# Scheme and Syllabus
# of
# M.E. Mechanical Engineering

## 1st to 4th Semester

## Applicable to batch 2025-2027

## One Batch One Scheme (OBOS)

## PANJAB UNIVERSITY
## CHANDIGARH

# The Department of Mechanical Engineering

## Vision

To be Fountainhead of Technological solutions for Needs of Society and Industry.

## Mission

1. To impart fundamental engineering skills and knowledge for analysis of engineering problems.
2. To engage with Industry/Society for taking up stimulating problems on merits.
3. To take the project execution to "Minimum Usable Prototype (MUP)" stage/Pilot-testing and secure IP rights.

## Core values

1. 100% coverage of syllabus by faculty.
2. Actual delivery of around 40 lectures for a subject.
3. Delivery of lecture for around 50 minutes by a faculty in a lecture class of one hour.
4. 100% engagement of Tutorials.
5. Presence of faculty in the lab during the entire time of lab class.
6. Regular checking of practical files by faculty.

## Program Educational Objectives (PEO’s)

1. To develop professionals with strong conceptual and practical skills.
2. To enable graduates to acquire research and development competence for implementation at work.
3. To inculcate professional integrity, ethics, responsibility to contribute towards the community for sustainable development.
4. To keep abreast with the latest research in Mechanical Engineering and its applications.

## Program Outcomes (PO’s)

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

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

3.Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program

# Summary of Scheme

| Semester | Contact Hours | Credits |
|---|---|---|
| Semester 1 | 20 | 20 |
| Semester 2 | 20 | 20 |
| Semester 3 | 28 | 18 |
| Semester 4 | 28 | 14 |
| Total | 96 | 72 |

**M.E. Mechanical Engineering**
**First Semester**

| S. No. | Subject Code | Subject Name | Scheme of Teaching | | | Scheme of Examination | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | L-T-P | Contact hrs/week | Credits | Marks | | | | | |
| | | | | | | Theory | | | Practical* | | |
| | | | | | | Internal Assessment | Univ Exam | Total | Internal Assessment | Univ Exam | Total |
| 1. | MME101 | Advanced Engineering Mathematics | 3-1-0 | 4 | 4 | 50 | 50 | 100 | - | - | - |
| 2. | MME102 | Design of Experiments | 3-1-0 | 4 | 4 | 50 | 50 | 100 | - | - | - |
| 3. | MME103 | Advanced Mechanics of Materials | 3-1-0 | 4 | 4 | 50 | 50 | 100 | - | - | - |
| 4. | MME104 | Rapid Manufacturing | 3-1-0 | 4 | 4 | 50 | 50 | 100 | - | - | - |
| 5. | MME105(a-j) | Elective-I | 3-1-0 | 4 | 4 | 50 | 50 | 100 | - | - | - |
| Total | | | | 20 | 20 | 250 | 250 | 500 | - | - | - |

* Practical marks include continuous and end semester evaluation

**M.E. Mechanical Engineering**
**Second Semester**

| S. No. | Subject Code | Subject Name | Scheme of Teaching | | | Scheme of Examination | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Marks | | | | | |
| | | | | | | Theory | | | Practical* | | |
| | | | L-T-P | Contact hrs/week | Credits | Internal Assessment | Univ Exam | Total | Internal Assessment | Univ Exam | Total |
| 1. | MME201 | Continuum Mechanics | 3-1-0 | 4 | 4 | 50 | 50 | 100 | - | - | - |
| 2. | MME202 | Advanced Manufacturing Processes | 3-1-0 | 4 | 4 | 50 | 50 | 100 | - | - | - |
| 3. | MME203 | Advances in Engineering Materials | 3-1-0 | 4 | 4 | 50 | 50 | 100 | - | - | - |
| 4. | MME204 | Structural Dynamics | 3-1-0 | 4 | 4 | 50 | 50 | 100 | - | - | - |
| 5. | MME205(a-h) | Elective-II | 3-1-0 | 4 | 4 | 50 | 50 | 100 | - | - | - |
| Total | | | | 20 | 20 | 250 | 250 | 500 | - | - | - |

* Practical marks include continuous and end semester evaluation

**M.E. Mechanical Engineering**
**Third Semester**

| S. No. | Subject Code | Subject Name | Scheme of Teaching | | | Scheme of Examination | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Marks | | | | | |
| | | | | | | Theory | | | Practical* | | |
| | | | L-T-P | Contact hrs/week | Credits | Internal Assessment | Univ Exam | Total | Internal Assessment | Univ Exam | Total |
| 1 | MME301 | Advanced Machine Design | 3-1-0 | 4 | 4 | 50 | 50 | 100 | - | - | - |
| 2 | MME302(a-f) | Elective-III | 3-1-0 | 4 | 4 | 50 | 50 | 100 | - | - | - |
| 3 | MME353 | Preliminary Thesis | - | 20 | 10 | - | - | - | 250 | - | 250 |
| Total | | | | 28 | 18 | 100 | 100 | 200 | 250 | - | 250 |

*Marks will be awarded by internal institution committee

## M.E. Mechanical Engineering
## Fourth Semester

| S. No. | Subject Code | Subject Name | Scheme of Teaching | | | Scheme of Examination | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Marks | | | | | |
| | | | L-T-P | Contact hrs/week | Credits | Theory | | | Practical* | | |
| | | | | | | Internal Assess ment | Univ Exam | Total | Internal Assess ment | Univ Exam | Total |
| 1 | MME451 | Thesis work | - | 28 | 14 | - | - | - | 175 | 175 | 350 |
| Total | | | | 28 | 14 | | | | 175 | 175 | 350 |

*Marks will be awarded by internal institution committee

**For Internal assessment only**

M.E. Thesis grade will be awarded as

| S. No. | Grade | Requirement |
|---|---|---|
| 1 | A+ | Publication in SCI/ SCI-E Journal/ E-SCI Journal/Patent |
| 2 | A | Publication in Scopus |
| 3 | B+ | Paper presented in International conference |
| 4 | B | Paper presented in National conference |

**For External Evaluation**

Grade as awarded by examiner

**Final Grade for thesis**

The grade awarded in internal assessment and grade awarded in external assessment are combined and averaged and then final grade is awarded.

## Elective-1 Courses in Semester 1

1. MME105(a) Quality Control and Reliability
2. MME105(b) Manufacturing Science
3. MME105(c) Welding Techniques
4. MME105(d) Tool and Cutter Design
5. MME105(e) Condition Monitoring and Fault Diagnosis
6. MME105(f) Advanced Heat Transfer
7. MME105(g) Gas Dynamics
8. MME105(h) Introduction to Modern Fortran
9. MME105(i) Industrial Tribology
10. MME105(j) Design of Biomedical Devices and Systems

## Elective-II Courses in Semester 2

1. MME205 (a) Fluid Dynamics
2. MME205 (b) Experimental Stress Analysis
3. MME205 (c) Mechanical Behavior of Materials
4. MME205 (d) Composite Materials
5. MME205 (e) Model Updating
6. MME205 (f) Mechatronics
7. MME205 (g) Advanced Control System
8. MME205 (h) Imaging and Additive Manufacturing

## Elective-III Courses in Semester 3

1. MME302(a) Modeling of Manufacturing Systems
2. MME302(b) Finite Element Method
3. MME302(c) Computational Fluid Dynamics
4. MME302(d) Vibration Testing
5. MME302(e) Optimization Techniques
6. MME302(f) Materials Design

| | |
|---|---|
| **Course Code** | **MME101** |
| **Course Title** | **Advanced Engineering Mathematics** |
| **Type of Course** | Core |
| **L T P** | 3 1 0 |
| **Credits** | 4 |
| **Course Assessment Methods**<br>End Semester Assessment (University Exam.)<br>Continuous Assessment (Sessional, Assignments, Quiz) | <br>50<br>50 |
| **Course Prerequisites** | Calculus, Differential Equations |
| **Course Objectives** | 1. Acquire the knowledge of special functions and their properties<br>2. The applications and usefulness of special functions in various engineering problems<br>3. Solution of ordinary and partial differential equations using an appropriate numerical method.<br>3. Implementation of numerical methods for a variety of multidisciplinary applications. |
| **Course Outcomes** | 1.Adequate knowledge of the power series method to find an analytical solution of differential equations and special functions that arise from the method.<br>2. Familiarize with derivations of various properties of special functions (Legendre polynomials and Bessel functions) and their recurrence relations.<br>3. Numerical methods for solving ordinary and partial differential equations.<br>3. Approximate solutions to otherwise intractable physical engineering problems using numerical techniques. |

**SYLLABUS**

***Note for Examiner***- *The examiner shall set 8 questions i.e., 4 from each part and students shall be required to attempt a total of 5 questions with at least 2 questions from each part.*

## SECTION-A

Series solution of differential equations, Power series methods, Legendre's polynomial, Generating functions, Recurrence relations. Frobenius method, Series solution of Bessel's differential equation, Modified Bessel's functions, Generating functions, Recurrence relations.Equations reducible to Bessel's equation. Sturm Liouville's problem, orthogonal functions, Orthogonality of eigenfunctions, Eigenfunction expansions.

## SECTION-B

Numerical solutions of simultaneous and higher order differential equations: Runge-Kutta method, Picard's method. Approximate methods for B.V. problems: Finite difference method.
Approximate and numerical solutions of PDE's: Finite difference approximation to derivatives.
Numerical solutions of elliptic equations (Laplace and Poisson's equations), Parabolic equations and Hyperbolic equations.

| **RECOMMENDED BOOKS** | | | |
|---|---|---|---|
| | **NAME** | **AUTHOR(S)** | **PUBLISHER** |
| 1 | Advanced Engineering Mathematics | Kreyszig, Erwin | John Wiley |
| 2 | Numerical Solution of Differential Equations | Jain, R.K. | New Age International Publishers |
| 3 | Introductory Methods of Numerical Analysis, | Sastry, S.S. | Prentice Hall of India |
| 3 | Numerical Methods for Scientific and Engineering Computation | Jain, M. K., Iyengar, S. R. K., Jain, R. K. | New Age International Publishers |
| 5 | Numerical Methods for Engineers | Steven C. Chapra, Raymond P. Canale | Tata McGraw Hill |
| 6 | Elementary Differential Equations and Boundary Value Problems | William E. Boyce, Richard C. DiPrima: | John Wiley |

| | |
|---|---|
| **Course Code** | **MME102** |
| **Course Title** | **Design of Experiments** |
| **Type of Course** | Core |
| **L T P** | 3 1 0 |
| **Credits** | 4 |
| **Course Assessment Methods**<br>End Semester Assessment (University Exam.)<br>Continuous Assessment (Sessional, Assignments, Quiz) | <br>50<br>50 |
| **Course Prerequisites** | Calculus, Linear Algebra, Introductory Probability and Statistics |
| **Course Objectives** | The course objective is to learn how to plan, design and conduct experiments efficiently and effectively, and analyze the resulting data to obtain objective conclusions. Both design and statistical analysis issues are discussed. |
| **Course Outcomes** | 1. Introduction of the experimental Design<br><br>2. Understanding the optimization using Response Surface Methodology<br><br>3. Understanding the optimization using Taguchi Philosophy |

## SYLLABUS

***Note for Examiner****- The examiner shall set 8 questions i.e., 4 from each part and students shall be required to attempt a total of 5 questions with at least 2 questions from each part.*

## SECTION-A

**Introduction:**

Strategy of experimentation, Some typical applications of experimental design, Basic principles, Guidelines for designing experiments, A brief history of statistical design, Using statistical design in experimentation

**Simple Comparative Experiments:**

Introduction, Basic statistical concepts, Sampling and sampling Distribution, Inferences about the Differences in means, randomized designs, Paired comparison Designs, Inferences about the Variances of Normal Distributions

**Introduction To Factorial Design:**
Basic definition and principles, Advantages of factorials, The two factor factorial design, General factorial design, Fitting response curves and Surfaces, Blocking in a factorial design
2k and 3k factorial designs Introduction, analysis of the 2k factorial design and 3k factorial design, related problems
Confounding Introduction, confounding in the 2k and 3k factorial design, partial confounding, related problems
Fractional factorial designs Introduction, fractional replication of the 2k factorial design-one-half, one-quarter and the general 2k-p fractional factorial design, design of resolution III, IV and V, related problems

**SECTION-B**

**Regression analysis**
Introduction, simple linear regression, hypothesis testing in simple linear regression, interval testing in simple linear regression, model adequacy checking-residual analysis, the lack-of-fit test, the coefficient of determination, Multiple linear regression, hypothesis testing in multiple linear regression, other linear regression models. Related problems

**Taguchi Method Of Design Of Experiments:**
Concept design, Parameter design, Tolerance design, Quality loss function, Signal-to-Noise ratio, Orthogonal array experiments, Analysis of Mean (ANOM), Quality characteristics, Selection and testing of noise factors, Selection of control factors, Parameter optimization experiment, Parameter design case study.

