Common to Design Engineering (MDE), Engineering Analysis & Design (MEA), Machine Design (MMD)

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM

SCHEME OF TEACHING AND EXAMINATION FOR
M.TECH. Machine Design

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APPLIED MATHEMATICS
(Common to MDE, MMD, MEA, CAE, MCM, MAR, IAE, MTP, MTH, MTE, MST, MTR)

Sub Code : 16MDE11   IA Marks : 20
Hrs/ Week : 04   Exam Hours : 03
Total Hrs: 50   Exam Marks : 80

Course Objectives:
The main objectives of the course are to enhance the knowledge of various methods in finding the roots of an algebraic, transcendental or simultaneous system of equations and also to evaluate integrals numerically and differentiation of complex functions with a greater accuracy. These concepts occur frequently in their subjects like finite element method and other design application oriented subjects.

Course Content:
1. Approximations and round off errors: Significant figures, accuracy and precision, error definitions, round off errors and truncation errors. Mathematical modeling and Engineering problem solving: Simple mathematical model, Conservation Laws of Engineering. 06 Hours


3. Numerical Differentiation and Numerical Integration: Newton –Cotes and Guass Quadrature Integration formulae, Integration of Equations, Romberg integration, Numerical Differentiation Applied to Engineering problems, High Accuracy differentiation formulae 06 Hours


5. Linear Transformation: Introduction to Linear Transformation, The matrix of Linear Transformation, Linear Models in Science and Engineering

**Text Books:**

**Reference Books:**

**Course Outcomes:**
The Student will be able to
1. Model some simple mathematical models of physical Applications.
2. Find the roots of polynomials in Science and Engineering problems.
3. Differentiate and integrate a function for a given set of tabulated data, for Engineering Applications
FINITE ELEMENT METHOD
(Common to MDE, MEA, MMD, CAE, MTR)

Sub Code: 16MDE12    IA Marks: 20
Hrs/ Week: 04        Exam Hours: 03
Total Hrs: 50        Exam Marks: 80

Course Objectives

1. To present the Finite element method (FEM) as a numerical method for engineering analysis of continua and structures
2. To present Finite element formulation using variational and weighted residual approaches
3. To present Finite elements for the analysis of bars & trusses, beams & frames, plane stress & plane strain problems and 3-D solids, for thermal and dynamics problems.

Course Content:

1. **Introduction to Finite Element Method**: Basic Steps in Finite Element Method to solve mechanical engineering (Solid, Fluid and Heat Transfer) problems: Functional approach and Galerkin approach, Displacement Approach: Admissible Functions, Convergence Criteria: Conforming and Non Conforming elements, \( C_0 \), \( C_1 \) and \( C_n \) Continuity Elements. Basic Equations, Element Characteristic Equations, Assembly Procedure, Boundary and Constraint Conditions.

   **10 Hours.**

2. **Solid Mechanics: One-Dimensional Finite Element Formulations and Analysis** – Bars: uniform, varying and stepped cross section- Basic(Linear) and Higher Order Elements Formulations for Axial, Torsional and Temperature Loads with problems. Beams: Basic (Linear) Element Formulation for uniform, varying and stepped cross section- for different loading and boundary conditions with problems. Trusses, Plane Frames and Space Frame Basic(Linear) Elements Formulations for different boundary condition -Axial, Bending, Torsional, and Temperature Loads with problems.

   **10 Hours.**
3. **Two Dimensional Finite Element Formulations for Solid Mechanics Problems:** Triangular Membrane (TRIA 3, TRIA 6, TRIA 10) Element, Four-Noded Quadrilateral Membrane (QUAD 4, QUAD 8) Element Formulations for in-plane loading with sample problems. Triangular and Quadrilateral Axi-symmetric basic and higher order Elements formulation for axi-symmetric loading only with sample problems.

**Three Dimensional Finite Element Formulations for Solid Mechanics Problems:** Finite Element Formulation of Tetrahedral Element (TET 4, TET 10), Hexahedral Element (HEXA 8, HEXA 20), for different loading conditions. Serendipity and Lagrange family Elements

10 Hours.

4. **Finite Element Formulations for Structural Mechanics Problems:** Basics of plates and shell theories: Classical thin plate Theory, Shear deformation Theory and Thick Plate theory. Finite Element Formulations for triangular and quadrilateral Plate elements. Finite element formulation of flat, curved, cylindrical and conical Shell elements

5. **Dynamic Analysis:** Finite Element Formulation for point/lumped mass and distributed masses system, Finite Element Formulation of one dimensional dynamic analysis: bar, truss, frame and beam element. Finite Element Formulation of Two dimensional dynamic analysis: triangular membrane and axisymmetric element, quadrilateral membrane and axisymmetric element. Evaluation of eigen values and eigen vectors applicable to bars, shaft, beams, plane and space frame.

10 Hours.

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**Text Books:**

**Reference Books:**

**Course Outcome:**
On completion of the course the student will be
1. Knowledgeable about the FEM as a numerical method for the solution of solid mechanics, structural mechanics and thermal problems
2. Developing skills required to use a commercial FEA software
CONTINUUM MECHANICS
(Common to MDE, MEA, MMD, CAE)

Sub Code: 14CAE13
Hrs/ Week: 04
Total Hrs: 50
IA Marks: 20
Exam Hrs: 03
Exam Marks: 80

Course Objective:
The course Continuum Mechanics aims at a comprehensive study of Mechanics of Solids and Mechanics of Fluids. The topics covered are: Analysis of Stress, Deformation and Strain, Generalized Hooke’s law, Formulation of Two Dimensional Electrostatic problems, Basic equations of Viscoelasticity.

