimental designs, Basic design concepts, Steps for the design of experiments, Types of experimental designs, Analysis of Means, Experimental designs and six sigma **(6hrs)**

2. **Completely Randomized Design**
   Model for a completely randomized design with a single factor, ANOM for a completely randomized design, Randomized Block Design, Incomplete Block Designs, Latin Square Design, Graeco-Latin Square Design **(8hrs)**

3. **Full Factorial Designs With Two Levels**
   Nature of Factorial Designs, Deleterious Effects of Interactions, Effect Estimates, The 2^3 Design, Built –In- Replication, Role of expected mean squares in experimental design **(6 hrs)**

4. **Fractional Factorial Designs with two Levels**
   2^{k-1} Designs, Effect Estimates and Regression Coefficients, 2^{k-2} Designs, Design Efficiency, John's ¾ Designs **(6hrs)**

5. **Robust Designs**
   DOE and Taguchi Approach, Experimental Design using orthogonal arrays; Experimental Designs With Two-Level Factors Only; Experimental Designs With Three and Four Level Factors; ANOVA; Analysis using Signal- to Noise Ratios; Some case studies; QT4 Software; Response Surface Methodology; Response surface experimentation; Process improvement with Steepest Ascent; Analysis of Second-order response Surfaces; Central Composite Design; Box-Behnken Design; Analyzing the fitted surface; Design-Expert Software **(10hrs)**

Course Outcomes:

1. Become conversant with different types of experimental designs
2. Select a suitable design for undertaking experimental investigation in any field of engineering
3. Learn effectively Taguchi's parameter design approach for solving all kinds of Industrial problems
4. Learn effectively Response Surface Methodology for modeling and optimizing responses

Reference Books:

1. Modern Experimental Design by Thomas P Ryan. John Wiley
2. Response Surface Methodology by Myers R H and Montgomery Dc. John Wiley
3. Design of Experiments using the Taguchi Approach by Ranjit K Roy. John Wiley
4. Design and analysis of Experiment by Montgomery D.C. Wiley India
5. Taguchi Methods: A Hands-on Approach by Glen Stuart Peace Addison-Wesley

MME2C05
COMPUTER AIDED MANUFACTURING

L	T	P/D	Cr
3	0	-	3

Course Learning Objectives

1) To understand the basic concepts of Computer –Aided Manufacturing and its scope
2) To understand the basic concepts of Group Technology and Cellular Manufacturing, clustering algorithm as well as methods to carry out arrangement of machines with in a cell
3) To understand Computer aided process planning and its types and associated aspects
4) To understand Flexible manufacturing systems and related aspects
5) To understand CNC manual part programming and prepare part programs

Course Contents

1. Introduction to Manufacturing

Basic definitions, design activities for manufacturing systems, Planning and control activates for manufacturing system, Manufacturing control, Types of production –low, Medium and high quantity production, Recent Developments (**6 hrs**)

2. Group Technology and Cellular Manufacturing

Part families, parts classifications and coding, Production flow Analysis, cellular Manufacturing- composite part concept, machine cell design, applications of group technology, Grouping parts and machines by Rank order clustering technique, Arranging machines in a G.T. cell. (**10 hrs**)

3. Process Planning

Introduction, Manual process planning, Computer aided process planning – variant, generative, Decision logic- decision tables, decision trees, Introduction to Artificial intelligence. (**6 hrs**)

4. Flexible Manufacturing

Introduction, FMS components, Flexibility in Manufacturing – machine, Product, Routing, Operation, types of FMS, FMS layouts, FMS planning and control issues, deadlock in FMS, FMS benefits and applications. (**8 hrs**)

5. CNC Basics and Part Programming

Introduction, Principle of CNC, Classification of CNC – point to point and continuous path, positioning system- fixed zero and floating zero, Dimensioning- absolute and incremental, Coordinate system, Basic requirements of CNC machine control, CNC words, Manual part programming, (G&M codes only) canned cycles, tool length and radius compensation.