**Response surface methodology**
Introduction, the method of steepest ascent, analysis of quadratic models, response surface designs-designs for fitting the 1st order and 2nd order models, related problems

**Analysis of Variance (ANOVA):**
Introduction, Example of ANOVA process, Degrees of freedom, Error variance and pooling, Error variance and application, Error variance and utilizing empty columns, the F-test (12 Hrs)

| **TEXT BOOKS** | | | |
|---|---|---|---|
| **S. No.** | **NAME** | **AUTHOR(S)** | **PUBLISHER** |
| 1 | Introduction to Linear Regression Analysis | Montgomery D.C., Runger G.C., | John Wiley |
| **RECOMMENDED BOOKS** | | | |

| | | | |
|---|---|---|---|
| 1 | Process and Product Optimization Using Designed Experiments | Myers R.H. and Montgomery D.C | John Wiley |
| 2. | Introduction to Quality Engineering | Taguchi , G | UNIPUB,WhitePlains,New York |

| | |
|---|---|
| **Course Code** | **MME103** |
| **Course Title** | **Advanced Mechanics of Materials** |
| **Type of Course** | Core |
| **L T P** | 3 1 0 |
| **Credits** | 4 |
| **Course Assessment Methods**<br>End Semester Assessment (University Exam.)<br>Continuous Assessment (Sessional, Assignments, Quiz) | <br>50<br>50 |
| **Prerequisites** | Mechanics of Materials |
| **Course Objectives** | 1. Ability to understand extension of elementary theories to more general settings.<br>2.Ability to make and understand simplifying assumptions about kinetics and kinematics so as to reduce PDEs of the general theory to ODEs.<br>3. Use FEM to find approximate solutions to BVP which otherwise would be difficult or impossible to solve. |
| **Course Outcomes** | 1. Demonstrate the ability to apply theory to specific practical situations.<br>2. Understand types of Failure and specific criteria for design decisions.<br>3. Develop rudimentary understanding of numerical methods to solve solid mechanics problems. |

## SYLLABUS

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## SECTION-A

**Stress, Strain, Stress-Strain Relations, and Introductory Elasticity**
Stress, Stress Tensor,2D and 3D Stress and Mohr Circle.Strain, Equations of Compatibility, Strain Measurement.Stress-Strain Relations, Hooke’s Law, Poisson’s Ratio. Strain Energy, Strain Energy for Common Structural Members, Components of

Strain Energy, Saint-Venant's Principle. Plastic Deformation, Simple Tension True Stress-True Strain curve and Instability, Plastic Stress-Strain Relations, Plastic Stress-Strain Increment Relations. Plane Stress Problems, Plane Stress Problems, Airy Stress Function, Solution of Elasticity Problem, Thermal Stresses, Stress due to Concentrated Load, Stress Concentration, Contact Stress.

**Failure Criteria**
Failure by and Criteria for Yielding and Fracture, Failure Theories: Max. Shearing Stress, Max. Distortion Energy, Octahedral Shearing Stress, Max. Principal Stress, Mohr's, Coulomb-Mohr; Fracture Mechanics, Failure Criteria for Metal Fatigue, Fatigue Life, Impact Load, Dynamic and Thermal Effects.

**Torsion of Prismatic Bars**
Elementary Theory, General Solution of Torsion Problem, Prandtl'sStress Function and Membrane Analogy, Torsion of Thin-walled Members: Open Cross-section, Multiply Connected, Restrained; Fluid Analogy and Stress Concentration, Curved Circular Bars, Helical Springs. Elastic-Plastic Torsion.

**Beams, Plates, and Shells**
Beams: Exact and Approximate Solutions, Curved Beams. Beams on Elastic Foundations: Infinite, Semi-infinite, Finite Beams, Beams Supported by equally Spaced Elastic Elements, Finite Difference Solutions. Thin Plates: Basic Assumptions and Relations, Boundary Conditions, Simply Supported Rectangular Plates, Axisymmetrically Loaded Circular Plates, Deflection by Energy Method, Finite Element Solution. Thin Shells: Basic Assumptions, Membrane Action, Shells of Revolution, Cylindrical Shells of General Shape.

(12 hours)

**SECTION-B**

**Numerical Methods**
Finite Differences and Equations, Curved Boundaries, Boundary Conditions, Finite Element Method, Properties of a Finite Element, Formulation of the Finite Element Method, Triangular Element, Use of Digital Computers.

**Axisymmetrically Loaded Members**
Thick-walled Cylinders, Max. Tangential Stress, Failure Theories, Compound Cylinders, Perfectly Plastic Thick-Walled Cylinders. Rotating Disks: Constant and Variable Thickness, Uniform Stress; Elastic-Plastic Stresses in Rotating Disks, Thermal Stresses in Thin Disks and Long Cylinders, Finite Element Solution.

**Energy Methods**
Work done in Deformation,Theorems: Reciprocity, Castigliano, Crotti-Engesser; Statically Indeterminate Systems, Principles: Virtual work, Minimum Potential Energy; Rayleigh-Ritz Method.

**Elastic Stability**

Critical Load, Buckling of Column, End Conditions, Critical and Allowable Stress, Initially Curved, Eccentrically Loaded and Secant Formula, Energy Methods, Finite Differences Solution.

(12 hours)

| **TEXT BOOKS** | | | |
|---|---|---|---|
| **S. No.** | **NAME** | **AUTHOR(S)** | **PUBLISHER** |
| 1 | Advanced Strength and Applied Elasticity | Ugural and Fenster | Prentice Hall, 2003 |
| 2 | Advanced Mechanics of Material | Boresi and Schmidt | Wiley, 1993 |
| 3 | Advanced Strength and Applied Stress Analysis | Budynas | McGrawHill, 1999 |

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|---|---|
| **Course Code** | MME104 |
| **Course Title** | Rapid Manufacturing |
| **Type of Course** | Core |
| **L T P** | 3 1 0 |
| **Credits** | 4 |
| **Course Assessment Methods**<br>End Semester Assessment (University Exam.)<br>Continuous Assessment (Sessional, Assignments, Quiz) | <br>50<br>50 |

## SYLLABUS

***Note for Examiner***- *The examiner shall set 8 questions i.e., 4 from each part and students shall be required to attempt a total of 5 questions with at least 2 questions from each part.*

### SECTION-A

1. **Introduction to Rapid Manufacturing:** Definition, Characteristics, Feature based manufacturing, Advantages, Applications
2. **Product Design Process:** Product, Product design, Design thinking as the foundation for design process, User analysis, Product research, User interaction with product, Prototyping, Testing and validation
3. **Design for Modularity:** Modular and non-modular design, Components and fabrication for modular design products, Benefits of modularity in product design, Modularity approach in product designing, Five elements of modular design
4. **Reverse Engineering:** 3 stages of reverse engineering, 6 steps of reverse engineering with examples, Computer integrated manufacturing, 3D measurements and laboratory demonstration

### SECTION-B

5. **Polymerization and Powder based RM processes:** Polymerization in additive manufacturing, Vat polymerization types, powder bed fusion process, Process optimization, principle and properties, Strength and weakness, Applications
6. **Liquid based and Sheet stacking RM processes:** Materials, Process principle and applications, Process optimization

7. **Beam Deposition RM processes and materials in RM:** Direct metal laser sintering, SLM, principles and applications, process optimization

8. **Post-processing and Costing in RM:** Meaning and need of post processing, Post processing operations/ techniques in additive manufacturing, Product costing, Material selection

| **TEXT BOOKS** | | | |
|---|---|---|---|
| **S. No.** | **NAME** | **AUTHOR(S)** | **PUBLISHER** |
| 1 | Additive Manufacturing Technologies | I Gibson, D Rosen, B Stucker | Springer |
| 2 | Additive Manufacturing | C.P. Paul , A.N. Jinoop | McGraw Hill |
| 3 | Additive Manufacturing: Applications and Innovations | R. Singh, and JP Davim | CRC Press |
| 4 | 3D Printing and Design; | Sabrie Soloman | Khanna Publishing |

| | |
|---|---|
| **Course Code** | **MME201** |
| **Course Title** | **Continuum Mechanics** |
| **Type of Course** | Core |
| **L T P** | 3 1 0 |
| **Credits** | 4 |
| **Course Assessment Methods**<br>End Semester Assessment (University Exam.)<br>Continuous Assessment (Sessional, Assignments, Quiz) | <br>50<br>50 |
| **Course Prerequisites** | Mechanics of Materials, Fluid Mechanics, and Vector Calculus |
| **Course Objectives** | 1. Provide students with necessary continuum theory to pursue a formal course in advanced solid mechanics and fluid mechanics.<br>2. Mastering the contents of this course will provide the necessary foundation to make the student a skilled user of advanced design tools that use nonlinear kinematics and Finite Elements.<br>3. Provide understanding with respect to restrictions on constitutive equations. |
| **Course Outcomes** | 1. Ability to tackle modern literature in the field of mechanics of materials.<br>2. Ability to intelligently use modern numerical analysis tools.<br>3. Ability to pursue studies in various areas of solid and fluid mechanics. |

## SYLLABUS

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## SECTION-A

**Introduction -** What is Continuum Mechanics?

**Tensors –** Indicial notation, Tensor Algebra, Tensor Calculus, Curvilinear Coordinates

**Kinematics of a Continuum -** Description of motions of a continuum, Kinematic equation for rigid body motion, Infinitesimal deformation, Infinitesimal rotation tensor, rate of deformation and spin tensor, Conservation of mass, Compatibility conditions for infinitesimal strain and rate of deformation components, Deformation gradient, local rigid body motion, Finite deformation, Polar decomposition theorem, Stretch and Rotation tensors, Right Cauchy-Green, Lagrangian strain tensor, Left Cauchy-Green, Eulerian strain tensor, Change of area and volume due to deformation, Components of deformation tensors in other coordinates, Current configuration as the reference configuration

**Stress –** Stress Tensor, Symmetry-Principle Of Moment Of Momentum, Equations Of Motion-Principle Of Linear Momentum, Boundary Condition , Piola Kirchhoff Stress Tensors, Equations Of Motion w.r.t. Reference Configuration, Stress Power, Heat Flow, Energy Equation, Entropy Inequality, Integral Formulations of the General Principles of Mechanics.

**SECTION-B**

**Elastic Solid –** Isotropic Linear Elastic Solid, Anisotropic Linear Elastic Solid, Isotropic Solid under Large Deformation.

**Newtonian Viscous Fluid** – Fluids, Compressible and Incompressible Fluids, Newtonian Fluids, Interpretation of $\lambda$ and $\mu$, Incompressible Newtonian Fluid, Navier-Stokes Equations for Incompressible Fluids, Boundary Conditions, Streamline, Pathline, Steady, Unsteady, Laminar, and Turbulent Flow. Plane Couette Flow, Plane Poiseuille Flow, Hagen-Poiseuille Flow, Dissipation Functions for Newtonian Fluids, Energy Equation For A Newtonian Fluid, Vorticity Vector, Irrotational Flow, Concept Of A Boundary Layer, Compressible Newtonian Fluid, Energy Equation In Terms Of Enthalpy, Acoustic Wave.

**Reynolds Transport Theorem and Applications –** Green's Theorem, Divergence Theorem, Integrals Over A Control Volume And Integrals Over A Material Volume, The Reynolds Transport Theorem, The Principle Of Conservation Of Mass, The Principle Of Linear Momentum, Moving Frames, A Control Volume Fixed With Respect To A Moving Frame,The Principle Of Moment Of Momentum, The Principle Of Conservation Of Energy, The Entropy Inequality: The Second Law Of Thermodynamics.

**Non-Newtonian Fluids –** Linear Maxwell Fluid, Relaxation Spectra; Nonlinear Viscoelastic Fluid, Relative Deformation Tensor; Viscometric Flow, Channel Flow, Couette Flow.

| **TEXT BOOKS** | | | |
|---|---|---|---|
| **S. No.** | **NAME** | **AUTHOR(S)** | **PUBLISHER** |
| 1 | Continuum Mechanics | Lai, Rubin, and Krempl. | Elsevier, 2010 |
| **RECOMMENDED BOOKS** | | | |

| | | | |
|---|---|---|---|
| 1 | Continuum Mechanics | Malvern | Pearson, 1966 |
| 2. | Mechanics and Thermodynamics of Continua | Gurtin, Fried, Anand | Cambridge, 2010 |
| 3. | Continuum Mechanics for Engineers | Mase and Mase | CRC, 1999 |
| 4. | Continuum Mechanics – A concise Theory | Chadwick | Dover, 1976 |
| 5. | Fundamentals of Continuum Mechanics | Bechtel | Springer, 2014 |

| | |
|---|---|
| **Course Code** | **MME202** |
| **Course Title** | **Advanced Manufacturing Processes** |
| **Type of Course** | Core |
| **L T P** | 3 1 0 |
| **Credits** | 4 |
| **Course Assessment Methods**<br>End Semester Assessment (University Exam.)<br>Continuous Assessment (Sessional, Assignments, Quiz) | <br>50<br>50 |
| **Course Prerequisites** | Manufacturing Processes, Manufacturing Technology, Mechanical Engineering Drawing |
| **Course Objectives** | 1.The objective of the course is to provide the students the knowledge of modern manufacturing processes such as Ultrasonic machining, Abrasive machining processes, Electrochemical machining, Electro discharge machining & their modifications into hybrid processes.<br>2. This course alsoA introduce them to advanced topics such as Laser beam welding/machining, Electron beam welding/machining & state of art in various research are |
| **Course Outcomes** | 1. Understanding the need and importance of non conventional manufacturing processes<br>2. Understanding the different non conventional manufacturing processes<br>3. Understanding the construction, working, input and output process controlling parameters and their effect for various non conventional processes |

**SYLLABUS**

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**SECTION-A**

**Introduction:**
Classification, Advantages & limitations of non conventional machining, Hybrid Machining, Ultrasonic machining (USM)-Principle of operation, process details, applications and advantages, limitations of USM.

**Abrasive and Water Jet Machining:**
Basic principle, mechanism of material removal, working principle of Abrasive jet machining (AJM), water jet machining (WJM), merits & demerits, application.

**Chemical Machining (CM):**
Working principle, process characteristics, procedures, advantages & disadvantages of chemical machining.

## SECTION-B

**Thermal Metal Removal Processes:**
Working principles, Mechanism of material removal, process parameters, advantages & limitations, applications of processes like electric discharge machining(EDM), Electron Beam Machining (EBM), Ion beam machining (IBM), Plasma arc machining (PAM), Laser beam machining(LBM).