Course Content:

1. Analysis of Stress: Definition and Notation for forces and stresses. body force, surface force Components of stresses, equations of Equilibrium, Specification of stress at a point. Principal stresses, maximum and minimum shear stress, Mohr’s diagram in three dimensions. Boundary conditions .Stress components on an arbitrary plane, Stress invariants, Octahedral stresses, Decomposition of state of stress, deviator and spherical stress tensors, Stress transformation. 10 Hours
2. Deformation and Strain: Deformation, Strain Displacement relations, Strain components, The state of strain at a point, , Principal strain, strain invariants, Strain transformation, Compatibility equations, Cubical dilatation, spherical and deviator strains, plane strain, Mohr’s circle, and compatibility equation
3. Relations and the General Equations of Elasticity: Generalized Hooke’s; law in terms of engineering constants. Formulation of elasticity Problems. 12 Hours
4. Two Dimensional Problems in Cartesian Co-Ordinates: Airy’s stress function, investigation of simple beam problems. Bending of a narrow cantilever beam under end load, simply supported beam with uniform load, Use of Fourier series to solve two dimensional problems. 9 Hours.
5. Two Dimensional Problems in Polar Co-Ordinates: General equations, stress distribution symmetrical about an axis, Strain components in polar co-ordinates, Rotating disk and cylinder, Concentrated force on semi-infinite plane, Stress concentration around a circular hole in an infinite plate.
6. Thermal Stresses: Introduction, Thermo-elastic stress-strain relations, thin circular disc, long circular cylinder. 9 Hours
**Elastic Stability:** Axial compression of prismatic bars, Elastic stability, buckling load for column with constant cross section. **Viscoelasticity:** Linear viscoelastic behavior. Simple viscoelastic models-generalized models, linear differential operator equation. Creep and Relaxation- creep function, relaxation function, hereditary integrals. Complex moduli and compliances. (Note: No numerical) 10 Hours

**Text Books:**

**References:**

**Course Outcome:**
Continuum Mechanics background essential to mathematically model physical problems in Solid Mechanics
Course Objective:
This course aims at a comprehensive study of mechanics of solids. The topics covered are
The objective of this course is to familiarize the student with state of the art experimental techniques namely strain gauges, photo elasticity, moiré interferometry, brittle coating, moiré fringes and holography.

Course Content:
1. **Introduction**: Definition of terms, calibration, standards, dimension and units, generalized measurement system, Basic concepts in dynamic measurements, system response, distortion, impedance matching, experiment planning.
   
   **Analysis of Experimental Data**: Cause and types of experimental errors, error analysis. Statistical analysis of experimental data- Probability distribution, gaussian, normal distribution. Chi-square test, Method of least square, correlation coefficient, multivariable regression, standard deviation of mean, graphical analysis and curve fitting, general consideration in data analysis.
   
   **10 Hours**

2. **Data Acquisition and Processing**: General data acquisition system, signal conditioning revisited, data transmission, Analog-to-Digital and Digital-to- Analog conversion, Basic components (storage and display) of data acquisition system. Computer program as a substitute for wired logic.
   
   **Force, Torque and Strain Measurement**: Mass balance measurement, Elastic Element for force measurement, torque measurement. Strain Gages -Strain sensitivity of gage metals, Gage construction, Gage sensitivity and gage factor, Performance characteristics, Environmental effects Strain, gage circuits, Potentiometer, Wheat Stone's bridges, Constant current circuits. Strain Analysis Methods-Two element and three element, rectangular and delta rosettes, Correction for transverse strains effects, stress gage - plane shear gage, Stress intensity factor gage.
   
   **10 Hours**

3. **Stress Analysis**: Two Dimensional Photo elasticity - Nature of light, - wave theory of light,- optical interference - Polariscopes stress optic law - effect of stressed model in plane and circular Polariscopes, IsoclinicsIso chromatics fringe order determination - Fringe multiplication
techniques - Calibration Photoelastic model materials. Separation methods shear difference method, Analytical separation methods, Model to prototype scaling.

4. **Three Dimensional Photo elasticity:** Stress freezing method, General slice, Effective stresses, Stresses separation, Shear deference method, Oblique incidence method Secondary principals stresses, Scattered light photo elasticity, Principals, Polari scope and stress data analyses.


**Holography:** Introduction, Equation for plane waves and spherical waves, Intensity, Coherence, Spherical radiator as an object (record process), Hurter, Driffeld curves, Reconstruction process, Holographicinterferomerty, Realtime. and double exposure methods, Displacement measurement, Isopachics.

**Text Books:**

**Reference Books:**

**Course Outcome:** It helps the students to
1. Undertake experimental investigations to verify predictions by other methods.
2. To acquire skills for experimental investigations an accompanying laboratory course is desirable.
Elective-I

COMPUTER GRAPHICS
(Common to MDE,MEA,MMD,CAE)
Sub Code: 16MDE151  IA Marks: 20
Hrs/ Week: 04    Exam Hours: 03
Total Hrs: 50    Exam Marks: 80

Course Objective:
This course will help the student to be knowledgeable of concepts, principles, processes and techniques essential to all areas of computer graphics.

Course Content:

1. **Transformations**: Representation of points, Transformations: Rotation, Reflection, Scaling, Shearing, Combined Transformations, Translations and Homogeneous Coordinates, A geometric interpretation of homogeneous coordinates, Over all scaling, Points at infinity, Rotation about an arbitrary point, Reflection through an arbitrary line, Rotation about an axis parallel to coordinate axis, Rotation about an arbitrary axis in space, Reflection through an arbitrary plane.  
   **10 Hours**

   **Types and Mathematical Representation of Surfaces** Surface entities and parametric representation- Plane, Ruled, surface of revolution, Offset surface, Coons patch, Bezier surface, B-spline surface  
   **10 Hours**

3. **Types and Mathematical Representation of Solids**
   Solid entities: Block, Cylinder, Cone, Sphere, Wedge, Torus, Solid representation, Fundamentals of solid modeling, Set theory, Regularized set operations, Set membership classification, Half spaces, Basic elements, Building operations, Boundary representation and Constructive solid geometry, Basic elements, Building operations.
**Scan Conversion and Clipping:** Representation of points, lines, Drawing Algorithms: DDA algorithm, Bresenham's integer line algorithm, Bresenham’s circle algorithm, Polygon filling algorithms: Scan conversion, Seed filling, Scan line algorithm. Viewing transformation, Clipping - Points, lines, Text, Polygon, Cohen-Sutherland line clipping, Sutherland-Hodgmen algorithm.