(**10 hrs**)

Course Outcomes:

1) Understand Scope of Computer aided manufacturing
2) Apply knowledge of Group Technology and Cellular Manufacturing for formation of cells as well as arrangement of machines within a cell
3) Understand CAPP and its general architecture as well as types and related concepts
4) Understand FMS, manufacturing flexibility, production planning and control in FMS and related issues such as deadlock
5) Prepare manual part programs of simple components

Reference Books:

1. Automation, Productions systems and Computer-Integrated Manufacturing by M.P. Groover, Prentice – Hall
2. Computer Aided Manufacturing by Chang, Wang &WySK
3. Numerical Control and Computer – Aided Manufacturing by Kundra, Rao and Tiwari, Tata Mc Graw Hill.
4. International Journal of Production Research
5. International Journal of Flexible Manufacturing system.

MME2E51/MME2E52
STRATEGIC ENTREPRENEURSHIP

L	T	P/D	Cr.
3	0	-	3

Course Learning Objectives

1) To make students aware on significance and various facets of entrepreneurship.
2) To create awareness on role of SSIs and EDPs in economic development of the country.
3) To make students understand basics of marketing and financial management.
4) To create awareness on basics of business incubation and create awareness on incubation facilities in the country.

Course Contents

1. Entrepreneurs and Entrepreneurship

Concept, Role and Significance of Entrepreneurship; Entrepreneurial Myths; Entrepreneurs - Types and Characteristics; Need for Entrepreneurs; Special Entrepreneurial Aspects - Social Entrepreneurship, Women Entrepreneurship, International Entrepreneurship, Rural Entrepreneurship, Corporate Entrepreneurship, Technical Entrepreneurship; Entrepreneurship. **(8hrs)**

2. Small Scale Industries And Entrepreneurship Development

Concept, Types and Role of Small Scale Industries; Problems of Small Scale Industries; Industrial Sickness and Remedies; Entrepreneurship Development; Entrepreneurship Development Programmes (EDPs) - Objectives and Contentss; Government and Non-Government Agencies involved in Entrepreneurship Development. **(10hrs)**

3. Marketing Management and Financial Management

Market Analysis; Industrial Potential Survey; Demand Forecasting; Marketing Aspects for Entrepreneurs - Pricing, Branding, Packaging, After Sales Service, Advertising, Sales Promotion etc.; Sources of Finance for Entrepreneurs; Factors affecting Selection of Sources of Finance; Role of Banks and Financial Institutions in Entrepreneurship Development. **(12hrs)**

4. Business Incubation

Introduction; Origin and Development of Business Incubators in India and Other Countries; Types of Business Incubator Models; Business Supports; Thrust Areas for Business Incubation in India; Role of Business Incubators for Entrepreneurs, Institutes, Government and Society; Sustainability Issues for Business Incubators in India. **(10hrs)**

Course Outcomes:

1) Understanding the dynamic role of entrepreneurship and small businesses
2) Role of SSIs in economic development and government support for entrepreneurship development.
3) Market research and financial planning for small business.
4) Strategic business supports being provided by Business Incubators.

Reference Books:

1. Small Business Management An Entrepreneur's Guidebook (McGraw-Hill)
2. Project Management - Strategic Design and Implementation by David Cleland (McGraw-Hill).
3. Marketing Management by Kotler (Prentice Hall of India)
4. Sustainable Strategic Management by Steed and Steed (Prentice Hall of India)
5. Engineering Economics Principles by Henry Steiner (McGraw-Hill).

MME2C03
OPERATIONS MANAGEMENT

L	T	P/D	Cr.
3	0	-	3

Course Learning Objectives

1) To understand concept of operation management
2) Apply this knowledge to understand the working of corporate world.

Course Contents

1. Basics of Production Management:

Types of production, life cycle approach to production system, Productivity and Productivity measures, types of productivity index, productivity improvement, MRP.