**Electrochemical Processes:**
Fundamentals, details of machining setup, materials and selection of tools, applications, Concept of others processes like ECG, Electrochemical deburring etc.

| **TEXT BOOKS** | | | |
|---|---|---|---|
| **S. No.** | **NAME** | **AUTHOR(S)** | **PUBLISHER** |
| 1 | Advanced Machining Processes, | V K Jain | Allied |
| 2. | Unconventional machining Methods | Benedict | McGraw-Hill |
| 3 | Production Technology | HMT | TMH |
| 4 | Non Convectional Machining | M. Adithan | John Wiley |
| 5. | Non Conventional Machining | P.K.Mishra | Narosa |
| 6. | Modern machining process | Shan &Pandey | TMH |

| | |
|---|---|
| **Course Code** | **MME203** |
| **Course Title** | **Advances In Engineering Materials** |
| **Type of Course** | Core |
| **L T P** | 3 1 0 |
| **Credits** | 4 |
| **Course Assessment Methods**<br>End Semester Assessment (University Exam.)<br>Continuous Assessment (Sessional, Assignments, Quiz) | <br>50<br>50 |
| **Course Prerequisites** | Material Science |
| **Course Objectives** | To learn about characterisation of materials and advanced materials |
| **Course Outcomes** | 1. Understanding of different materials characterization techniques<br>2. Analysis and interpretation of the properties of materials<br>3. Understanding of scope and applications of advanced materials |

## SYLLABUS

***Note for Examiner**- The examiner shall set 8 questions i.e., 4 from each part and students shall be required to attempt a total of 5 questions with at least 2 questions from each part.*

## SECTION-A

**Selection of materials:** Service requirement, Structure-Property correlations and reappraisal of the role of crystal structure and structural defects on properties.

**Material Characterization:-** Stereographic Projections, X-ray diffraction, crystal structure and phase identification, residual stress measurement and other applications.

**Thermal Analysis Techniques:** Outline of thermal analysis, technique, description of DTA/DSC/TGA techniques and instrumentation, applications, and case studies

**Optical microscopy:** light optics, microscope components, possibilities, and limitations.

**Scanning Electron Microscopy :** Optics and performance of a SEM, Image interpretation, crystallographic information in a SEM, analytical microscopy

**Scanning Tunneling Microscopy:** Construction and operation, Image interpretation

**Transmission Electron Microscopy:** Construction and operation of a TEM, Electron Diffraction and image interpretation.

**SECTION-B**

**Synthetic materials**: Classifications and structure of polymers, class transition temperature, mechanical properties of polymers. Artificial and synthetic materials.
Nano materials: Classification, the structure, methods of their production, their properties and their sphere of applications.

**Smart materials**: Shape Memory Alloys, Varistors and Intelligent materials for bio-medical uses including poly-acrylates, ABS plastics, polymethacrylates, nylon and teflon. Applications and development of these materials.

| **TEXT BOOKS** | | | |
|---|---|---|---|
| **S. No.** | **NAME** | **AUTHOR(S)** | **PUBLISHER** |
| 1 | Callister'sMaterials Science and Engineering | William D. Callister | John Wiley India Pvt. Ltd., 2010 |
| 2. | Engineering Material Technology | James A. Jacobs & Thomas F. Kilduff. | Prentice Hall, 2005. |
| 3 | Foundations of Materials Science and Engineering | William F. Smith. | McGraw Hill. |
| 4 | Materials characterization techniques | Sam Zhang; L Li; Ashok Kumar | CRC Press, 2009 |

| | |
|---|---|
| **Course Code** | **MME204** |
| **Course Title** | **Structural Dynamics** |
| **Type of Course** | Core |
| **L T P** | 3 1 0 |
| **Credits** | 4 |
| **Course Assessment Methods**<br>End Semester Assessment (University Exam.)<br>Continuous Assessment (Sessional, Assignments, Quiz) | <br>50<br>50 |
| **Course Prerequisites** | No prerequisites |
| **Course Objectives** | 1. To understand basics of structural dynamics<br><br>2. To solve governing equations of undamped and damped SDOF systems<br><br>3. To develop finite element model of simple mechanical system<br><br>4. To evaluate dynamic responses such as natural frequencies, mode-shapes and FRFs |
| **Course Outcomes** | 1. Ability to recognize the fields where structural dynamics knowledge can be applicable<br><br>2. Ability to analyze the behavior of different types of SDOF systems under different working conditions<br><br>3. Ability to formulate structural dynamic finite element model problem of simple mechanical system<br><br>4. Ability to post-process the FE models to predict dynamic responses |

## SYLLABUS

***Note for Examiner**- The examiner shall set 8 questions i.e., 4 from each part and students shall be required to attempt a total of 5 questions with at least 2 questions from each part.*

## SECTION-A

**Basic concepts:**
Introduction to structural dynamics; Modeling of structural components and systems; FE route of structural dynamics and its limitations; Experimental route of structural dynamics and its limitations; Understanding structural dynamics in time domain versus frequency domain. Spring-mass model; Free vibrations of SDOF, 2-DOF and MDOF system; Dynamic matrix equation; Eigenvalues; Eigenvectors; Modeshapes; Orthogonality of normal modes; Damping ratios; Drive point and cross frequency response functions; Receptance, Mobility, Accelerance, Real modes, Complex modes.

**SDOF system:**
Degrees of freedom; Undamped system; Springs in parallel or in series; Newton's law of motion; Free body diagram; D' Alembert's principle; Solution of differential equation of motion; Frequency and period; Amplitude and motion.Proportional versus non-proportional damping; Equation of motion; Analysis of critically damped system; Analysis of under-damped system; Analysis of over-damped system. Harmonic excitation for undamped and damped systems; Evaluation of damping at resonance; Bandwidth method to evaluate damping; Energy dissipated by viscous damping; Equivalent viscous damping; Response to support motion; Force transmitted to foundation; Seismic instruments; Response of SDOF system to harmonic loading. Nonlinear SDOF model; Integration of the nonlinear equation of motion; Constant acceleration method; Linear acceleration step-by-step method; The Newmark beta method.

## SECTION-B

**Introduction to finite element method:**
Types of finite elements; Types of loading; Element division; Element connectivity; Linear shape functions; Isoparametric formulation of shape functions; Types of shape functions; Development of elemental stiffness matrix; Assembly of global stiffness matrix; Development of elemental body force vector; Development of elemental traction force vector; Assembly of global load vector; Development of elemental mass matrix; Assembly of global mass matrix.

**Structural dynamic analysis of beams using MATLAB:**
Flexural vibrations of uniform beams; Solution of equation of motion in free vibration; Natural frequencies and mode-shapes for uniform beams with both ends simply supported, both ends free, both ends fixed, one end fixed and other end free, one end fixed and other end simply supported; Orthogonality condition between normal modes.

| TEXT BOOKS | | | |
|---|---|---|---|
| **S. No.** | **NAME** | **AUTHOR(S)** | **PUBLISHER** |
| 1 | Structural Dynamics Theory and Computation | Mario Paz and William Leigh | Kluwer Academic Publisher, 2004 |
| 2. | Fundamentals of Structural Dynamics | R. Craig and Andrew Kurdila | John Wiley and Sons, 2006 |
| 3 | Dynamics of Structures | J. L. Humar | Balkema Publishers, Edition 2002 |
| 4 | Structural Dynamics for Engineers | Hans Anton Buchholdt | Thomas Telford Publishers, 1997 |

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|---|---|
| **Course Code** | **MME301** |
| **Course Title** | **Advanced Machine Design** |
| **Type of Course** | Core |
| **L T P** | 3 1 0 |
| **Credits** | 4 |
| **Course Assessment Methods**<br>End Semester Assessment (University Exam.)<br>Continuous Assessment (Sessional, Assignments, Quiz) | <br>50<br>50 |
| **Course Prerequisites** | No prerequisites |
| **Course Objectives** | 1. To study and apply principles of fatigue, surface failure, impact, vibration and thermal aspects in designing the products<br>2. To study and apply principles of accelerated life testing<br>3. To study and apply principles of optimization techniques |
| **Course Outcomes** | 1. Ability to design products considering fatigue, surface failure, impact, vibration and thermal aspects<br>2. Ability to predict expected life and reliability of product through accelerated life testing<br>3. Ability to apply optimization technique in evaluating the optimal design solution |

## SYLLABUS

***Note for Examiner****- The examiner shall set 8 questions i.e., 4 from each part and students shall be required to attempt a total of 5 questions with at least 2 questions from each part.*

## SECTION-A

**Introduction:**

Importance of machine design in industry; Basic concepts of machine design including types of loading, stress, strain, strength, factor of safety, types of failures, computer-aided-design, stress concentration, statistical nature of mechanical properties of materials, fits, tolerances and surface finish.

**Fatigue failure based design:**
Stress-life approach; strain-life approach; LEFM approach, Estimated S-N diagrams; Notch sensitivity; Residual stresses; Designing for high cycle fatigue; Designing for fully reversed uni-axial stresses; designing for fluctuating uniaxial stresses, Designing for multiaxial stresses in fatigue.

**Surface failure based design:**
Surface geometry; mating surfaces; Effect of roughness, velocity, rolling and lubricant on friction; Adhesive wear coefficient; Abrasive wear; Corrosion wear; Surface fatigue; Spherical contact; Cylindrical contact; General contact; Dynamic contact stress, Surface fatigue failure models of dynamic contact.

**Impact based design:**
Energy methods, longitudinal stress waves in elastic media impact on beams, torsional impact on shafts and longitudinal impacts on helical springs

## SECTION-B

**Vibration based design:**
Methods of dynamic design of machines; Structural dynamic modifications; Application of vibration based design to an industrial case study such as a drilling machine.

**Thermal based design:**
Effect of short term and long term properties of materials on design; creep and stress relaxation; Elementary analysis of thermal stresses; thermal fatigue based design.

**Reliability based design:**
Guarantee versus warranty; Accelerated life testing (ALT); Design of ALT plans; Exponential Model and its application; Weibullmodel and its applications.

**Optimum design:**
Design vector; Design constraints; Constraint surface; Objective function surfaces; Multi-objective optimization using response surface method and its application in machine design.

| **TEXT BOOKS** | | | |
|---|---|---|---|
| **S. No.** | **NAME** | **AUTHOR(S)** | **PUBLISHER** |
| 1 | Mechanical Engineering Design | Joseph Edward Shigley& Charles R. Mischke | Mc. Graw Hill (2007) |
| 2. | Machine Design, An Integrated Approach | Robert L. Norton | Pearson Education (2007) |
| 3 | Design of Machine Members | Vallance and Doughtie | McGraw Hill, New York, 2005 |

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|---|---|
| **Course Code** | **MME353** |
| **Course Title** | **Preliminary Thesis Work** |
| **Type of Course** | Core |
| **L T P** | 0-0-20 |
| **Credits** | 10 |
| **Course Assessment Methods**<br>Continuous Assessment | <br>250 |
| **Course Prerequisites** | Research Methodology, Design of Experiments<br>The student should have taken all required courses. A supervisor must also be assigned before the student can start writing the thesis. |
| **Course Objectives** | 1. Ability to identify Gaps in literature surveys and define the problem.<br>2. Ability to set objectives and state the methodology to be adopted.<br>3. Preparing the blueprint of research work to be carried out. |
| **Course Outcomes** | 1. Effectively engage in an independent, sustained critical investigation and evaluation of a chosen relevant research topic.<br>2. Systematic findings and critical review of appropriate literature by demonstrating the use of adequate research methods and tools.<br>3.Identify relevant gaps, theory and concepts, relate these to appropriate methodologies and evidence, apply appropriate techniques and draw conclusions.<br>4. Communicate research concepts and contexts clearly and effectively both in writing and orally. |

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|---|---|
| **Course Code** | **MME451** |
| **Course Title** | **Thesis Work** |
| **Type of Course** | Core |
| **L T P** | 0-0-28 |
| **Credits** | 14 |
| **Course Assessment Methods**<br>End of Semester Assessment<br>Continuous Assessment | <br>175<br>175 |
| **Course Prerequisites** | Research Methodology, Design of Experiments |
| **Course Objectives** | 1. Skill and ability to conduct research<br>2. Identification of methodology and technical solution to problem<br>3. Ensure Dissemination to society |
| **Course Outcomes** | 1. Plan and engage in an independent and sustained critical investigation and evaluation of a chosen research topic relevant to the program.<br>2. Demonstrate knowledge to create and analyse different technical solutions.<br>3. Appropriately apply qualitative and/or quantitative evaluation processes to the problem under study.<br>4. Communicate research concepts and contexts clearly and effectively both in writing and orally. |

## ELECTIVE-I
## Courses In Semester 1

| | |
|---|---|
| **Course Code** | **MME105(a)** |
| **Course Title** | **Quality Control & Reliability** |
| **Type of Course** | Elective |
| **L T P** | 3 1 0 |
| **Credits** | 4 |
| **Course Assessment Methods**<br>End Semester Assessment (University Exam.)<br>Continuous Assessment (Sessional, Assignments, Quiz) | <br>50<br>50 |
| **Course Prerequisite** | Industrial Engineering and Management |
| **Course Objectives** | 1.Demonstrate the approaches and techniques to assess and improve process and/or product quality and reliability.<br>2.Introduce the principles and techniques of Statistical Quality Control and their practical uses in product and/or process design and monitoring<br>3.Illustrate the basic concepts and techniques of modern reliability engineering tools. |
| **Course Outcomes** | 1. Attain the basic techniques of quality improvement, fundamental statistics and probability<br>2. Use control charts to analyze for improving the process quality.<br>3. Describe different sampling plans<br>4. Acquire basic knowledge of total quality management<br>5. Understand the concepts of reliability and maintainability |

**SYLLABUS**

***Note for Examiner****- The examiner shall set 8 questions i.e., 4 from each part and students shall be required to attempt a total of 5 questions with at least 2 questions from each part.*

**SECTION-A**

**INTRODUCTION** :
Definition of Quality, Dimensions of Quality, Quality Planning, Quality costs - Analysis

Techniques for Quality Costs, Basic concepts of Total Quality Management, Historical Review, Principles of TQM, Leadership – Concepts, Role of Senior Management, Quality Council, Quality Statements, Strategic Planning, Deming Philosophy, Barriers to TQM Implementation.