**5. Applications:** Colouring- RGB, CMY, HSV, HSL colour models, Data Exchange: Evolution of Data exchange, IGES, PDES, Animation: Conventional animation-key frame, Inbetweening, Line testing, Painting, Filming, Computer animation, Entertainment and Engineering Animation, Animation system hardware, Software architecture, Animation types, Frame buffer, Colour table, Zoom-pan-scroll, Cross bar, Real time play back, Animation techniques- key frame, Skelton. Path of motion and p-curves.

**TextBooks:**

**ReferenceBooks:**

**Course Outcome:**
This course will enable students to:
1. Recognize how a visual image can be an effective means of communication
2. Acquire and develop the skills needed to creatively solve visual communication problems.
3. Understand, develop and employ visual hierarchy using images and text
COMPUTER APPLICATIONS IN DESIGN  
(Common to MDE, MEA, MMD, CAE)

Sub Code : 16MDE152    IA Marks : 20
Hrs/ Week : 04    Exam Hours : 03
Total Hrs: 50    Exam Marks : 80

Course Objective
It helps the students to learn the principles of CAD/CAM/CAE Systems, Graphics Programming, Geometric Modeling Systems, CAD, CAM and CAE Integration, Standards for Communicating between Systems

Course Content:

1. Introduction To CAD/CAM/CAE Systems


2. Basic Concepts of Graphics Programming:

   Standards

3. Geometric Modeling Systems

   Representation and Manipulation of Curves: Types of Curve Equations, Conic Sections, Circle or Circular Arc, Ellipse or Elliptic Arc, Hyperbola, Parabola, Hermite Curves, Bezier Curve, Differentiation of a Bezier Curve Equation, Evaluation of a Bezier Curve

**Representation and Manipulation of Surfaces:** Types of Surface Equations, Bilinear Surface, Coon’s Patch, Bicubic Patch, Bezier Surface, Evaluation of a Bezier Surface, Differentiation of a Bezier Surface, B-Spline Surface, Evaluation of a B-Spline Surface, Differentiation of a B-Spline Surface, NURBS Surface, Interpolation Surface, Intersection of Surfaces.

5. **CAD and CAM Integration**

**Text Books:**

**Reference Books:**

**Course Outcome:**
Students develop expertise in generation of various curves, surfaces and volumes used in geometric modeling systems.
MECHATRONICS SYSTEM DESIGN
(Common to MDE, MEA, MMD, CAE)

Sub Code : 16MDE153   IA Marks :20
Hrs/ Week : 04          Exam Hours : 03
Total Hrs: 50          Exam Marks :80

Course Objective

1. To educate the student regarding integration of mechanical, electronics, electrical and computer systems in the design of CNC machine tools, Robots etc.
2. To provide students with an understanding of the Mechatronic Design Process, actuators, Sensors, transducers, Signal Conditioning, MEMS and Microsystems and also the Advanced Applications in Mechatronics.

Course Content:


Text Books:

2. HSU “MEMS and Microsystems design and manufacture” - Tata McGraw-Hill Education, 2002

Reference Books:


Course Outcome:
This course makes the student to appreciate multidisciplinary nature of modern engineering systems. Specifically mechanical engineering students to collaborate with Electrical, Electronics, Instrumentation and Computer Engineering disciplines.
Course Objective:

To educate students a clear understanding of factors to be considered in designing parts and components with focus on manufacturability

Course Content:


   Tolerance Analysis: Process capability, mean, variance, skewness, kurtosis, Process capability metrics, Cp, Cpk, Cost aspects, Feature tolerances, Geometries tolerances, Geometric tolerances, Surface finish, Review of relationship between attainable tolerance grades and different machining process. Cumulative effect of tolerance- Sure fit law and truncated normal law. 12 Hours

2. Selective Assembly: Interchangeable part manufacture and selective assembly, Deciding the number of groups -Model-1 : Group tolerance of mating parts equal, Model total and group tolerances of shaft equal. Control of axial play-Introducing secondary machining operations, Laminated shims, examples.

   Datum Features : Functional datum, Datum for manufacturing, Changing the datum. Examples.12 Hours


   Component Design: Component design with machining considerations link design for turning components-milling, Drilling and other related processes including finish- machining operations. 13 Hours

5. Design of Gauges: Design of gauges for checking components in assembly with emphasis on various types of limit gauges for both hole and shaft. **6 Hours**

Text Books:


Course Outcome:

Students will have added capability to include manufacturability in mechanical engineering design of parts and their assemblies.
ADVANCED FLUID DYNAMICS
(Common to MDE,MEA,MMD,CAE)

Sub Code : 16MEA155 IA Marks : 20
Hrs/ Week : 04 Exam Hours : 03
Total Hrs: 50 Exam Marks : 80

Course Objective:
The student will gain knowledge of dynamics of fluid flow under different conditions.


2. **Integral Flow Analysis**: Reynolds transport theorem, Continuity, momentum, moment of momentum, energy equations with applications such as turbo machines, jet propulsion & propellers;

   - **Exact solution of viscous flow equations**: Steady flow: Hagen Poiseuille problem, plane Poiseuille problem, Unsteady flow: Impulsively started plate

   - **12 Hours**

3. **Low Reynolds number flows**: Lubrication theory (Reynolds equation), flow past rigid sphere, flow past cylinder

   - **Boundary Layer Theory**: Definitions, Blasius solution, Von Karman integral, Separation

   - **10 Hours**

4. **Thermal Boundary layer and heat transfer, (Laminar & turbulent flows)**;

   - **Experiments in fluids**: Wind tunnel, Pressure Probes, Anemometers and flow meters

   - **10 Hours**

5. **Special Topics**: Stability theory; Natural and forced convection; Rayleigh Benard problem; Transition to turbulence; Introduction to turbulent flows

   - **10 Hours**

Text Books:

Reference Books:

Course Outcome:
The student will be able to apply concepts of fluid dynamics in solving real time problems.
Design Engineering Laboratory – Lab 1
(Common to MDE, MEA, MMD, CAE, MCS)

Sub Code: 16MDE16  IA Marks: 20
Hrs/ Week: 3  Exam Hours: 03
Total Hrs: 42  Exam Marks: 80

Note:
1) These are independent laboratory exercises
2) A student may be given one or two problems stated herein
3) Student must submit a comprehensive report on the problem solved and give a
   Presentation on the same for Internal Evaluation
4) Any one of the exercises done from the following list has to be asked in the Examination for evaluation.