(7 hrs)

2. JIT:

JIT, requirements and problems in implementing JIT, Benefits of JIT, Introduction to JIT purchasing and JIT quality management, Lean manufacturing, Agile manufacturing

(**6 hrs)**

3. Supply chain management:

Supply chain management, its importance, objectives and applications. Tenabled supply chain supply chain drives concepts of stockless, VRM and CRM. **(6 hrs)**

4. Business Process Reengineering:

Re-engineering-characteristics, organizational support, responsibility of re-engineering, re-engineering opportunities, choosing the process to re-engineer, success factors and advantages. **(6 hrs)**

5. ERP:

Evolution of ERP, Characteristics, approaches, methodology for implementation, Success factors. **(6 hrs)**

6. Waste Management:

Introduction, classification of waste, systematic approach to waste reduction, waste disposal. **(5 hrs)**

7. Some Case Studies in OM

Minimum four Case Studies to be explained. **(4 hrs)**

Course Outcomes:

1) Develop an understanding of Production systems and their characteristics.
2) Understand and analyze operations and supply chain management issues in a firm.
3) Evaluate MRP and JIT systems against traditional inventory control systems.
4) Understand basics of ERP and methodology for implementation of ERP.
5) Discuss the approach to waste reduction.

Reference Books:

1. Mohanty, R. P. and Deshmukh, S. G. "Advanced Operations Management" Pearson Education.
2. Krishnaswamy, K. N.,"Case in Production/ Operations management" Prentice Hall of India.
3. Muhlemann, A., Oakland, J., Lockyer, K., Sudhir, B. and Katyayani, J., "Production and Operations Management", Pearson Education South Asia.
4. Adam, E.E and Ebert, J.R.J," Production and Operations Management" Prentice Hall of India.

MME2E53/MME2E54
TOTAL QUALITY MANAGEMENT

L	T	P/D	Cr.
3	0	-	3

Course Objectives:

To understand concept of quality management and apply this knowledge to understand the working of corporate world.

Course Contents

1. **Concept of Quality**
   Products and services, quality of products and services, definition of quality, dimensions of quality and their measure **(4 hrs)**

2. **Quality Management Practices**
   Various approaches to control and management of quality,: inspection oriented, statistical process control oriented, assurance oriented and TQM oriented approaches.
   (8 hrs)

3. **Cost of Quality**
   Productivity and quality relationship, concept of cost of quality, cost of conformance, prevention, appraisal and failure cost, internal and external failures, quality cost estimation in engineering and service industries. **(4 hrs)**

4. **Organizing for Quality**
   Company wide organization for quality management, prevention, control and improvement, continuous improvement process. **(4 hrs)**

5. **Human Aspects in Management of Quality**
   Commitment, motivation, and involvement for quality,top management, management and worker participation, zero defects, quality circle, small group activity.
   (4 hrs)

6. **Quality Systems**
   Introduction, ISO 9000 Series of standards, Other quality systems, ISo 14000 series standards, concepts of ISO 14001, requirements of ISO 14001, EMS benefits.
   (6 hrs)

7. **Some Case Studies TQM**
   Minimum four Case Studies to be explained. **(4 hrs)**

Course Outcomes:

1) Develop an understanding of quality management philosophies and framework.
2) Discuss the need of customer expectations, employee involvement and supplier partnership.
3) Analyze the TQM tools and techniques to improve the product and process quality.
4) Apply modern tools to improve quality of the product.
5) Describe ISO 9001, Environmental Management Standards and ISO 14001 Certification process.

Reference Books:

1. Besterfield, D.H, Michna, C.B, Besterfield, G. H and Sacre, M.B, "Total Quality Management" Pearson Education Asia.
2. Mukherjee, P. N., "Total Quality Management" Prentice Hall of India.
3. Rajaram, S., "Total Quality Management" Biztantra.
4. Ramasamy, S. "Total Quality Management" Mc Graw Hill Education.