**STATISTICAL PROCESS CONTROL (SPC):** The seven tools of quality – Statistical fundamentals – Measures of central tendency and dispersion – Population and sample – Normal curve – Control charts for variables and attributes – Process capability – Concept of six sigma – New seven management tools.

**TQM TOOLS:** Benchmarking – Reasons to benchmark – Benchmarking process – Quality Function Deployment (QFD) – House of quality – QFD process – Benefits – Taguchi quality loss function – Total Productive Maintenance (TPM) – Concept – Improvement needs – FMEA – Stages of FMEA.

**QUALITY SYSTEMS :** Need for ISO 9000 and other quality systems – ISO 9000:2000 quality system – Elements – Implementation of quality system – Documentation – Quality auditing – TS 16949 – ISO 14000 – Concept – Requirements and benefits.

## SECTION-B

**RELIABILITY**

Introduction to reliability, types of failures, definition and factors influencing system effectiveness, various parameters of system effectiveness.

**RELIABILITY EVALUATION**

Types of system- series, parallel, series parallel, stand by and complex; development of logic diagram, methods of reliability evaluation; cut set and tie set methods, matrix methods event trees and fault trees methods, reliability evaluation using probability distributions, Markov method, frequency and duration method.

**RELIABILITY IMPROVEMENT**

Techniques of reliability improvement, component redundancy, system redundancy, types of redundancies-series, parallel, series – parallel, standby redundancy.

**RELIABILITY TESTING**

Life testing, requirements, methods, test planning, data reporting system, data reduction and analysis.

| TEXT BOOKS | | | |
|---|---|---|---|
| **S. No.** | **NAME** | **AUTHOR(S)** | **PUBLISHER** |
| 1 | Total Quality Management | Feigenbaum. A.V. | Mc. Graw Hill |

| | | | |
|---|---|---|---|
| 2. | Total Quality Management | Dale H.Besterfield | Pearson Education, Inc. 2003 |
| 3 | Reliability Engineering | A.K. Govil | TATA McGraw-Hill |
| 4. | Reliability Engineering | L.S.Srinath | East West press, 1991 |

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|---|---|
| **Course Code** | **MME105(b)** |
| **Course Title** | **Manufacturing Science** |
| **Type of Course** | Elective |
| **L T P** | 3 1 0 |
| **Credits** | 4 |
| **Course Assessment Methods**<br>End Semester Assessment (University Exam.)<br>Continuous Assessment (Sessional, Assignments, Quiz) | <br>50<br>50 |
| **Course Prerequisites** | Manufacturing Process/Technology |
| **Course Objectives** | Analysis/design/selection of manufacturing processes for materials |
| **Course Outcomes** | 1. Analysis of the machining/casting process<br>2. Understanding and design of the manufacturing process based on requirements<br>3. Understanding and selection of process for an application |

**SYLLABUS**

***Note for Examiner****- The examiner shall set 8 questions i.e., 4 from each part and students shall be required to attempt a total of 5 questions with at least 2 questions from each part.*

**SECTION-A**

**Engineering Materials**

Applications and Important Properties of ferrous materials-cast iron, steels and alloy steels, non-ferrous materials-Cu, Al and their alloys.New industrial materials and their properties with special emphasis to composites, Selection of materials.

(12 hours)

**Metal Machining**

Tool Geometry, different system of representation, mechanics of orthogonal and oblique cutting, shear angle relation in orthogonal cutting, shear angle & chip flow direction in oblique cutting, chip control methods, analysis of cutting process like turning, drilling, milling. Temp. Distribution at the tool chip interface

(12 hours)

**SECTION-B**

**Casting Processes**

Nucleation and growth in metals and alloys.constitutional supercooling. Columnar equi acquiesced and dendritic structures.Freezing of alloys centre line feeding resistance. Rate of solidification, time of solidification, mechanism of solidifications, rate of solidification, continuous casting process, Riser Design and its placement, defects in casting, inspection of casting process.

(12 hours)

**Welding:**

Introduction, Principle of solid state welding, Heat source, Metal Transfer in Arc Welding, Heat flow characteristics, Gas Metal Reactions, Cooling of fusion weld, weld defects and inspection, Advance welding process, Ultrasonic Welding, Electronic beam welding, Laser beam welding, Explosive Welding, Plasma welding, Development in welding Technology, Some research trends in welding, quality control of weldments.

(12 hours)

| **TEXT BOOKS** | | | |
|---|---|---|---|
| **S. No.** | **NAME** | **AUTHOR(S)** | **PUBLISHER** |
| 1 | Manufacturing Science | Ghosh and Malik | EWP |
| 2 | Welding Processes and Technology | R.S. Parmar | Khanna Publishers |
| 3 | Production Technology | | HMT |

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|---|---|
| **Course Code** | **MME105(c)** |
| **Course Title** | **Welding Techniques** |
| **Type of Course** | Elective |
| **L T P** | 3 1 0 |
| **Credits** | 4 |
| **Course Assessment Methods**<br>End Semester Assessment (University Exam.)<br>Continuous Assessment (Sessional, Assignments, Quiz) | <br>50<br>50 |
| **Course Prerequisites** | Manufacturing Processes, Manufacturing Technology, Mech Engg Drawing |
| **Course Objectives** | 1. To understand the advanced welding processes and the process parameters.<br>2. Acquire knowledge on various advanced welding processes for engineering industry applications.<br>3. Knowledge on the design of welded joints and the quality control of weldments. |
| **Course Outcomes** | 1. Understanding the various metal joining processes<br>2. Understanding and Practice of the different welding techniques 3. Understanding the construction, working, input and output process controlling parameters and their effect for various welding techniques |

**SYLLABUS**

***Note for Examiner****- The examiner shall set 8 questions i.e., 4 from each part and students shall be required to attempt a total of 5 questions with at least 2 questions from each part.*

**SECTION-A**

**Introduction**

Welding– Definition, industrial importance, applications; welding vs. other fabrication processes; classification of welding and allied processes.

**Welding Safety and Hazards**
Hazards associated with gas and arc welding processes, protection against electric shock, arc radiations, fumes and dust, compressed gases, fire and explosions.

(12 hours)

**Arc Welding & Power Sources**
Arc- arc characteristics- arc physics, arc plasma, arc structure, arc stability, arc efficiency; brief introduction to bead geometry and melting rate, mode of metal transfer- short circuit, globular and spray mode of transfer, various factors and forces affecting metal transfer; welding power sources- introduction to transformers, rectifiers, transistors, thyristers, diodes, inverters; basic principle and characteristics of welding transformers, rectifiers, generators and inverters; power source characteristics- static and dynamic volt-ampere characteristics, duty cycle; arc blow- causes and its control.

**Shielded Metal Arc Welding (SMAW)**
Basic principle and equipment used; welding parameters and their effect on weld bead characteristics; covered electrodes- functions of electrode coating, types of coating and their characteristics, classification and coding of covered electrodes as per IS & AWS standards; advantages, limitations and applications.

(12 hours)

**SECTION-B**

**Gas Metal Arc Welding (GMAW)**
Basic principle and equipment used; welding parameters and their effect on weld bead characteristics; shielding gases- types, characteristics and applications; pulsed MIG welding; introduction to flux cored arc welding; advantages, limitations and applications.

**Gas Tungsten Arc Welding (GTAW)**
Basic principle and equipment used; arc initiation method and arc stability; types of tungsten electrode and their applications; shielding gases and their applications; effect of polarity on weld characteristics, difference between SAME and GTAW power sources, requirement for DC suppressor unit; pulse TIG welding; electrode contamination; advantages, limitations and applications.

**Submerged Arc Welding (SAW)**
Basic principle and equipment used; welding parameters and their effect on weld bead characteristics; SAW fluxes- classification and their characteristics; coding of flux wire combination as per BIS and AWS; introduction to multi-wire and multi power systems, strip cladding, narrow gap welding; advantages, limitations and applications.

**Plasma Arc Welding (PAW)**
Basic principle and equipment used; plasma forming and shielding gases; transferred and non-transferred arc modes; micro-plasma welding; advantages, limitations and applications.

**Resistance Welding**

Basic principle; Brief introduction to spot, seam, projection and flash butt welding; welding variables; heat balance; process capabilities and applications.

(12 hours)

| TEXT BOOKS | | | |
|---|---|---|---|
| **S. No.** | **NAME** | **AUTHOR(S)** | **PUBLISHER** |
| 1 | Modern Arc Welding Technology | S.V.Nadkarni | Oxford & IBH |
| 2 | Modern Arc Welding Technology | H.B.Cary | Prentice Hall. |
| 3 | Production Technology | | HMT |
| 4 | Welding Hand book | Leonard P Connor | Volume I-III, AWS |
| 5 | Welding skills and technology | Dave Smith | McGraw Hill |

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|---|---|
| **Course Code** | **MME105(d)** |
| **Course Title** | **Tool and Cutter Design** |
| **Type of Course** | Elective |
| **L T P** | 3 1 0 |
| **Credits** | 4 |
| **Course Assessment Methods**<br>End Semester Assessment (University Exam.)<br>Continuous Assessment (Sessional, Assignments, Quiz) | <br>50<br>50 |
| **Course Prerequisites** | Manufacturing Processes, Manufacturing Technology, Jigs and Fixture Design |
| **Course Objectives** | 1. Study of various machining processes<br>2. Material removal methods, input parameters during machining<br>3. Tool wear mechanism, Automation during machining |
| **Course Outcomes** | 1. Understanding the basic tools nomenclature and their geometry<br>2. Design the lathe single point cutting tool, milling cutter and drilling tools<br>3. Calculate the various types of stresses in the different cutting tools and cutters |

**SYLLABUS**

***Note for Examiner****- The examiner shall set 8 questions i.e., 4 from each part and students shall be required to attempt a total of 5 questions with at least 2 questions from each part.*

**SECTION-A**

**Introduction**

Fundamentals of cutting Tool design, Cutting tools ad their principal elements, tool Geometry, system of nomenclature and their relations, setting for the grinding of various basis cutting tool (Turning, drilling, Milling)

**Tool Materials**

Development of various tool materials then relative characteristics, Modern trend I tool development, Concept of tool life.

Single point cutting tools, Purpose and principal, types and their characteristics, Design procedures of single point tools, design of various high production tools, design of carbide tools.

(12 hours)

## SECTION-B

**Tool & Design**
Form tools, purpose and types, design procedure and sharpening

**Drills**
Purpose and principal types ad their construction and Geometry, development I the shape of twist drills.

**Milling Cutters**
Purpose ad type and their construction procedure of profile sharpened and form relieved cutter, design of hobs.

**Broaches**
Purpose and types, design features of various broaches.

(12 hours)

| **TEXT BOOKS** | | | |
|---|---|---|---|
| **S. No.** | **NAME** | **AUTHOR(S)** | **PUBLISHER** |
| 1 | Tool design | Donaldson | TMH |
| 2 | Principal of machine Tools | Sen & Bhattacharya | New central Book Agency |
| 3 | Principal of metal Cutting | Shaw | Oxford |

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|---|---|
| **Course Code** | **MME105(e)** |
| **Course Title** | **Condition Monitoring and Fault Diagnosis** |
| **Type of Course** | Elective |
| **L T P** | 3 1 0 |
| **Credits** | 4 |
| **Course Assessment Methods**<br>End Semester Assessment (University Exam.)<br>Continuous Assessment (Sessional, Assignments, Quiz) | <br>50<br>50 |
| **Course Prerequisites** | Manufacturing Processes, Manufacturing Technology, CAD/CAM, Calculus |
| **Course Objectives** | 1. Provide an overview of the fundamental principles of maintenance and condition monitoring techniques<br>2. Acquire knowledge of data acquisition and signal processing techniques<br>3. Explain about diagnosis of machinery faults and methods to correct faults |
| **Course Outcomes** | 1. Understanding the basic construction and working of various machine tools<br>2. Understand the various condition monitoring techniques and their use<br>3. Understand the various fault diagnosis techniques and their use in different machine tools |

## SYLLABUS

***Note for Examiner**- The examiner shall set 8 questions i.e., 4 from each part and students shall be required to attempt a total of 5 questions with at least 2 questions from each part.*

## SECTION-A

**Introduction**

Introduction to maintenance techniques, maintenance Strategies, Classifications (Plant maintenance, Running maintenance, Shut Down, Emergency corrective, curative, Breakdown, preventive predictive, Reliability, Total productive Maintenance, Guidelines for selecting best strategy.