Course Content:

Experiment #1
Numerically Calculation and MATLAB Simulation
Part A: Invariants, Principal stresses and strains with directions
Part A: Maximum shear stresses and strains and planes, Von-Mises stress
Part C: Calculate and Plot Stresses in Thick-Walled Cylinder

Experiment #2
Stress analysis in Curved beam in 2D
Part A: Experimental studies using Strain Gauge Instrumentation.
Part B: 2D Photo elastic Investigation.
Part C: Modelling and Numerical Analysis using FEM.

Experiment #3
Stress analysis of rectangular plate with circular hole under i. Uniform Tension and ii. shear
Part A: Matlab simulation for Calculation and Plot of normalized hoop Stress at hole boundary in Infinite Plate
Part B: Modelling of plate geometry under chosen load conditions and study the effect of plate geometry.
Part C: Numerical Analysis using FEA package.
Experiment #4
Single edge notched beam in four point bending.
Part A: Modeling of single edge notched beam in four point bending. Part B: Numerical Studies using FEA.
Part C: Correlation Studies.

Experimental #5
Torsion of Prismatic bar with Rectangular cross-section. Part A: Elastic solutions, MATLAB Simulation
Part B: Finite Element Analysis of any chosen geometry. Part C: Correlation studies.

Experiment #6
Contact Stress Analysis of Circular Disc under diametrical compression
Part C: 2D Photo Elastic Investigation.

Experiment #7
Part B: MATLAB Simulation. Part C: Correlation Studies.

Experiment #8
Modelling and Simulation of Control Systems using MATLAB.
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M.TECH. Machine Design

II SEMESTER

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** ELEcTIVE-II

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** Between the II Semester and III Semester, after availing a vacation of 2 weeks.
II Semester

COMPOSITE MATERIALS TECHNOLOGY
(Common to MDE, MEA, MMD, CAE)

Sub Code: 16MST21   IA Marks: 20
Hrs/ Week: 04       Exam Hours: 03
Total Hrs: 50       Exam Marks: 80

Course Objective:
Mechanics of composite materials provides a methodology for stress analysis and progressive failure analysis of laminated composite structures for aerospace, automobile, marine and other engineering applications.

Course Content:

Module 1: Introduction to Composite Materials: Definition, Classification, Types of matrices material and reinforcements, Characteristics & selection, Fiber composites, laminated composites, Particulate composites, Prepegs, and sandwich construction.

Metal Matrix Composites: Reinforcement materials, Types, Characteristics and selection, Base metals, Selection, Applications


10 Hours


Experimental Characterization of Lamina- Elastic Moduli and Strengths

Failure Criteria: Failure criteria for an elementary composite layer or Ply, Maximum Stress and Strain Criteria, Approximate strength criteria, Inter-laminar Strength, Tsai-Hill theory, Tsai, Wu tensor theory, Numerical problem, practical recommendations.

10 Hours

Module 3: Macro Mechanical Analysis of Laminate: Introduction, code, Kirchhoff hypothesis, Classical Lamination Theory, A, B, and D matrices (Detailed derivation), Special cases of laminates, Numerical problems. Shear Deformation Theory, A, B, D and E matrices (Detailed derivation)

10 Hours
Module 4: **Analysis of Composite Structures**: Optimization of Laminates, composite laminates of uniform strength, application of optimal composite structures, composite pressure vessels, spinning composite disks, composite lattice structures. Applications: Aircrafts, missiles, Space hardware, automobile, Electrical and Electronics, Marine, Recreational and sports equipment-future potential of composites. 10 Hours

Module 5: **Manufacturing and Testing**: Layup and curing - open and closed mould processing, Hand lay-up techniques, Bag moulding and filamentwinding. Pultrusion, Pulforming, Thermoforming, Injection moulding, Cutting, Machining, joining and repair. NDT tests – Purpose, Types of defects, NDT method - Ultrasonic inspection, Radiography, Acoustic emission and Acoustic ultrasonic method. 10 Hours

Text Books:

Reference Books:

Course Outcome:
This course provides the background for the analysis, design, optimization and test simulation of advanced composite structures and Components.

Scheme of Examination:
Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.
ADVANCED MACHINE DESIGN
(Common to MDE, MEA, MMD, CAE)

Sub Code : 16MDE22   IA Marks :20
Hrs/ Week : 04       Exam Hours : 03
Total Hrs: 50        Exam Marks :80

Course Objective:
This course enables the student to identify failure modes and evolve design by analysis methodology. Design against fatigue failure is given explicit attention.

Course Content:

Module 1: Introduction: Role of failure prevention analysis in mechanical design, Modes of mechanical failure, Review of failure theories for ductile and brittle materials including Mohr’s theory and modified Mohr’s theory. Numerical examples.

Fatigue of Materials: Introductory concepts, High cycle and low cycle fatigue, Fatigue design models, Fatigue design methods, Fatigue design criteria, Fatigue testing, Test methods and standard test specimens, Fatigue fracture surfaces and macroscopic features, Fatigue mechanisms and microscopic features.  


Module 3: LEFM Approach: LEFM concepts, Crack tip plastic zone, Fracture toughness, Fatigue crack growth, Mean stress effects, Crack growth life estimation.

Notches and their effects: Concentrations and gradients in stress and strain, S-N approach for notched membranes, mean Stress effects and Haigh diagrams, Numerical examples.

10 Hours

10 Hours

10 Hours
Module 4: **Fatigue from Variable Amplitude Loading:** Spectrum loads and cumulative damage, Damage quantification and the concepts of damage fraction and accumulation, Cumulative damage theories, Load interaction and sequence effects, Cycle counting methods, Life estimation using stress life approach. Numerical examples.