MME2E45/MME2E46
MODELING AND SIMULATION

Course Learning Objectives:

1. To understand the basics of modeling and simulation
2. To understand the various statistical models used in modeling and simulation
3. To understand stochastic simulation and its applications to queuing models and inventory models
4. To understand the modeling and simulation of manufacturing and material handling systems
5. To carry out modeling of simulation of manufacturing and material handling systems

Course Contents

1. Introduction to Modeling: Concept of system, continuous and discrete systems; Types of models and simulation; Discrete event simulation: Time advance mechanisms, components and organization of simulation model, steps in simulation study, advantages and disadvantages of simulation (**6hrs)**

2. Statistical Models in Simulation: Discrete, continuous, Poisson and empirical distributions, output data analysis for a single system, comparing alternative system configurations, statistical procedures for comparing real world observations with simulation output data, generation of arriving processes, verification and validation of simulation models. (**12hrs)**

3. Stochastic Simulation: Random number generation: Properties of random numbers, techniques of generating random numbers, generation of random variates, Monte Carlo simulation and its applications in queuing models and inventory models. (**10hrs)**

4. Simulation of Manufacturing and Material Handling Systems:
Models of manufacturing systems, models of material handling systems, goals and performance measures; Issues in manufacturing and material handling simulation: Modeling downtime failures, trace driven models. (**8hrs)**

5. Case Studies on Simulation Packages: Simulation of queuing system (bank/job shop), simulation of manufacturing and material handling systems. (**6hrs)**

Course Outcomes:

1. Understand the basics of modeling and simulation
2. Understand the various statistical models used in modeling and simulation
3. Understand stochastic simulation and its applications to queuing models and inventory models
4. Understand the modeling and simulation of manufacturing and material handling systems
5. Carry out modeling of simulation of manufacturing and material handling systems

Reference Books:

1. Banks, J., Nelson, B.L., Carson, J. S., and Nicol, D., "Discrete EventSystem Simulation", Pearson Education.
2. Law, A.M., and Kelton, W.D., "Simulation Modeling and Analysis",McGraw-Hill.
3. Schwarzenbach, J., and Gill, K.F., "System Modeling and Control",Butterworth-Heinemann.
4. Carrie, A., "Simulation of Manufacturing Systems", John Wiley &Sons.
5. Viswanadham, N., and Narahari, Y., "Performance Modeling ofAutomated Manufacturing System", Prentice-Hall of India.
6. Theory of Modeling & Simulation, B.P. Zeigler, Taqgon Kim and Herbert Praehofer, Academic Press.
7. Handbook of Simulation: Principles, Methodology, Advances, Applications & Practice, Jerry Banks.
8. Discrete Systems Simulation, Khoshnevis.
9. Simulation Made Easy, Charles Harrell and KerimTumay, Engineering and Management Press.
10. Simulation with Arena, W. David Kelton, Randall P. Sadowski, and Deborah A. Sadowski, McGraw-Hill.
11. Pro Model Software - Student Version, Published by the Day Grp.

MME2C02
SOFT COMPUTING

L	T	P/D	Cr
3	-	-	3

Course Learning Objectives

1) To understand basics of Artificial Neural Network , Genetic Algorithm, Particle Swarm optimization and fuzzy logic
2) To learn soft computing techniques so as to build computationally intelligent systems that possess human like abilities to reason, learn and handle the uncertainty and vagueness often inherent in real world problems.
3) To solve complex practical problems for which conventional mathematical and analytical methods are inefficient.
4) To implement the soft computing solutions using appropriate tools.