Fault Tree analysis, Methodology for tree development, Family tree definitions in symbols. Fault Tree construction, fault tree simplification, fault tree evaluation, common cause failure, Probability evaluation in fault trees, Simulation approach. (12 hours)

## SECTION-B

**Analysis and Diagnosis**

Wear analysis through thermograph and Ferrography

Various Techniques of condition Monitoring, condition based Maintenance, visual monitoring, performance monitoring, vibration monitoring, war debris monitoring, Decision elements in condition based maintenance detection, diagnosis, Prescription, Benefits of condition maintenance. Application of diagnostic maintenance to Industrial Machine & plants (12 hours)

| TEXT BOOKS | | | |
|---|---|---|---|
| **S. No.** | **NAME** | **AUTHOR(S)** | **PUBLISHER** |
| 1 | Diagnostic maintenance & condition Monitoring | Kelly | A.Butterworth & Co |
| 2 | Maintenance and spare parts management | Krishan G | Prentice Hall,1991 |
| 3 | MaintenanceEngg. handbook | Higgins | McGraw Hill |
| 4 | Engg. Maintenance Management | Niebel | Routledge |

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|---|---|
| **Course Code** | **MME105(f)** |
| **Course Title** | **Advanced Heat Transfer** |
| **Type of Course** | Elective |
| **L T P** | 3 1 0 |
| **Credits** | 4 |
| **Course Assessment Methods**<br>End Semester Assessment (University Exam.)<br>Continuous Assessment (Sessional, Assignments, Quiz) | <br>50<br>50 |
| **Course Prerequisites** | Thermodynamics, Heat and Mass Transfer |
| **Course Objectives** | 1.To provide fundamental and advanced knowledge of unsteady state in multi dimensional heat transfer in condition with derivations<br>2. To Analyse Radiation heat transfer to calculate radiation exchange between surfaces and gas radiation.<br>3. To provide knowledge of convection heat transfer to understand convection phenomenon in forced flow and natural flow.<br>4.To provide understanding the laws of mass diffusion for steady and unsteady states in common geometries. |
| **Course Outcomes** | Student will be able to<br>1.Explain two dimensional heat conduction equation for steady and unsteady heat transfer with their solutions<br>2.Explain radiation properties and apply radiation networks to calculate radiation exchange between surfaces, and gas radiation.<br>3.Analyse forced convection heat transfer and free convection heat transfer during internal flow and external flow.<br>4.Explain the laws of mass diffusion for steady and unsteady states in common geometries. |

## SYLLABUS

***Note for Examiner**- The examiner shall set 8 questions i.e., 4 from each part and students shall be required to attempt a total of 5 questions with at least 2 questions from each part.*

## SECTION-A

**Review**

Review of the basic laws of conductions, radiation and convection.

**Conduction**

One dimensional steady state conduction with variable thermal conductivity and with internal distributed heat source, local heat source in non-adiabatic plate. Extended surfaces-review, fins of non-uniform cross section, performance of fins (fin efficiency, thermal resistance of a fin, total surface efficiency), design consideration.
Two dimensional steady and unsteady state conduction, semi-infinite and finite flat plates; temperature field in finite cylinders and infinite semi-cylinders, numerical method, graphical method. Unsteady state conduction; sudden changes in the surface temperatures of infinite plate, cylinders and spheres; solutions using Groeber's and Heisler's charts for plates, cylinders and spheres suddenly immersed in fluids.
(9 hrs)

**Radiation**

Introduction, properties and definitions, review of radiation principles (Planck's law, Kirchoff's law, Stefan Boltzman law, Lambert's cosine law). Radiation through non-absorbing media; Hottel's method of successive reflections; Radiation through absorbing media; logarithmic decrement of radiation; apparent absorptivity of simple shaped gas bodies; net heat exchange between surfaces separated by absorbing medium; radiation of luminous gas flames. (9)

**Convection**

Heat transfer in laminar flow; free convection between parallel plates; forced internal flow through circular tubes; fully developed flow; velocity and thermal entry lengths; solutions with constant wall temperature and with constant heat flux; forced external flow over a flat plate; the two dimensional velocity and temperature boundary layer equations; Karman Pohlhousen approximation integral method. Heat transfer in turbulent flow; eddy heat diffusivity; Reynold's analogy between skin friction and heat transfer; Von Karman integral equations, analogy between momentum and heat transfer, flow across cylinders, spheres and other bluff shapes and packed beds.
(8 hrs)

**Mass Transfer**

Introduction, concentration, velocities and fluxes, Fick's law of diffusion, steady state diffusion in common geometries, equimolal counter-diffusion in gases, steady state diffusion in liquids, transient mass diffusion in common geometries, mass transfer coefficient, convective mass transfer
(5 hrs)

| TEXT BOOKS | | | |
|---|---|---|---|
| **S. No.** | **NAME** | **AUTHOR(S)** | **PUBLISHER** |
| 1 | Analysis of Heat and Mass Transfer | Eckert and Drake | McGraw Hill |
| 2. | Fundamentals of Heat Transfer | Grober, Erk and Grigul | McGraw Hill |
| 3 | Heat Transfer | Holman J.P. | McGraw Hill |
| 4 | Conduction Heat Transfer | Schneider | Addison Wesley |
| 5 | Thermal Radiation | Siegel and Howel | McGraw Hill |
| 6. | Heat, Mass and Momentum | Rohsenow and Choi | Prentice Hall |

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|---|---|
| **Course Code** | **MME105(g)** |
| **Course Title** | **Gas Dynamics** |
| **Type of Course** | Elective |
| **L T P** | 3 1 0 |
| **Credits** | 4 |
| **Course Assessment Methods**<br>End Semester Assessment (University Exam.)<br>Continuous Assessment (Sessional, Assignments, Quiz) | <br>50<br>50 |
| **Course Prerequisites** | Fluid Dynamics, Thermodynamics, Basic Numerical Techniques. |
| **Course Objectives** | 1. To provide fundamental knowledge in Gas dynamic concepts and to analyze compressible flow through constant and variable area ducts.<br>2. To analyze propulsive systems. |
| **Course Outcomes** | 1. Apply the governing equation to one dimensional compressible flow through a variable area duct.<br>2. Derive the conditions for the change in pressure, density and temperature for flow through a normal shock.<br>3. Analyze Prandtl-Meyer, Fanno and Rayleigh flows.<br>4. Interpret the operating principle of Propulsive systems, their working and application. |

## SYLLABUS

***Note for Examiner**- The examiner shall set 8 questions i.e., 4 from each part and students shall be required to attempt a total of 5 questions with at least 2 questions from each part.*

## SECTION-A

**Elementary Principles and introduction to compressible flow**
Introduction, units, thermodynamics concepts for control mass analysis, flow dimensionality and average velocity, comment on entropy, pressure energy

equation.The stagnation concept, stagnation pressure-energy equation, momentum equation.
Introduction, Objectives, speed of propagation of pressure front, Mach Number, sonic velocity, field due to a moving source of disturbance, Mach cone ,Mach angle, equation for a perfect gas in terms of Mach number, h. s.& t. s. diagrams .

**Varying area adiabatic flow**
Introduction, adiabatic flow with and without losses, the reference concept, isentropic tables, convergent & divergent nozzles, diffuser performance, frictional effects on nozzle flow problems.

**Standing normal waves**
Introduction, shock analysis-general fluid, working equations for perfect gas, normal-shocks
tables, shocks in nozzles, supersonic wind tunnel operation, thermodynamic directions of a
normal shock, rankine hugoniot relation, strength of shock, operation of nozzle (12 hours)

## SECTION-B

**Moving and oblique shocks, Prandtl-Meyer flow**
Introduction, normal shocks tangential velocity superposition -oblique shocks, oblique-shocks, analysis, oblique-shock tables and charge, boundary conditions of flow direction, boundary condition of pressure equilibrium, introduction to Prandtl Meyer flow, analysis of Prandtl Meyer flow, Prandtl Meyer function.

**Fanno and Rayleigh flows**
Introduction, analysis for general fluid, working equations for a perfect gas, reference state and fanno tables, application, correlation with shocks, friction chocking. Analysis for a general fluid, working equations for a perfect gas reference state and Rayleigh tables, applications, correlation with shocks, thermal choking due to heating.

**Propulsion Systems**
Introduction, Brayton cycle, propulsion engines, thrust power and efficiency, thrust
Consideration, power consideration, and efficiency consideration, open Brayton cycle for propulsion systems, turbojet, turbo propulsion, ram jet, pulse jet. (12 hours)

| **TEXT BOOKS** | | | |
|---|---|---|---|
| **S. No.** | **NAME** | **AUTHOR(S)** | **PUBLISHER** |
| 1 | Fundamentals of Gas Dynamics | Yaha, S.M | TMI-I, India |
| 2 | Fluid Mechanics | A.K. Mohanty | Prentice Hall of India |
| 3 | Fundamentals of Fluid Mechanics | Yuan, S.W | Prentice Hall of India. |

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|---|---|---|---|
| 4 | Fundamentals of Gas Dynamics | Robert D. Zucker | Met tire Publication |
| 5 | Gas Dynamics | E. Radha Krishnan | Prentice Hall of India |

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|---|---|
| **Course Code** | **MME105(h)** |
| **Course Title** | **Introduction to Modern Fortran** |
| **Type of Course** | Elective |
| **L T P** | 3 1 0 |
| **Credits** | 4 |
| **Course Assessment Methods**<br>End Semester Assessment (University Exam.)<br>Continuous Assessment (Sessional, Assignments, Quiz) | <br>50<br>50 |
| **Course Prerequisites** | Introductory Programming. familiarity with Linux programming environment |
| **Course Objectives** | 1. Students should both pick up the basics of the Fortran language and the techniques of programming.<br>2. Students should learn top down design technique before implementing the code.<br>3. Students will learn to thoroughly unit test separately implemented individual logical units. |
| **Course Outcomes** | 1. Students should be able to use the Fortran language in their research and other practical projects.<br>2. Students should be able to write maintainable programs |

## SYLLABUS

***Note for Examiner**- The examiner shall set 8 questions i.e., 4 from each part and students shall be required to attempt a total of 5 questions with at least 2 questions from each part.*

## SECTION-A

**Introduction to Computers and The Fortran Language:** The Computer * Data Representation in a Computer * Computer Languages * The History of the Fortran Language * The Evolution of Fortran

**Basic Elements of Fortran:** The Fortran Character Set * The Structure of a Fortran Statement *

The Structure of a Fortran Program * Constants and Variables * Assignment Statements and Arithmetic Calculations * Intrinsic Functions * List-Directed Input and Output Statements * Initialization of Variables * The IMPLICIT NONE Statement * Debugging Fortran Programs
* Alternate KINDS of the REAL, INTEGER, and CHARACTER Data RType * COMPLEX Data Type.

**Program Design and Branching Structures:** Introduction to Top-Down Design Techniques * Use of Pseudocode and Flowcharts * Logical Constants, Variables, and Operators * Control Constructs: Branches.

**Loops:** Control Constructs: Loops.

**Characters:** Character Assignments and Character Manipulations * Character comparison operations * Intrinsic Character Functions * Passing Character Variables to Subroutines and Functions * Variable-Length Character Functions * Internal Files

**I/O Concepts:** Formats and Formatted WRITE Statements * Output Devices, Control Characters in Printer Output * Format Descriptors * Formatted READ Statements * An Introduction to Files and File Processing * Namelist I/O * Unformatted files * Direct Access Files * Stream Access Mode * Non Default I/O for derived types
(12 hours)

**SECTION-B**

**Arrays:** Declaring Arrays * Using Array Elements in Fortran Statements * Using Whole Arrays and Array Subsets in Fortran Statements * Input and Output * Multidimensional Arrays * Using Intrinsic Functions with Arrays * Masked Array assignment : the WHERE construct * FORALL construct * Allocatable Arrays

**Procedures:** Subroutines * Sharing Data Using Modules * Module Procedures * Fortran Functions * Passing Procedures as Arguments to Other Procedures. * Passing Multidimensional Arrays to Subroutines and Functions * The SAVE Attribute and Statement * Allocatable Arrays in Procedures * Automatic Arrays in Procedures * Allocatable Arrays as Dummy Arguments in Procedures* Pure and Elemental Procedures * Internal Procedures * Submodules.

**Derived Data Types:** Derived Data Types * Working with Derived Data Types * Input and Output of Derived Data Types * Declaring Derived Data Types in Modules * Returning Derived Types from Functions * Dynamic Allocation of Derived Data Types * Parameterized Derived Data Types * Type Extension * Type-Bound Procedures * The ASSOCIATE Construct

**Pointers and Dynamic Data Structures:** Pointers and Targets
* Using Pointers in Assignment Statements * Using Pointers with Arrays * Dynamic Memory Allocation with Pointers *Using Pointers as Components of Derived Data Types
* Arrays of Pointers *Using Pointers in Procedures * Procedure Pointers

**Object-Oriented Programming in Fortran:** An Introduction to Object-Oriented Programming
* The Structure of a Fortran Class * The CLASS Keyword * Implementing Classes and Objects in Fortran * Categories of Methods * Controlling Access to Class Members * Finalizers * Inheritance and Polymorphism * Abstract Classes.

**Coarrays and Parallel Processing:** Parallel Processing in Coarray Fortran * Coarrays * Synchronization between Images *Allocatable Coarrays and Derived Data Types *Passing Coarrays to Procedures * Critical Sections * The Perils of Parallel Programming. (12 hours)

| **TEXT BOOKS** | | | |
|---|---|---|---|
| **S. No.** | **NAME** | **AUTHOR(S)** | **PUBLISHER** |
| 1 | Fortran for Scientists and Engineers | Chapman | McGraw-Hill |
| 2 | Modern Fortran Explained | Metcalf | Oxford |
| 3 | Guide to Fortran Programming | Brainerd | Springer |
| 4 | Introduction to Programming with Fortran | Chivers | Springer |

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|---|---|
| **Course Code** | **MME105(i)** |
| **Course Title** | **Industrial Tribology** |
| **Type of Course** | Elective |
| **L T P** | 3 1 0 |
| **Credits** | 4 |
| **Course Assessment Methods**<br>End Semester Assessment (University Exam.)<br>Continuous Assessment (Sessional, Assignments, Quiz) | <br>50<br>50 |
| **Course Prerequisites** | Engineering Mechanics, Materials Science and Engineering |
| **Course Objectives** | 1. Basic objective is to deal with the fundamentals of friction, wear and lubrication.<br>2. Subject is useful in understanding the nature of surfaces of engineering materials.<br>3. Course is useful in understanding the various tribological applications. |
| **Course Outcomes** | 1. Understanding and importance of Tribological Phenomenon.<br>2. Understand the concept of Wear and friction Mechanism.<br>3. Determine the application of Lubricants and Mechanical Elements. |

## SYLLABUS

***Note for Examiner****- The examiner shall set 8 questions i.e., 4 from each part and students shall be required to attempt a total of 5 questions with at least 2 questions from each part.*

## SECTION-A

**Introduction**

Definition and Scope of tribology, Contact of solids, nature of surfaces, surface topography, surface interactions and characterization, micro and nanotribology, surface roughness measurement techniques.