**Notch strain analysis:** Strain – life approach, Neuber’s rule, Glinka’s rule, applications of fracture mechanics to crack growth at notches. Numerical examples.  

**Module 5: Surface Failure:** Introduction, Surface geometry, Mating surface, Friction, Adhesive wear, Abrasive wear, Corrosion wear.

**Surface fatigue:** spherical contact, Cylindrical contact, General contact, Dynamic contact stresses, Surface fatigue strength, Surface fatigue failure modes, Design to avoid Surface failures.  

**Text Books:**

**Reference Books:**

**Course Outcome:**
This course enriches the student with state of the art design methodology namely design by analysis and damage tolerant design.

**Scheme of Examination:**
Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.
Course Objective:
To include dynamics considerations in the design of mechanisms for engineering applications is the objective of this course.

Course Content:

Module 1: Geometry of Motion: Introduction, analysis and synthesis, Mechanism terminology, planar, Spherical and spatial mechanisms, mobility, Grashoffs law, Equivalent mechanisms, unique mechanisms.

Kinematic analysis of plane mechanisms: Auxiliary point method using rotated velocity vector, Hall - Ault auxiliary point method, Goodman's indirect method. Numerical examples. 08 Hours


Lagrange's Equation: Lagrange's equation from D'Alembert's principles, Examples, Hamilton's equations, Hamilton's principle, Lagrange's, equation from Hamilton's principle, Derivation of Hamilton's equations, Numerical examples. 12 Hours

Module 3: Synthesis of Linkages: Type, number, and dimensional synthesis, Function generation, Path generation and Body guidance, Precision positions, Structural error, Chebychev spacing, Two position synthesis of slider crank mechanisms, Crank-rocker mechanisms with optimum transmission angle.

Motion Generation: Poles and relative poles, Location of poles and relative poles, polode, Curvature, Inflection circle. Numerical examples. 10 Hours
**Module 4: Graphical Methods of Dimensional Synthesis:** Two position synthesis of crank and rocker mechanisms, Three position synthesis, Four position synthesis (point precision reduction) Overlay method, Coupler curve synthesis, Cognate linkages.

**Analytical Methods of Dimensional Synthesis:** Freudenstein's equation for four bar mechanism and slider crank mechanism, Examples, Bloch's method of synthesis, Analytical synthesis using complex algebra.  

**Module 5: System Dynamics:** Gyroscopic action in machines, Euler's equation of motion, Phase Plane representation, Phase plane Analysis, Response of Linear Systems to transient disturbances.

**Spatial Mechanisms:** Introduction, Position analysis problem, Velocity and acceleration analysis, Eulerian angles. Numerical examples.  

**Text Books:**


**References Books:**


**Course Outcome:**  
The knowledge of dynamics considerations in mechanism design is essential to use commercial multi body dynamics software in mechanical engineering design.  

**Scheme of Examination:**  
Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.
ADVANCED THEORY OF VIBRATIONS
(Common to MDE, MEA, MMD, CAE)

Sub Code: 16MDE24   IA Marks: 20
Hrs/ Week: 04              Exam Hours: 03
Total Hrs: 50                 Exam Marks: 80

Course Objective:
To teach students how to use the theoretical principles of vibration, and vibration analysis techniques, for the practical solution of vibration problems. The course builds on student’s prior knowledge of vibration theory, and concentrates on the applications. The student will understand the importance of vibrations in mechanical design of machine parts subject to vibrations.

Course Content:

Module 1: Review of Mechanical Vibrations: Basic concepts; free vibration of single degree of freedom systems with and without damping, forced vibration of single DOF-systems, Natural frequency.


12 hours


10 hours


Random Vibrations: Random phenomena, Time averaging and expected value, Frequency response function, Probability distribution, Correlation, Power spectrum and power spectral density, Fourier transforms and response.  

10 hours
Module 4: Non Linear Vibrations: Introduction, Sources of nonlinearity, Qualitative analysis of nonlinear systems. Phase plane, Conservative systems, Stability of equilibrium, Method of isoclines, Perturbation method, Method of iteration, Self-excited oscillations. 10 hours

Module 5: Continuous Systems: Vibration of string, longitudinal vibration of rods, Torsional vibration of rods, Euler equation for beams. 08 hours

Text Books

Reference Books

Course Outcome:
At the end of the course the student will be able to solve major and realistic vibration problems in mechanical engineering design that involves application of most of the course syllabus.

Scheme of Examination:
Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.
Elective-II

DESIGN OPTIMIZATION
(Common to MDE, MEA, MMD, CAE)

Sub Code: 16CAE251   IA Marks: 20
Hrs/ Week: 04                  Exam Hours: 03
Total Hrs: 50                   Exam Marks: 80

Course Objective:
It aids the students to acquire the basics of optimum design, Classical Optimization Techniques, Non-linear Programming, Unconstrained Optimization Techniques, Integer Programming and Dynamic Programming.

Course Content:


Optimization Disciplines: Conceptual Design Optimization and Design Fine Tuning, Combined Optimization, Optimization of Multiple Static and Dynamic Loads, Transient Simulations, Equivalent Static Load Methods. Internal and External Responses, Design Variables in Each Discipline.
Module 4: Manufacturability in Optimization Problems: Design For Manufacturing, Manufacturing Methods and Rules, Applying Manufacturing Constraints to Optimization Problems.
Design Interpretation: Unbound Problems, Over Constrained Problems, Problems with No of Multiple Solutions, Active and Inactive Constraints, Constraint Violations and Constraint Screening, Design Move Limits, Local and Global Optimum . 10 Hours

Module 5: Dynamic Programming: Introduction, Multistage decision processes, Principle of optimality, Computational Procedure in dynamic programming, Initial value problem, Examples. 10 Hours

Text Books:

Reference Books:

Course Outcome:
It provides the student with knowledge required to optimize an existing design with single or multiple objective functions. However the skills have to be acquired through commercial optimization programs

Scheme of Examination:
Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.
THEORY OF PLASTICITY

((Common to MDE, MEA, MMD, CAE)

Sub Code : 16MDE252  IA Marks : 20
Hrs/ Week : 04    Exam Hours : 03
Total Hrs: 50       Exam Marks : 80

Course Objective:
This course focuses on stress-strain relations, yield criteria and associated flow rules for elastic-plastic analysis of components and structures.