Course Contents

UNIT-1

Introduction to soft computing, Hard Computing versus Soft Computing, Introduction to artificial neural network, Biological Neural network, Comparison between Artificial and Biological Neural Network , Model of an Artificial Neuron, Characteristics of Neural Network , Basic building blocks of Artificial Neural Network: Network Architecture, Learning methods, Activation function

(5 hrs)

UNIT-II

McCulloch Pitts Neuron Model, Simple perceptron model, Limitations of Perceptron Single layer feed forward network, Learning process in single layer feed forward network, Multi layer feed forward neural network, Back propagation learning, Stopping criteria, Problems with backpropagation **(8 hrs)**

UNIT-III

Introduction to Genetic Algorithm, Advantages and Disadvantages, GA's Basic Terms, Implementation of GA, Fitness function, genetic operators, Representation/Encoding Schemes, Selection of parents, cross over methods and rate, mutation operator and rate, Convergence of genetic algorithm, Optimizing numerical functions using GA, difference and similarities between GA and other traditional methods **(9 hrs)**

UNIT-IV

Basic Particle Swarm Optimization, Global Best PSO, Local Best PSO, gbest versus lbest PSO, Velocity Components, Algorithm Aspects: (particle initialization, stopping conditions and defining the terms iteration and function evaluation) Social Network Structures, Basic PSO Parameters, Basic variations: velocity clamping, Inertia weights. **(6 hrs)**

UNIT-V

Fuzzy versus crisp, Crisp set Theory , operation on crisp sets, properties of crisp sets ,crisp relation, Fuzzy sets: Membership function, basic fuzzy set operations, properties of fuzzy sets ,fuzzy relations, Crisp logic, Predicate Logic, Fuzzy logic, Fuzzy quantifiers, Fuzzy inference, Fuzzy rule based system, De-fuzzification methods **(12 hrs)**

Course Outcomes

1) Student will be able to understand concept of soft computing and fundamental theory and concepts of neural networks
2) Student will be able to apply neural networks to prediction and pattern classification problems
3) Student will be able to apply Genetic Algorithm to solve optimization problems
4) Student will be able to apply Particle swarm optimization to solve optimization problems
5) Students will be able to apply fuzzy logic to solve engineering problems having uncertainty

1.1 Recommended Books/Journals:

1. Saroj Kauhik and Sunita Tiwari, Soft computing fundamentals, Techniques and Applications , McGraw Hill Education Private Limited
2. S. Rajasekaran & G. A. Vijayalakshmi Pai, Neural Networks, Fuzzy Logic and Genetic Algorithms: Synthesis & Applications, PHI.
3. David.E. Goldberg, Genetic Algorithms in Search, Optimization and machine learning, Addison Wesley.
4. S. N. Sivanandam & S. N. Deepa, Principles of Soft Computing, Wiley - India, 2007.
5. Saroj Kaushik, Artificial Intelligence, Cengage Learning.
6. M. Mitchell, An Introduction to Genetic Algorithms, Prentice-Hall.
7. S. N. Sivanandam , Sumuthi & S. N. Deepa, Introduction to Neural Networks using MATLAB
8. S. N. Sivanandam , Sumuthi & S. N. Deepa, Introduction to fuzzy logic using MATLAB
9. Timothy ,J.Ross Fuzzy Logic with Engineering Applications,Wiley.

MME2E31/MME2E32
WELDING SCIENCE & TECHNOLOGY

L	T	P/D	Cr.
3	0	-	3

Course Learning Objectives

6) To understand the physics of welding arc, its theories, metal transfer modes and various forces acting on metal droplet
7) To understand various welding power sources, characteristics desired and their selection
8) To understand various welding processes
9) To understand coated welding electrodes, their composition and selection
10) To understand weldability of metals such as steel, Cast iron Aluminum
11) To understand various non destructive methods of testing weldments
12) To understand weld joint design

Course Contents

1. **Introduction**
   Evolution of welding, Classification, Importance and applications, Heat Sources and Shielding Methods **(4 hrs)**

2. **Physics of Welding Arc**
   Welding Arc, Voltage Distribution along arc, theories of cathode and anode mechanism, arc characteristics, arc efficiency, heat generation at cathode and anode, effect of shielding gas on arc, isotherms of arc, modes of metal transfer, forces acting on metal droplet, arc blow **(9 hrs)**

3. **Welding Power Sources**
   Types, static and dynamic characteristics, selection **(3 hrs)**