**Friction**

Types, laws, modern theories, dry sliding friction, temperature of sliding surface, Mechanism of rolling friction, friction instabilities, measurement of friction.

W**ear**

Classification, theories of adhesive, abrasive, surface fatigue and corrosives wear, erosive, cavitation and fretting wear, wear models, wear of miscellaneous machine components such as gears, plain bearings and rolling element bearings, ASTM standards for wear measurement, wear resistant materials, wear resistant components, Study of abrasion in grinding, lapping and honing.

(12 hours)

**SECTION-B**

**Lubrication Theories**

Lubrication regimes: hydrodynamic lubrication, hydrostatic lubrication, elastohydrodynamic lubrication, boundary lubrication, squeeze films, turbulent lubrication. Reynold's equation, Pressure distribution, load carrying capacity, friction forces in oil film and co-efficient of friction in journal bearing.

**Bearing Design**

Clearance in journal bearing, minimum film thickness, Sommerfeld Number. Oil grooves and flow of oil in axial and circumferential grooves, cavitation and turbulence in oil bearing. Heat generation and cooling of bearing. Design of air bearing and other gas bearings.

**Applications**

Application of tribology in manufacturing processes, Metal machining, Metal cutting, Tool wear, Action of lubricants, Friction welding, Extrusion process

(12 hours)

| **TEXT BOOKS** | | | |
|---|---|---|---|
| **S. No.** | **NAME** | **AUTHOR(S)** | **PUBLISHER** |
| 1 | Basic Lubrication Theory | A Comeron | Ellis Horwood |
| 2 | Friction Wear & Lubrication | Kenneth C.Ludema | CRC Press |
| 3 | Engineering Tribology | J.A.Williams | Cambridge |
| 4 | Fundamentals of Tribology | Basu, Sengupta &Ahuja | World Scientific |
| 5 | Engineering Tribology | Stachowiak & Bachelor | Elsevier |

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|---|---|
| **Course Code** | **MEC 105(j)** |
| **Course Title** | **Design Of Biomedical Devices And Systems** |
| **Type of Course** | Elective |
| **LTP** | 3 1 0 |
| **Credits** | 4 |
| **Continuous Assessment** | 50 marks |
| **Course Prerequisites** | Machine design, solid mechanics, solid modelling, FEA |
| **Course Objectives** | 1. Introduce design aspects in biomedical devices to the students<br>2. Educate students on clinical trials<br>3. Familiarize students with variants in biomedical devices based on medical specialities |
| **Course Outcomes** | 1. Ability to design medical devices in fields of dentistry and surgery<br>2. Evaluate design aspects related to manufacture implants<br>3. Modeling of bone structures |

**Syllabus**

| S.No | Topics | Lectures |
|---|---|---|
| **PART A** | | |
| 1 | Principles of design in medical devices; Design Process; classification rules of devices | 7 |
| 2 | Implementation of design procedures; develop design and product specifications; applications of devices in dentistry; case studies | 8 |
| 3 | Material selection; applications of devices in surgical procedures; case studies | 5 |
| **PART B** | | |
| 4 | Quality in Design; Design Realization; Finite Element modelling in bones and implants | 8 |
| 5 | Manufacturing of devices; Rapid prototyping and milling technologies | 7 |
| 6 | Validation and verification procedures; Various aspects involved in ethical approvals and clinical trials Labelling and instructions for use | 7 |

**Recommended books**

| S.NO. | NAME | AUTHOR(S) | PUBLISHER |
|---|---|---|---|
| 1 | Medical Device Design | Peter J. Ogrodnik | Academic Press |
| 2 | Design of biomedical devices and systems | Paul H. Hing ; Richard C Fries; Arthur T Johnson | CRC Press |
| 3 | Introduction to biomedical | Laurence J Street | CRC Press |

| | | | |
|---|---|---|---|
| | engineering | | |
| 4 | Sample Size calculations and clinical research | Chow; Shao; Wang; Lokhnygina | CRC Press |

## ELECTIVE-II

## Courses In Semester 2

| | |
|---|---|
| **Course Code** | **MME205(a)** |
| **Course Title** | Fluid Dynamics |
| **Type of Course** | Elective |
| **L T P** | 3 1 0 |
| **Credits** | 4 |
| **Course Assessment Methods**<br>End Semester Assessment (University Exam.)<br>Continuous Assessment (Sessional, Assignments, Quiz) | <br>50<br>50 |
| **Course Prerequisites** | Fluid Mechanics |
| **Course Objectives** | 1. Explain the physical properties of a fluid and the consequence of such properties on fluid flow.<br>2. State the conservation principles of mass, linear momentum, and energy for fluid flow.<br>3. Apply the basic applied-mathematical tools that support fluid dynamics.<br>4. Create models of inviscid, steady fluid flow over simple profiles and shapes.<br>5. Determine the basic forces and moments acting on simple profiles and shapes in an inviscid, steady fluid flow |
| **Course Outcomes** | 1. Classify and exploit fluids based on the physical properties of a fluid.<br>2. Apply correctly the conservation principles of mass, linear momentum, and energy to fluid flow systems with emphasis on aerodynamics.<br>3. Demonstrate the ability to model correctly inviscid, steady fluid flow over simple aerodynamic profiles and shapes. |

| | |
|---|---|
| | 4. Compute the lift, drag, and moments acting on simple aerodynamic profiles and shapes in inviscid, steady fluid flows |

## SYLLABUS

***Note for Examiner**- The examiner shall set 8 questions i.e., 4 from each part and students shall be required to attempt a total of 5 questions with at least 2 questions from each part.*

### SECTION-A

Introduction & overview of Fluid Dynamics, units and basic flow concepts.Continuums, velocity fields, viscosity, classifications of fluids.Conduction  Kinematics of Fluid in motion, Equations of Motion of  inviscid fluid, One-dimensional inviscid incompressible flow (Bornoulli's equations and its applications). Navier-Stokes' equations.  Potential flow theory and transformation. Flow around bodies, cylinders and aerofoil. Transformation of circle into aerofoil.  Prediction of velocity and pressure distribution, boundary layer problems, laminar and turbulent boundary layers, separation criterion.

### SECTION-B

Motion in two dimensions, sources and sinks, General theory of irrotational motion, Motion of cylinders.General differential equations of continuity, momentum and energy applied to compressible inviscid fluids, Sonic Velocity, Mach number and propagation of disturbance in a fluid flow.  Isentropic  flow and stagnation properties.  Flow through nozzles and diffusers, Fanno, Reyleigh and isothermal flows through pipes.Dynamical Similarity, Inspection Analysis and Dimensional Analysis, Laminar flow of viscous incompressible fluids, Theory of Very Slow Motion, Boundary layer theory. Thermal Boundary Layers, Thermal Boundary Layer.

| **TEXT  BOOKS** | | | |
|---|---|---|---|
| **S. No.** | **NAME** | **AUTHOR(S)** | **PUBLISHER** |
| 1 | Fluid Dynamics | M. D. Raisinghania, | S. Chand |
| 2. | Compressible Fluid Flow | Patrick Oosthuizen | |
| 3 | Fundamental of Compressible Flow | S.M. Yahya | |
| 4 | An Introduction to Fluid Dynamics, | Batchelor G K, | Cambridge (2007) |

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|---|---|
| **Course Code** | **MME205(b)** |
| **Course Title** | Experimental Stress Analysis |
| **Type of Course** | Elective |
| **L T P** | 3 1 0 |
| **Credits** | 4 |
| **Course Assessment Methods**<br>End Semester Assessment (University Exam.)<br>Continuous Assessment (Sessional, Assignments, Quiz) | <br>50<br>50 |
| **Course Prerequisites** | Mechanics of Materials, Advanced Mechanics of Materials |
| **Course Objectives** | 1. Students learn to apply modern experimental stress analysis techniques to measure strains and stresses in engineering components and structures. The course includes strain gage measurements and analysis, photoelasticity, and stress analysis.<br>2. Ability to understand the role of Experimental Stress Analysis in supporting Analytical and Numerical techniques. |
| **Course Outcomes** | 1. Students will demonstrate a basic understanding of experimental methods commonly used in experimental solid mechanics.<br>2. Students will demonstrate the ability to complete a detailed laboratory report and present their findings in a structured, logical manner.<br>3. Students will demonstrate the ability to analyze experimental data and develop appropriate, logical conclusions based on comparisons to theoretical results and other experimental evidence. |

## SYLLABUS

***Note for Examiner**- The examiner shall set 8 questions i.e., 4 from each part and students shall be required to attempt a total of 5 questions with at least 2 questions from each part.*

## PART-A

**Stress –** Stress at a point, Stress Equations of Equilibrium, Stress Transformation, Principal Stresses, Maximum Shear Stress, 2D State of Stress, Special states of Stress.
**Strain and Stress-Strain Relationships –** Definition of Displacement and Strain, Strain Transformation, Principal Strains, Compatibility, Dilatation, Stress-Strain Relations, 2D Strain Transformation and Stress-Strain Relations.
**Plane Elasticity –** Field Equations, Plane Stress, Plane Strain, Airy Stress Function: Cartesian and Polar Coordinates, Problems: Circular Cylinder subject to internal and external Pressure, Thin infinite plate with circular hole under Tensile Load
**Elementary Fracture Mechanics –** Stress due to Elliptical hole in Uniformly Loaded Plate, Westergaard Stress Funtion, Stress Intensity Factor for select Geometries, Three modes of Loading, Crack-tip Plasticity, Equations for region adjacent to crack-tip, shaper of plastic zone, Energy approach, Criteria for Crack Instability, Fracture Control.
**Introduction to Strain Measurement –** Definition of strain and its relation to experimental determination, Properties of Strain-gage systems, Types of Strain-gages, Semiconductor Strain-gages, Grid Method of Strain Analysis.
**Electrical-Resistance Strain–gages** – Strain Sensitivity in Metallic Alloys, Gage construction, Strain-gage adhesives and mounting methods, Gage sensitivities and Gage factor, Performance characteristics of Foil Strain-gages, Environmental Effects.
**Strain-gage Circuits** – Potentiometer and its application to Strain Measurement, Wheatstone Bridge, Constant-current circuits, Calibrating Strain-gage circuits, Effect of lead wires, switches, and slip rings, Electrical noise, Transducer applications.
**Recording Instruments** – Static recording and data logging, Digital processing of Analog signals, Dynamic recording of very low/intermediate/high/very high frequencies, digital conversion rates and frequency response, telemetry systems.
**Strain Analysis Methods** – Three-element rectangular rosette, corrections for transverse strain effects, stress gage, torque gage, stress intensity factor gage, determine mixed mode stress intensity factors, over deterministic methods of strain analysis, residual stress determination.

## PART-B

**Basic Optics –** Nature of Light, Wave Theory of Light, Reflection and Refraction, Image formation by Lenses and Mirrors, Optical Diffraction and Interference, Optical instruments: Polariscope, Interferometer, Shadow Caustics.
**Moiré Methods –**Moiré Fringes produced by Mechanical Interference, Moiré Fringe Analysis: Geometrical, and Displacement-Field approach, Out-of-plane displacement and slope measurements, Sharpening and multiplication of Moiré Fringes, Experimental procedures and techniques, Moiré Interferometer.
**Theory of Photoelasticity** - Stress-optics Law, Relative retardation, Effects of stressed

model in: Plane Polariscope, Circular Polariscope (Dark Field, Arbitrary Analyzer position, Tardy Compensation), Photoelastic Photography, Fringe Multiplication with Partial Mirrors.

**Applied Photoelasticity 2D and 3D Stress Analysis** – 2D Photoelastic Stress Analysis, Materials for 2D Photoelasticity, Properties of commonly applied Photoelastic materials, 3D Photoelasticity Stress Freezing, Materials for 3D Photoelasticity, Slicing the model and interpretation of Fringe Patterns, Effective Stresses, Shear-Difference method in 3D, Application of Frozen Stress method.

**Optical Methods for Determining Fracture Parameters** – Irwin's method to determine $K_I$ from isochromatic fringe patterns, Modification of Irwin's 2-Parameter Method, Higher Parameter Methods, Determining $K_I$: from isopachic and Moiré fringe patterns, Methods for determining $K_I$ in 3D bodies, Mixed mode stress intensity factors $K_I$ and $K_{II}$, Birefringent coatings in fracture mechanics.

**Photoelastic Coatings and Brittle Coatings** – Coating Stresses, Birefringent Coatings, Stress-optic and Strain-optic relations for coatings, Coating Sensitivity, Coating Materials, Bonding the Coatings, Effect of Coating Thickness, Fringe-Order Determination of Coatings, Brittle Coatings, Test procedures for Resin-based coatings, Analysis of Brittle coating data.