Course Content:

Module 1: Definition and scope of the subject, Brief review of elasticity, Octahedral normal and shear stresses, Spherical and deviatoric stress, Invariance in terms of the deviatoric stresses, Idealised stress-strain diagrams for different material models, Engineering and natural strains, Mathematical relationships between true stress and true strains, Cubical dilation, finite strains co-efficient, Octahedral strain, Strain rate and the strain rate tensor.  

Module 2: Material Models, Stress-strain relations, Yield criteria for ductile metal, Von Mises, Tresca, Yield surface for an Isotropic Plastic materials, Stress space, Experimental verification of Yield criteria, Yield criteria for an anisotropic material, flow rule normality, Yield locus, Symmetry convexity, Deformation of isotropic and kinematic hardening, bilinear stress-strain relationship, power law hardening, deformation theory of plasticity, J2 flow theory, J2 incremental theory.

Module 3: Plastic stress-strain relations, Prandtl- Rouss Saint Venant, Levy-Von Mises, Experimental verification of the Prandtl- Rouss equation, Upper and lower bound theorems and corollaries, Application to problems: Uniaxial tension and compression, Stages of plastic yielding.

Module 4: Bending of beams, Torsion of rods and tubes, nonlinear bending and torsion equations. Application of metal forming: Drawing and Extrusion process, stresses in drawing and extruding with and without friction.

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Module 5: Slip line theory, Introduction, Basic equations for incompressible two dimensional flow, continuity equations, Stresses in conditions of plain strain convention factors, Slip lines, Geometry of slip lines, Properties of slip lines, Computational Plasticity - Finite element method, Formulations, Plasticity models

Text Books

Reference Books

Course Outcome:
The students learn the theory of plasticity as a background for nonlinear analysis (Material nonlinearity) by the Finite element method.

Scheme of Examination:
Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.
Course Objective:
The course aims at bringing in clear understanding of finite element modeling for simulation of various manufacturing processes.

Course Content:


Formability of Sheet Metals: Evaluation of the Sheet Metal Formability-method based on simulation test and limit dome height diagram, Forming Limit Diagram- definition, experimental determination, methods of determining the limit strain, factors influencing the forming limit, Theoretical Predictions of the Forming Limit Curves, Semi-empirical Model. 10 Hours


Forging: Classification, various stages during forging, Forging equipment, brief description, deformation in compression, forging defects. Residual stresses in forging. 10 Hours

Module 4: Rolling: Classification, forces and geometrical relationships in rolling., Deformation in rolling, Defects in rolled products, Residual stresses in rolled products. Torque and Horsepower.

Drawing and Extrusion: Principles of Rod and wire drawing, variables in wire drawing, Residual stresses in rod, wire and tube drawing, Defects in Rod and
wire drawing. Extrusion equipment, Classification, variables in extrusion, Deformation in extrusion, Extrusion defects, Work done in extrusion. 10 Hours

**Module 5: Composite Materials and Honeycomb Structures:** Manufacturing processes and environmental requirements for manufacturing of composite components, NDT methods and quality control, sandwich structures and adhesive bonding. Heat Treatment Processes: Purpose of heat treatment and theory of heat treatment processes, heat treatment of alloys of aluminum, magnesium, titanium, steel and case hardening. 10 Hours

**Text Books**
3. ASM Metals Handbook –Volume II.

**Reference Books:**

**Course Outcome:**
Students will be able to analyse the behaviour of materials during forming.

**Scheme of Examination:**
Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.
Course Objective:
This course is of interest to turbo machinery designers. Specifically modeling of bearings, shafts and rotor stages (compressors, turbines including blades) to predict instability like whirling including gyroscopic and corialis effect.

Course Content:

Module 1: Fluid Film Lubrication: Basic theory of fluid film lubrication, Derivation of generalized Reynolds equations, Boundary conditions, Fluid film stiffness and Damping coefficients, Stability and dynamic response for hydrodynamic journal bearing, Two lobe journal bearings. Stability of Flexible Shafts: Introduction, equation of motion of a flexible shaft with rigid support, Radial elastic friction forces, Rotary friction, friction independent of velocity, friction dependent on frequency, Different shaft stiffness Constant, gyroscopic effects, Nonlinear problems of large deformation applied forces, instability of rotors in magnetic field. 12 Hours

Module 2: Critical Speed: Dunkerley's method, Rayleigh's method, Stodola's method. Rotor Bearing System: Instability of rotors due to the effect of hydrodynamic oil layer in the bearings, support flexibility, Simple model with one concentrated mass at the center 08 Hours

Module 3: Turborotor System Stability by Transfer Matrix Formulation: General turborotor system, development of element transfer matrices, the matrix differential equation, effect of shear and rotary inertia, the elastic rotors supported in bearings, numerical solutions. 10 Hours

Module 4: Turborotor System Stability by Finite Element Formulation: General turborotor system, generalized forces and co-ordinates system assembly element matrices, Consistent mass matrix formulation, Lumped mass model, linearised model for journal bearings, System dynamic equations Fix stability analysis non dimensional stability analysis, unbalance response and Transient analysis. 12 Hours

Module 5: Blade Vibration: Centrifugal effect, Transfer matrix and Finite element, approaches. 08 Hours
Reference Books:


Course Outcome:

Provides the student understanding of modeling a rotating machine elements theoretically. However rotor dynamic analysis demands FE Modeling using a commercial FEA software

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.
AUTOMOBILE SYSTEM DESIGN
(Common to MDE, MMD, MEA and CAE)

Sub Code : 16 MEA255 IA Marks : 20
Hrs/ Week : 04 Exam Hours : 03
Total Hrs. : 52 Exam Marks : 80

Course Objective:
This course would facilitate understanding of the stages involved in automobile system design. The student will be exposed to industrial practices in design of various systems of an automobile.