4. **Arc Welding Processes**
   Manual metal arc welding, Gas tungsten Arc welding, metal inert gas welding, pulsed MIG welding, submerged arc welding, electroslag welding, electrogas welding, resistance welding, friction welding, laser beam welding, electron beam welding **(8 hrs)**

5. **Welding Electrodes**
   Types, electrode coating ingredients and their functions, types of heavy coated electrodes, specification and selection of electrodes **(3 hrs)**

6. **Weldability of Metals**
   Effect of alloying elements, weldability of steel, cast iron, Aluminum **(5 hrs)**

7. **Weld Joint Design**
   Types of welds and joints, joint design, description of welds: terminology, definitions and weld symbols, edge preparation, sizing of welds in structure, Design for static loading, weld calculations for lap, butt and fillet welds, design for fatigue loading **(4 hrs)**

8. **Non Destructive Testing of Weldments**
   Visual inspection, Dye-penetrant inspection, Magnetic particle inspection, Ultrasonic inspection, Radiographic inspection **(4 hrs)**

Course Outcomes:

1) Understand the welding arc and parameters affecting it
2) Understand various welding processes
3) Select welding power source as per requirement
4) Understand coated welding electrodes and its composition
5) Understand weldability of metals
6) Understand various non-destructive testing of weldments
7) Carry out weld design calculations in lap, butt and fillet welds

Reference Books:

1. Principles of Welding (processes, Physics, Chemistry and Metallurgy) by Robert W. Messler, Wiley
2. Metallurgy of Welding by Lancaster
3. Welding Metallurgy by S. Kuo, Wiley
4. Modern Welding Technology by Carry Howard B.
5. Welding Processes and Technology by R. S. Parmar
6. Welding Handbooks by AWS
7. Welding Technology and Design by V.M. Radha krishnan, New Age.
8. Physics of Welding by J.F. Lancaster, Pergamon
9. Welding Process Technology- Houldcroft, P.T., Cambridge University Press
10. Modern Arc Welding Technology by S.V. Nadkarni, Oxford IBH.

MME2E49/MME2E50
MACHINE VISION & ARTIFIAL INTELLIGENCE

L	T	P/D	Cr.
3	0	-	3

Course Learning Objectives

1) To gain an understanding of the fundamental issues and techniques for extracting information from digital images.
2) To have knowledge of well established methods for processing, segmentation, feature extraction and recognition of objects.
3) To provide the student with programming experience from implementing computer vision and object recognition applications

Course Contents

1. Introduction

Machine vision, difference between computer vision and machine vision, relationship of machine vision to other fields , Applications of machine vision, typical machine vision tasks, components of digital image processing system, Digital images , types of images, Elements of machine vision system, Basic relationship between pixels (neighbors of a pixel, connectivity, ,path, foreground, background, connected component, boundary, interior) Labeling of connected components, Distance measure **(7 hrs)**

2. Image Processing

Digitization, Noise, levels of operations, look up table, Image enhancement techniques by point processing (Negative of image, Contrast stretching, Histogram Equalization, Histogram specification), Image enhancement based on the neighborhood of pixels (spatial domain and frequency domain) spatial domain techniques (Low pass filters and high pass filters, High boost filter), Image enhancement in frequency domain (Low pass and High pass filters) **(8 hrs)**

3. Image Analysis

Segmentation of images (Region based, Edge detection),Region based- thresholding, Types of thresholds, Iterative threshold selection, Adaptive thresholding, Region growing by pixel aggregation, Split and merge algorithm, Edge detection- point detection, line detection, edge detection (Roberts, Prewitt, Sobel, Laplacian operations)

(7 hrs)

4. Description

Shape representation, Topological shape descriptors, Contour-based Shape Representation Techniques- Simple Shape Descriptors , Signatures, Fourier descriptors, Boundary moments, Polygon approximation , Chain code, Region based shape representation techniques- simple shape descriptors, Moment based features, Convex Hull, Skeleton of a region, Medial axis transform **(9 hrs)**