**Books Suggested:**

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| Experimental Stress Analysis, 3/e | Dally and Riley, McGrawHill, 1991 |
| Advanced Strength and Applied Elasticity | Budynas, McGrawHill, 1999 |

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|---|---|
| **Course Code** | **MME205(c)** |
| **Course Title** | **Mechanical Behavior of Materials** |
| **Type of Course** | Elective |
| **L T P** | 3 1 0 |
| **Credits** | 4 |
| **Course Assessment Methods**<br>End Semester Assessment (University Exam.)<br>Continuous Assessment (Sessional, Assignments, Quiz) | <br>50<br>50 |
| **Course Prerequisites** | Mechanics of Materials |
| **Course Objectives** | 1. How atomic bonding and microstructure affect the properties of materials<br>2. How processing and composition affect the microstructures of materials<br>3. Mechanical properties of metals, polymers, ceramics, and composites How to determine the strength of engineering components<br>4. How to determine the life of engineering components<br>5. How to select materials and use them in the design of engineering components |
| **Course Outcomes** | 1. Ability to co-relate/understand Elastic and Plastic Behaviour of different materials/Metals and correlate it to crystal structure and imperfection.<br>2. Ability to understand strengthening Mechanisms of different metals and also gain good insight into fracture mechanics of materials and predict failure based on experimental observations of a sample.<br>3. Ability to predict/understand Creep and Fatigue phenomenon of Engineering Materials. |

**SYLLABUS**

***Note for Examiner**- The examiner shall set 8 questions i.e., 4 from each part and students shall be required to attempt a total of 5 questions with at least 2 questions from each part.*

## SECTION-A

**1. Overview of Mechanical Behavior:** Elastic deformation, permanent deformation, Fracture.

**2. Elastic Behavior:** Range of elastic Moduli, Elastic properties, basis for linear elasticity, anisotropic linear elasticity, rubber elasticity, polymer elasticity and viscoelasticity, damping.

**3. Plastic Behavior:** ***Dislocations*** Yield strength of perfect crystal, Edge dislocation, screw and mixed dislocation, twinning, properties of dislocations, dislocation geometry and crystal structure, intersection of moving dislocations, dislocation density and macroscopic stress. ***Plastic Deformation in Single and Polycrystalline Materials*** initiation of plastic flow in single crystal, stress-strain behavior of single crystals, plastic flow in polycrystals, plastic flow behavior and material class, geometrically necessary dislocations. ***Strengthening of Crystalline Materials*** Strengthening, work hardening, boundary strengthening, solid-solution strengthening, particle hardening, strain gradient hardening, deformation of two phase aggregates, case studies on strength, microstructure, and processing ***High Temperature Deformation of Crystalline Materials*** Creep phenomena, Creep Mechanism, Materials aspect in Creep design, engineering aspects of creep behavior, superplasticity, hot working of metals ***Deformation of Non-crystalline Materials*** Crystalline vs. non-crystalline structure, viscosity, deformation of - inorganic glasses, metallic glasses, polymeric materials

## SECTION-B

**4. Composite Materials:** Reinforcement – basic principle, with particles, with aligned continuous and discontinuous fibers, fiber orientation effect, statistical failure of composites, strain-rate effects, microscopic effects, reinforcement of brittle matrices, modern composite materials.

**5. Fracture Mechanics**: Theoretical strength of a solid, crack-initiated fracture, fracture mechanics, fracture toughness and material class, impact test, fracture of brittle nonmetallic. ***Toughening*** in metals, ceramics, composites, polymers, ***Physics of Fracture*** Types of Low-Temperature Tensile Fracture, Relation among bonding, crystal structure and fracture, Mode II and Mode III brittle fracture, ductile fracture, High Temperature Fracture, modes and mechanism, intergranular creep fracture, Design and materials considerations, failure in superplastic materials, ***Fatigue Fracture*** characteristics, resistance, fatigue crack growth, design against fatigue, cyclic stress-strain behavior, creep-fatigue interaction, polymeric fatigue, fatigue in composites.

**6. Embrittlement**: Metal embrittlement, Stress-corrosion cracking, hydrogen embrittlement, impurity-atom embrittlement, radiation damage, embrittlement of inorganic glasses and ceramics, polymer embrittlement

**7. Cellular Solids:** Geometries and Densities of Cellular solids, Compressive behavior of Cellular Solids, Energy absorption in Cellular solids, Sandwich panels.

**Books**

| **Title** | **Author** | **Publisher** |
|---|---|---|
| Mechanical Behavior of Materials | Courtney | McGraw-HIll |
| Physical Metallurgy | George E. Dieter | McGraw-Hill |
| Mechanical Behavior of Materials | Norman Dowling | Pearson |
| Materials Science and Engineering | William D. Callister | Wiley |
| Advanced Mechanics of Materials | Boresi | WIley |

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|---|---|
| **Course Code** | **MME205(d)** |
| **Course Title** | **Composite Materials** |
| **Type of Course** | Elective |
| **L T P** | 3 1 0 |
| **Credits** | 4 |
| **Course Assessment Methods**<br>End Semester Assessment (University Exam.)<br>Continuous Assessment (Sessional, Assignments, Quiz) | <br>50<br>50 |
| **Course Prerequisites** | Mechanics of Materials, Manufacturing processes |
| **Course Objectives** | 1.To understand multiple material combinations<br>2.To educate students about fabrication techniques for composites<br>3. To familiarize students on usage of composite materials in engineering applications<br>4. To introduce students regarding various mechanical characterization techniques |
| **Course Outcomes** | 1. Understanding of types of composite materials<br>2. Analyzing characterization techniques for and comparing various composite materials<br>3. Learning mechanical properties of composite materials |

## SYLLABUS

***Note for Examiner****- The examiner shall set 8 questions i.e., 4 from each part and students shall be required to attempt a total of 5 questions with at least 2 questions from each part.*

## SECTION-A

**Basics of Materials**

Processing of metal, ceramic, and polymer composites, laminates; analysis of residual stresses. Advanced analysis of composite materials; anisotropic elasticity.

**Fabrication Methods of Polymer Composites**

Liquid resin impregnated routes, pressurized consolidation of resin pre-pegs, consolidation of resin molding compounds, injection molding of thermoplastics, hot press molding of thermoplastics, laminations, honeycomb.

**Fabrication of Ceramic Composites**
Powder based routes, reactive processing, layered ceramic composites, carbon/carbon composites.

(12 hours)

**SECTION-B**

**Characterization Techniques**
Visual characterization techniques-electron microscopy, atomic force microscopy, Raman, FTIR techniques

**Mechanical Characterization Techniques**
Micro and nano level static and dynamic mechanical properties evaluation techniques to study hardness, stress, strain, modulus etc.

**Introduction to Simulation**
Simulator technology, Applications, Software Packages.

(12 hours)

| **TEXT BOOKS** | | | |
|---|---|---|---|
| **S. No.** | **NAME** | **AUTHOR(S)** | **PUBLISHER** |
| 1 | Experimental Mechanics of Fiber Reinforced Composite Materials | J.M. Whitney, I.M. Daniel and R. Byron Pipes | Wiley |
| 2 | The Behavior of Structures Composed of Composite Materials | Martinus-Nijhoff | Springer |
| 3 | Mechanical Behavior of Engineering Materials | Roesler, Harders, Baeker | Springer |

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|---|---|
| **Course Code** | **MME205(e)** |
| **Course Title** | **Model Updating** |
| **Type of Course** | Elective |
| **L T P** | 3 1 0 |
| **Credits** | 4 |
| **Course Assessment Methods**<br>End Semester Assessment (University Exam.)<br>Continuous Assessment (Sessional, Assignments, Quiz) | <br>50<br>50 |
| **Course Prerequisites** | No prerequisites |
| **Course Objectives** | 1. To study and apply the principle of size compatibility technique<br>2. To compare experimental versus finite element results<br>3. To apply model updating technique for reducing errors of finite element model |
| **Course Outcomes** | 1. Ability to reduce or expand the size of a model by using size compatibility techniques<br>2. Ability to compare the experimental versus analytical dynamic responses<br>3. Ability to update the finite element model to improve its prediction accuracy |

## SYLLABUS

***Note for Examiner****- The examiner shall set 8 questions i.e., 4 from each part and students shall be required to attempt a total of 5 questions with at least 2 questions from each part.*

## SECTION-A

**Overview**:Introduction and industrial relevance of model updating; Overview of applications of model updating; Introduction to direct and iterative methods of model updating; Pros and cons of direct and iterative methods of model updating; simulated experiments method.

**Size Compatibility Techniques:**Needs and requirements of size compatibility techniques; Guyan static reduction method; Guyan dynamic reduction method; Improved reduced system (IRS); System equivalent reduction expansion process

(SEREP); Condensed versus reduced models; Expansion using mass and stiffness matrices.

**Correlation Techniques:**Needs and requirements of correlation techniques; Graphical comparison of eigenvalues; Overlay techniques of comparison of FRFs; Comparison of modeshapes; Modal scale factor and its limitations; Modal assurance criteria and its 3-D Plots; Normalized cross orthogonality and its 3-D Plots; Coordinate MAC and its Uses.

**Direct Methods of Model Updating:**Technical background of direct methods of model updating; Method of Baruch and Bar-Itzhack and its limitations; Method of Berman and its limitations; Method of Berman and Nagy and its limitations; Overall advantages and disadvantages of direct methods; Applications of direct methods of model updating.

## SECTION-B

**Response function method:** Response function method, RFM using damping identification, RFM using complex parameters, Normal response function method; Application of each method to a cantilever beam structure.

**Inverse eigen-sensitivity method:**Inverseeigen-sensitivity method and its application to a cantilever beam structure. Comparison of inverse eigen-sensitivity method with the response function method.

**Response surface method:**Generation of experimental design matrix using central composite design method; development of response surfaces using regression analysis; model updating of a cantilever beam structure using response surface method.

**Other methods of model updating:**Introduction to model updating using based excitation; neural network based model updating; Genetic algorithm based model updating; simulated annealing based model updating; Particle-swarm-optimization based model updating.

| **TEXT BOOKS** | | | |
|---|---|---|---|
| **S. No.** | **NAME** | **AUTHOR(S)** | **PUBLISHER** |
| 1 | Finite Element Model Updating in Structural Dynamics | M.I. Friswell and J.E. Mottershead | Kluwer Academic Publishers, Dordrecht, The Netherlands, 1995 |
| 2 | Modal Analysis | He and Fu | Butterworth Heinemann Publisher, Oxford, 2001 |
| **RECOMMENDED BOOKS** | | | |
| 1 | Structural Dynamics Theory and Computation | Mario Paz and William Leigh | Kluwer Academic Publisher, 2004 |

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|---|---|
| **Course Code** | **MME205(f)** |
| **Course Title** | **Mechatronics** |
| **Type of Course** | Elective |
| **L T P** | 3 1 0 |
| **Credits** | 4 |
| **Course Assessment Methods**<br>End Semester Assessment (University Exam.)<br>Continuous Assessment (Sessional, Assignments, Quiz) | <br>50<br>50 |
| **Course Prerequisites** | Mechanical Vibrations, Automatic Controls |
| **Course Objectives** | 1. To enable students to learn about the Mechatronic Systems, Sensors and Actuation Systems.<br>2. To enable students to appreciate the ubiquitous presence of Mechatronic systems in industry and everyday life.<br>3. To enable students to be able to design basic mechatronic systems |
| **Course Outcomes** | 1. Post graduates who can contribute to the industrial problems concerning implementation of Mechatronics solutions.<br>2. Post graduate students with the basic knowledge framework so as to contribute in the advancement of state-of-the-art in the field of Mechatronics. |

## SYLLABUS

***Note for Examiner***- *The examiner shall set 8 questions i.e., 4 from each part and students shall be required to attempt a total of 5 questions with at least 2 questions from each part.*

## SECTION-A

**MECHATRONICS, SENSORS AND TRANSDUCERS:** Introduction to Mechatronics Systems – Measurement Systems – Control Systems – Microprocessor based Controllers. Sensors and Transducers – Performance Terminology – Sensors for Displacement, Position and Proximity; Velocity, Motion, Force, Fluid Pressure, Liquid Flow, Liquid Level, Temperature, Light Sensors – Selection of Sensors

**ACTUATION SYSTEMS:** Pneumatic and Hydraulic Systems – Directional Control Valves – Rotary Actuators. Mechanical Actuation Systems – Cams – Gear Trains – Ratchet and pawl – Belt and Chain Drives – Bearings. Electrical Actuation Systems – Mechanical Switches – Solid State Switches – Solenoids – D.C Motors – A.C Motors – Stepper Motors.

**SYSTEM MODELS AND CONTROLLERS:** Building blocks of Mechanical, Electrical, Fluid and Thermal Systems, Rotational – Transnational Systems, Electromechanical Systems – Hydraulic – Mechanical Systems. Continuous and discrete process Controllers – Control Mode – Two – Step mode – Proportional Mode – Derivative Mode – Integral Mode – PID Controllers – Digital Controllers – Velocity Control – Adaptive Control – Digital Logic Control – Microprocessors Control.

**SECTION-B**

**PROGRAMMING LOGIC CONTROLLERS:** Programmable Logic Controllers – Basic Structure – Input / Output Processing – Programming – Mnemonics – Timers, Internal relays and counters – Shift Registers – Master and Jump Controls – Data Handling – Analogs Input / Output – Selection of a PLC Problem.

**RAPID PROTOTYPING FOR MECHATRONIC PROJECTS:** Prototyping Philosophies, Solid Modeling Tools, Modeling System Dynamics, Foam core, X-Acto Knives, 2-D Rapid Prototyping: Laser Cutting/Laser CAMM, Tab and Slot Construction, 3-D Rapid Prototyping: SLA, SLS, FDM and Soft Mold Castings.