Module 1: Body Shapes: Aerodynamic Shapes, drag forces for small family cars.
Fuel Injection: Spray formation, direct injection for single cylinder engines (both SI & CI), energy audit. 12 Hours

Module 2: Design of I.C. Engine I: Combustion fundamentals, combustion chamber design, cylinder head design for both SI & C. I. Engines. 08 Hours

Module 3: Design of I.C. Engine II: Design of crankshaft, camshaft, connecting rod, piston & piston rings for small family cars (max up to 3 cylinders). 10 Hours

Suspension System: Vibration fundamentals, vibration analysis (single & two degree of freedom, vibration due to engine unbalance, application to vehicle suspension. 10 Hours
Module 5: Cooling System: Heat exchangers, application to design of cooling system (water cooled).

Emission Control: Common emission control systems, measurement of missions, exhaust gas emission testing.

Text Books:
1. Design of Automotive Engines, - A. Kolchin & V. Demidov, MIR Publishers, Moscow
2. The motor vehicle, Newton steeds & Garratte - Iliffe & sons Ltd., London

Reference Books:
1. Introduction to combustion - Turns
4. Diesel engine design - Heldt P.M., Chilton company New York.

Course Outcome:
The student will be able to apply the knowledge in creating a preliminary design of automobile sub systems.

Scheme of Examination:
Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.
Design Engineering Laboratory - Lab 2
(Common to MDE, MEA, MMD, CAE, MCS)

Sub Code : 16MDE26    IA Marks : 20
Hrs/ Week : 6        Exam Hours : 03
Total Hrs: 42        Exam Marks : 80

Note:
1) These are independent laboratory exercises
2) A student may be given one or two problems stated herein
3) Student must submit a comprehensive report on the problem solved and give a
   Presentation on the same for Internal Evaluation
4) Any one of the exercises done from the following list has to be asked in the Examination for evaluation.

Course Content:
Experiment #1 Structural Analysis
Part B: Buckling, Bending and Modal analysis of stiffened Panels.
Part C: Parametric Studies.

Experiment #2
Design Optimization
Part A: Shape Optimization of a rotating annular disk.
Part B: Weight Minimization of a Rail Car Suspension Spring.
Part C: Topology Optimization of a Bracket.

Experiment #3
Thermal analysis
Part A: Square Plate with Temperature Prescribed on one edge and Opposite edge insulated.
Part B: A Thick Square Plate with the Top Surface exposed to a Fluid at high temperature, Bottom Surface at room temperature, Lateral Surfaces Insulated.
Experiment #4
Thermal Stress Analysis
Part A: A Thick Walled Cylinder with specified Temperature at inner and outer Surfaces.
Part B: A Thick Walled Cylinder filled with a Fluid at high temperature and Outer Surface exposed to atmosphere.

Experiment#5
CFD Analysis
Part A: CFD Analysis of a Hydro Dynamic Bearing using commercial code.
Part B: Comparison of predicted Pressure and Velocity distributions with Target solutions.
Part C: Experimental Investigations using a Journal Bearing Test Rig.
Part D: Correlation Studies.

Experiment #6
Welded Joints.
Part B : FE Modeling and Failure Analysis .
Part C : Correlation Studies.

Experiment #7
Bolted Joints.
Part B : FE Modeling and Failure Analysis .
Part C : Correlation Studies.

Experiment #8
Adhesive Bonded Joints.
Part B : FE Modeling and Failure Analysis .
Part C : Correlation Studies.
### Course Title
M.TECH. Machine Design

#### III Semester

<table>
<thead>
<tr>
<th>Subject Code</th>
<th>Name of the Subject</th>
<th>Teaching hours/week</th>
<th>Duration of Exam in Hours</th>
<th>Marks for</th>
<th>Total Marks</th>
<th>CREDITS</th>
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<tbody>
<tr>
<td>16MMD31</td>
<td>Seminar / Presentation on Internship (After 8 weeks from the date of commencement)</td>
<td>Lecture</td>
<td>25</td>
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<td>16MMD33</td>
<td>Evaluation and Viva-Voce of Internship</td>
<td>Practical / Field Work / Assignment/ Tutorials</td>
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<td>16MMD34</td>
<td>Evaluation of Project phase -1</td>
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<td>50</td>
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<td><strong>50</strong></td>
<td><strong>150</strong></td>
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</table>

Number of credits completed at the end of III semester: 22 + 22 + 21 = 65

**Note:** Internship of 16 weeks shall be carried out during III semester. Major part of the Project work shall also be carried out during the III semester in consultation with the Guide/s.
Common to Design Engineering (MDE), Engineering Analysis & Design (MEA), Machine Design (MMD), Computer Aided Engineering (CAE)

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
SCHEME OF TEACHING AND EXAMINATION FOR
M.TECH. Machine Design

<table>
<thead>
<tr>
<th>Subject Code</th>
<th>Name of the Subject</th>
<th>Teaching hours/week</th>
<th>Duration of Exam in Hours</th>
<th>Marks for Total Marks</th>
<th>CREDITS</th>
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<tbody>
<tr>
<td>16MMD41</td>
<td>Tribology and Bearing Design</td>
<td>04 - -</td>
<td>03</td>
<td>20 80</td>
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<td>16MMD42X</td>
<td>Elective - 3</td>
<td>03 - -</td>
<td>03</td>
<td>20 80</td>
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<td>16MMD43</td>
<td>Evaluation of Project phase -2</td>
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<td>16MMD44</td>
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<td><strong>Total</strong></td>
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<td><strong>07 - -</strong></td>
<td><strong>06</strong></td>
<td><strong>90 360</strong></td>
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Number of credits completed at the end of IV semester: 22+ 22 + 21 + 20 = 85

Elective -3

<table>
<thead>
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<th>Subject Code under 16MMD42X</th>
<th>Title</th>
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<tbody>
<tr>
<td>16CAE421</td>
<td>Fracture Mechanics</td>
</tr>
<tr>
<td>16MST422</td>
<td>Smart Materials &amp; Structures</td>
</tr>
<tr>
<td>16MDE423</td>
<td>Robust Design</td>
</tr>
<tr>
<td>16MEA424</td>
<td>Computational Fluid Dynamics</td>
</tr>
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</table>