5. **Pattern Recognition**
   Pattern recognition methods- Structural methods, syntactic methods, Template matching, Artificial neural network- biological neural model, neuron model, advantages and disadvantages, characteristics of artificial neural network, usefulness and capabilities perceptron-single layer, multi layer, Back propagation Neural Network **(9hrs)**

Course Outcomes:

1) Student will be able to understand the application of computer vision in industrial tasks
2) Students will have the knowledge of various methods of enhancing Images
3) Students will be able to segment the images using spatial domain and frequency domain methods
4) Student will be able to find features invariant to translation, rotation, scale
5) Student will be able to recognize /classify the objects using Artificial Neural Network

Reference Books:

1. Digital image processing by Rfael C. Gonzalez and Richard E. Woods.
2. Fundamentals of Digital image processing by Anil K. Jain
3. Digital image processing-Concepts, Algorithms and Scientific Applications by Bernd Jahne.
4. Machine vision by Ramesh Jain, Rangachar Kasturi, Brian G. Schunck.
5. Introduction to Neural Networks using MATLAB, S. N. Sivanandam , Sumuthi & S. N. Deepa.

MME2E35/MME2E36
PRODUCTION PLANNING & CONTROL

L	T	P/D	Cr.
3	0	-	3

Course Learning Objectives

1) To understand the basic concepts of Production Planning and Control, Preplanning Planning, Production Planning and Control Functions.
2) To understand the basic concepts of Product Development and Design.
3) To impart the knowledge of Inventory Control, V.E.D. analysis, S-D-E analysis, F-S-N analysis H-M-L analysis and ABC analysis, Safety stocks and service levels.
4) To impart the knowledge of Evaluation of Material Processes and Value Analysis Tests.

Course Contents

1. Introduction

Basic concepts of Production Planning and Control, Preplanning Planning, Production Planning and Control Functions: Estimating, Scheduling, Routing, Sequencing, Loading, Dispatching, Expediting, Inspection and Evaluation. **(4 hrs)**

2. Product Development and Design

Effect of competition on design, Long-range Planning, Company policy, product analysis, marketing aspects, the product characteristics, functional aspect, operational aspect, durability and dependability, Aesthetic aspect; Economic analysis, Profit and competitiveness, The three S's:- Standardization, Simplification and Specialization. Break Even Analysis.

(9 hrs)

3. Inventory Control

Definition, classification, objectives of inventory control, functions, economic order quantity various inventory models. Numericals on inventory control. Inventory carrying costs, factors affecting inventory costs. V.E.D. analysis, S-D-E analysis, F-S-N analysis H-M-L analysis and ABC analysis. Safety stocks, their objectives safety stocks and service levels.

(9 hrs)

4. **Evaluation of Material and Processes**
   Introduction, Value Analysis, consideration of new techniques and materials, Value Analysis Tests, material utilization of a product or assembly. Numerical problems on material utilization of a product. Value Engineering job plan and various phases of job plan in systematic value engineering approach. **(10 hrs)**

Course Outcomes:

1. Understand the basic concepts of Production Planning and Control and significance of Production Planning and Control function.
2. Understand the major concepts of Production Development and Design and their applications.
3. Develop an understanding of various inventory Control Concepts, Inventory models, Inventory Cost and ABC Analysis.
4. Understand the evaluation of materials and processes and concept of Value Analysis.

Reference Books:

1. Production Planning and Control: Samuel Eilon
2. Production Planning and Control: K.C. Aggarwal & K.C. Jain
3. Industrial Engg. & Operation Management by S.K. Sharma & Savita Sharma.
4. Production Planning and Control: King J.R.
5. Production Planning and Control: Sharma, Hari Rraghu Rama.
6. Production Planning and Control: Narasimhan Seetha-rama L.
7. Production Planning and Control: S.K. Mukhopadhyay
8. The Fundamentals of Production Planning and Control: Stephen N. Chapman