**Note:**
1. Project Phase-1: 6-week duration shall be carried out between 2nd and 3rd Semester vacation. Candidates in consultation with the guide shall carry out literature survey/ visit industries to finalize the topic of Project.
2. Project Phase-2: 16-week duration during 4th semester. Evaluation shall be done by the committee comprising of HoD as Chairman, Guide and Senior faculty of the department.
3. Project Evaluation: Evaluation shall be taken up at the end of 4th semester. Project work evaluation and Viva-Voce examination shall conducted
4. Project evaluation: a. Internal Examiner shall carry out the evaluation for 100 marks. b. External Examiner shall carry out the evaluation for 100 marks. c. The average of marks allotted by the internal and external examiner shall be the final marks of the project evaluation. d. Viva-Voce examination of Project work shall be conducted jointly by Internal and External examiner for 100 marks.
IV Semester
TRIBOLOGY AND BEARING DESIGN
(Common to MDE, MEA, MMD, CAE)

Sub Code: 16MDE41
Hrs/ Week: 04
Total Hrs: 50
IA Marks: 20
Exam Hours: 03
Exam Marks: 80

Course Objective:
Gives in-depth knowledge regarding hydrodynamic, hydrostatic lubrication and various bearings, with their design and applications

Course Content:


Text Books

Reference Books

Course Outcome:
Students develop skills to design and selection of bearings on Various tribological factors to be considered in moving and rotating parts.
Course Objective:
Fracture mechanics provides a methodology for prediction, prevention and control of fracture in materials, components and structures. It provides a background for damage tolerant design. It quantifies toughness as materials resistance to crack propagation.

Course Content:


Module 5. Fatigue crack propagation and applications of fracture mechanics: Crack growth and the stress intensity factor. Factors affecting crack propagation. Variable amplitude service loading. Means to provide fail-safety. Required information for fracture mechanics approach, Mixed mode (combined) loading and design criteria. 08 Hrs
Text Books

Reference Books

Course Outcome:
At the end of the course students will:
1. Develop basic fundamental understanding of the effects of cracklike defects on the performance of aerospace, civil, and mechanical Engineering structures.
2. Learn to select appropriate materials for engineering structures to insure damage tolerance.
3. Learn to employ modern numerical methods to determine critical crack sizes and fatigue crack propagation rates in engineering structures.
4. Gain an appreciation of the status of academic research in field of fracture mechanics.
Course Objective:
Knowledge of smart materials and structures is essential designing mechanical systems for advanced engineering applications, the course aims at training students in smart materials and structures application and analysis.

Course Content:


Text Books

Reference Books

Course Outcome:
At the completion of this course, students will be able to:
1. Understand the behavior and applicability of various smart materials
2. Design simple models for smart structures & materials
3. Perform simulations of smart structures & materials application
4. Conduct experiments to verify the predictions
IV Semester Elective -3
ROBUST DESIGN
(Common to MDE,MEA,MMD,CAE)

Sub Code : 16MDE423
Hrs/ Week : 04
Total Hrs: 50

IA Marks :20
E x a m H o u r s : 0 3
Exam Marks :80

Course Objective:
Course aims at giving orientation to design of experiments and taguchi’s orthogonal array techniques which are predominantly used in optimization of parameters.

Course Content:
Module 1. Quality by Experimental Design : Quality, western and Taguchi quality philosophy, Elements of cost, Noise factors causes of variation, Quadratic loss function and variation of quadratic loss functions. Robust Design : Steps in robust design : parameter design and tolerance design, reliability improvement through experiments, illustration through numerical examples.
Experimental Design: Classical experiments: factorial experiments, terminology, factors. Levels, Interactions, Treatment combination, randomization, 2-level experimental design for two factors and three factors. 3-level experiment design for two factors and three factors, factor effects, factor interactions, Fractional factorial design, Saturated design, Central composite designs, Illustration through numerical examples.


Module 4. Parameter Design and Tolerance Design: Parameter and tolerance design concepts, Taguchi’s inner and outer arrays, Parameter design strategy, Tolerance design strategy, Illustrations through numerical examples.  06 Hrs

Module 5. Reliability Improvement Through Robust Design: Role of S-N ratios in reliability improvement; Case study; Illustrating the reliability improvement of routing process of a printed wiring boards using robust design concepts.  04 Hrs

Text Books

Reference Books

Course Outcome:
After taking this course, a student will:
1. Have knowledge, understanding and the ability to apply methods to analyze and identify opportunities to improve design processes for robustness
2. Be able to lead product development activities that include robust design techniques.
IV Semester  Elective -3  
COMPUTATIONAL FLUID DYNAMICS  
(Common to MDE,MEA,MMD,CAE)

Sub Code : 16MEA424  
Hrs/ Week : 04  
Total Hrs: 50  
IA Marks :20  
Exam Hours : 03  
Exam Marks :80

Course Objective:  
This course would create awareness about the theory behind fluid dynamics computations as applied in analysis tools.

Course Content:  
Module 1.  Basic Concepts - Dimensionless form of equations; Simplified mathematical models; Hyperbolic, Parabolic & Elliptic systems; Properties of numerical solutions (Consistency, Stability, Conservation, Convergence and Accuracy).  
08Hrs

Module 2.  Finite Difference Methods - Discretisation; Boundary conditions; error propagation; Introduction to spectral methods; examples.  
10 Hrs

Module 3  Finite volume method - Surface & volume integrals; Interpolation & differentiation; Boundary conditions; Examples.  
10 Hrs

Module 4.  Gaussian Elimination; LU decomposition; Tridiagonal Systems; Iterative methods; convergence; ADI & other splitting methods.  
Multi-grid method - Coupled equations; Simultaneous solutions, sequential solutions & under relaxation.Non linear systems  
10 Hrs

12 Hrs

Text Books  
1986.
Reference Books

Course Outcome:
The student will be able to analyse and obtain numerical solutions to fluid dynamics problems.