**DESIGN OF MECHATRONICS SYSTEM:** Stages in designing Mechatronics Systems – Traditional and Mechatronics Design - Possible Design Solutions Case Studies of Mechatronics Systems, Pick and place robot – automatic Car Park Systems – Engine Management Systems.

| **TEXT BOOKS** | | | |
|---|---|---|---|
| **S. No.** | **NAME** | **AUTHOR(S)** | **PUBLISHER** |
| 1 | Mechatronics | W. Bolton | PearsonEducation, Second Edition, 1999 |
| 2 | Mechatronics Integrated Technologies for Intelligent Machines | Smaili. A and Mrad. F., | Oxford University Press, 2008 |
| **RECOMMENDED BOOKS** | | | |
| 1 | Structural Dynamics Theory and Computation | Nitaigour Premchand Mahadik, | Tata McGraw-Hill Publishing Company Limited , 2003 |

| | |
|---|---|
| **Course Code** | **MME205(g)** |
| **Course Title** | **Advanced Control System** |
| **Type of Course** | Elective |
| **L T P** | 3 1 0 |
| **Credits** | 4 |
| **Course Assessment Methods**<br>End Semester Assessment (University Exam.)<br>Continuous Assessment (Sessional, Assignments, Quiz) | <br>50<br>50 |
| **Course Prerequisites** | Introductory course on Automatic Controls |
| **Course Objectives** | To introduce modern control theory and state space analysis |
| **Course Outcomes** | Ability to control MIMO systems. Ability to control complex dynamic systems. |

## SYLLABUS

***Note for Examiner****- The examiner shall set 8 questions i.e., 4 from each part and students shall be required to attempt a total of 5 questions with at least 2 questions from each part.*

## SECTION-A

**TRANSIENT AND STEADY STATE RESPONSE:** Time domain representation –Laplace domain representation– Solution of second order differential equation with constant coefficients– System with proportional control– Proportional cum derivative control – Proportional cum integral control.

**CONTROL SYSTEM ANALYSIS USING STATE VARIABLE METHODS**: State variable representation–Conversion of state variable models to transfer functions–Conversion of transfer functions to canonical state variable models–Eigenvalues and eigenvectors–Solution of state equations–Concepts of controllability and observability–Equivalence between transfer function and state variable representations–Multivariable systems.

**STATE VARIABLE ANALYSIS OF DIGITAL CONTROL SYSTEMS:**State descriptions of digital processors–State description of sampled continuous-time plants–State description of systems with dead-time – Solution of state difference equations – Controllability and observability.

## SECTION-B

**POLE-PLACEMENT DESIGN AND STATE OBSERVERS:** Stability improvement by state feedback – Necessary and sufficient conditions for arbitrary pole-placement – State regulator design – Design of state observers – Compensator design by the separation principle

**Linear quadratic optimal control through Lyapunov Synthesis:** Concept of Lyapunov stability – Lyapunov functions for linear systems – Parameter optimization and optimal control problems – Quadratic performance index – Optimal state regulator – Optimal digital control systems

| **TEXT BOOKS** | | | |
|---|---|---|---|
| **S. No.** | **NAME** | **AUTHOR(S)** | **PUBLISHER** |
| 1 | Digital control and state variable methods | M. Gopal | Tata McGraw-Hill Publishing Company |
| 2 | Theory and applications of Automatic controls | B. C. Nakra | New Age International Publishers |
| **RECOMMENDED BOOKS** | | | |
| 1 | Automatic control systems | Benjamin.C.Kuo | Prentice Hall of India, 7th Edition,1995 |
| 2 | Linear control system analysis and design | John J. D'azzo & Constantine H.Houpis | Tata McGrow-Hill, Inc., 1995. |
| 3 | Modern Control Systems | Richard C. Dorf & Robert H. Bishop | Addidon – Wesley, 1999. |
| 4 | State Space Analysis of Control Systems | Ogata, K.. | Prentice Hall |
| 5 | Digital Control of Dynamic Systems,. | G. F. Franklin, J. D. Powell and M. L. Workman | Addison Wesley, 1998, Pearson Education, Asia, 3/e, 2000 |
| 6 | Computer Controlled Systems - Theory and Design | K. J. Astroms and B. Wittenmark | Prentice Hall, 3/e, 1997. |

| | |
|---|---|
| **Course Code** | **MME205(h)** |
| **Course Title** | **Imaging and Additive Manufacturing** |
| **Type of Course** | Elective |
| **L T P** | 3 1 0 |
| **Credits** | 4 |
| **Course Assessment Methods**<br>End Semester Assessment (University Exam.)<br>Continuous Assessment (Sessional, Assignments, Quiz) | <br>50<br>50 |
| **Course Prerequisites** | Manufacturing processes, CAD, Engineering Drawing |
| **Course Objectives** | 1. To learn process of image capturing and transformations.<br>2. To understand translation of medical images into 3D printed parts.<br>3. To conceptualize various processes of additive manufacturing.<br>4. To learn about material types and transformations during 3D printing |
| **Course Outcomes** | 1. Students will be able to understand types of medical images.<br>2. Students will be able to learn the complete process of additive manufacturing.<br>3. Students will be able to apply different types of additive manufacturing methods in medical and engineering applications. |

**SYLLABUS**

***Note for Examiner****- The examiner shall set 8 questions i.e., 4 from each part and students shall be required to attempt a total of 5 questions with at least 2 questions from each part.*

| Section A | | |
|---|---|---|
| S.No | Topics | Lectures |
| 1 | Introduction And Digital Image Fundamentals: The origins of Digital Image Processing Examples of Fields that Use Digital Image Processing Fundamentals Steps in Image Processing Elements of Digital Image Processing Systems. Elements of digital image processing, Image model, Sampling and quantization, Relationships between pixels | 10 |
| 2 | Medical Imaging applications: CT, MRI, X-Rays, USG, Sensing element, Adjacency, Neighborhood, | 5 |
| 3 | 2D & 3D Transformations: Translations, Scaling, Reflection, Rotation,Numericals, Homogeneous representation of transformation, Transformation matrix, Concatenation of transformations, Vector inner products, (Bi) Orthogonal, (Bi) Orthonormal, Role of basisfunctions, Perspective projections, Vanishing point, Axonometric projections | 10 |
| **Section B** | | |
| S.No | Topics | Lectures |
| 4 | Design of Surfaces and Solids:Differential geometry, Curves in space, Curves on surface, Ordinary and Singular Points, Developable surfaces, Surfaces of revolution, Curves of Intersection, Surface modeling, 16-point form, Coons patch, B-spline surfaces. Design of Solids: Solid entities, Boolean operations, B-rep of Solid Modeling, CSG approach of solid modeling, Advanced modeling methods. | 10 |
| 5 | Rapid Prototyping: FDM, SLA, SLS, Polymer filament wires, resins, powders, resolution, layer thickness, warping, build volume | 10 |
| 6 | 3D Scanning and Printing: STL, DICOM, surface scanning, types of 3D scanners, Transformation of images for 3D printing | 5 |

| TEXT BOOKS | | | |
|---|---|---|---|
| **S. No.** | **NAME** | **AUTHOR(S)** | **PUBLISHER** |
| 1 | Digital Image Processing | Gonzalez and woods | |
| 2 | Handbook of Medical Image Processing and Analysis | Isaac Bankman | |
| **RECOMMENDED BOOKS** | | | |
| 1 | Geometric Modeling | Michael E. Mortenson | |
| 2 | Computer Aided Engineering Design | AnupamSaxena, BirendraSahay | |

## Elective III
## Courses In Semester 3

| | |
|---|---|
| **Course Code** | **MME302(a)** |
| **Course Title** | **Modeling Of Manufacturing Systems** |
| **Type of Course** | Elective |
| **L T P** | 3 1 0 |
| **Credits** | 4 |
| **Course Assessment Methods**<br>End Semester Assessment (University Exam.)<br>Continuous Assessment (Sessional, Assignments, Quiz) | <br>50<br>50 |
| **Course Prerequisites** | Basic knowledge in mathematical methods and manufacturing processes at UG level |
| **Course Objectives** | To be capable of developing a thorough knowledge in computational techniques to aid in the modeling and analysis of manufacturing systems. |
| **Course Outcomes** | After the completion of the course the student should be able to:<br>Model, simulate, analyze and optimize the advanced manufacturing system. |

### SYLLABUS

***Note for Examiner****- The examiner shall set 8 questions i.e., 4 from each part and students shall be required to attempt a total of 5 questions with at least 2 questions from each part.*

### SECTION-A

**Introduction:**Introduction and Overview, concept of system environment, element of systems, system modeling, types of models. Monte Carlo method, system simulation, Simulation-Management Laboratory, Advantages limitations of systems, Simulation of Continuous and Discrete system. (12 Hrs)

**Modeling of Continuous system:**Characteristics of Continuous System, comparison of Numerical integration with continuous simulation system simulation of integration formula (12 Hrs)

**Modeling of Discrete System:**
Time flow mechanisms, Discrete and continuous probability density function, Generation of random numbers, Testing of random numbers for randomness and for auto correction, generation of random verities for discrete distribution, generation of random

varieties for continuous probability distribution-binomial, normal exponential and beta distribution, combination of discrete event and continuous models. (12 Hrs)

**Modelling of queuing system:**Concept of queuing theory, Characteristics of queues, stationary and time dependent queue, queue discipline, time series analysis, measure of system performance, Kendell's notation, autocovariance and autocorrelation function, auto correlation effects in queuing system, simulation of single server queues, Multi server queues, queues involving complex arrivals and service times with blanking and reneging (12 Hrs)

## SECTION-B

**Design of simulation experiments:** Length of run, elimination of initial bias. Variance reduction techniques, stratified sampling, antipathetic sampling common random numbers, time series analysis, spectral analysis, model validation, optimization procedures, search methods, single variable deterministic case search, single variable non-deterministic case search, regenerative techniques

(12 Hrs)

**Modelling & Simulation of PERT:** Simulation of –Maintenance and replacement problems, capacity planning production system, reliability

| **TEXT BOOKS** | | | |
|---|---|---|---|
| **S. No.** | **NAME** | **AUTHOR(S)** | **PUBLISHER** |
| 1 | Simulation and Modeling | Loffick | Tata McGraw Hill |
| 2 | System Simulation with Digital Computer | DeoNarsingh | Prentice Hall of India |
| **RECOMMENDED BOOKS** | | | |
| 1 | System Simulation | D.S. Hira | S. Chand & Co. |
| 2 | Simulation Modeling & Analysis | David Kelton | Tata McGraw Hill |
| 3 | System Simulation | Gorden | Prentice Hall |

| | |
|---|---|
| **Course Code** | **MME302(b)** |
| **Course Title** | **Finite Element Method** |
| **Type of Course** | Elective |
| **L T P** | 3 1 0 |
| **Credits** | 4 |
| **Course Assessment Methods**<br>End Semester Assessment (University Exam.)<br>Continuous Assessment (Sessional, Assignments, Quiz) | <br>50<br>50 |
| **Course Prerequisites** | Mechanics of Materials |
| **Course Objectives** | 1. To learn fundamental knowledge and basic principles of finite element analysis.<br>2. To learn about various finite elements which represent engineering structure.<br>3. To develop the knowledge and skill to effectively evaluate finite element solutions of structural, thermal and dynamic problems. |
| **Course Outcomes** | 1.Understand the concepts and theory of formulation methods in FEM.<br>2. Identify the characteristics of finite elements and their applications.<br>3. Develop global equations and apply suitable boundary conditions.<br>4. Able to get the finite element solution of various engineering problems. |

## Syllabus

***Note for Examiner****- The examiner shall set 8 questions i.e., 4 from each part and students shall be required to attempt a total of 5 questions with at least 2 questions from each part.*

## Section A

**1 Fundamental Concepts :** Historical Background, Stresses and Equilibrium, Boundary Conditions, Strain—Displacement Relations, Temperature Effects, The Rayleigh—Ritz Method, Galerkin's Method, Saint Venant's Principle, Von Mises Stress, Overview of the software used for FE methods, Advantages and disadvantages of FE methods

**2.Discretization of the Domain:** Types of elements, location of nodes, number of elements, simplification offered by physical configuration of body, node numbering scheme.

**3. One & Two Dimensional Problems :** Introduction, Coordinates and shape functions, Potential energy approach, Galerkin Approach, Assembly of the global stiffness matrix and load vector, FE equations and treatment of boundary conditions, Quadratic shape functions, ,Two dimensional problems using constant strain triangles. Quadrilateral elements.

**4. Axisymmetric solids subjected to axisymmetric loadings:** Axisymmetric formulation, FE modeling using triangular element, problem modelling and boundary conditions.

**Section B**

**5. Static Analysis:** Plane and three dimensional Trusses, Assembly of global matrix for the banded and skyline solutions, Beams and frames under various boundary conditions.

**6. Dynamic Analysis:** Formulation for solid body with distributed mass, Element mass matrices, Evaluation of eigenvalues and eigenvectors, Guyan reduction, Rigid body modes

**7. Pre-processing and Post processing:** Pre-processing, Mesh generation, Post processing, Deformed configuration and mode shape, Convergence requirements, Mesh refinement, Error: sources and detection

8. **FE based optimal design:** Design parameterization, Structural optimization, Topology optimization, Approximation techniques, and Design sensitivity analysis.

| **TEXT BOOKS** | | | |
|---|---|---|---|
| **S. No.** | **NAME** | **AUTHOR(S)** | **PUBLISHER** |
| 1 | FE Procedures | Bathe | Pearson, 2009 |
| 2 | Introduction to FEM | Reddy | McGraw-Hill, 2017 |
| 3 | Introduction to FE in Engineering | Chandupatla, Belegundu | Pearson, 2015 |
| 4 | FE Method for Engineers | Huebner | Wiley, 2009 |
| 5 | Fundamentals of FEA | Hutton | McGraw-Hill, 2003 |
| 6 | FEA with ANSYS | Moaveni | Pearson, 2011 |
| 7 | Introduction to FEM (2009) | Thompson | Wiley |

| | |
|---|---|
| **Course Code** | **MME302(c)** |
| **Course Title** | **Computational Fluid Dynamics** |
| **Type of Course** | Elective |
| **L T P** | 3 1 0 |
| **Credits** | 4 |
| **Course Assessment Methods**<br>End Semester Assessment (University Exam.)<br>Continuous Assessment (Sessional, Assignments, Quiz) | <br>50<br>50 |
| **Course Prerequisites** | Fluid Mechanics, Numerical Analysis, Thermodynamics, and Heat transfer |
| **Course Objectives** | 1. To understand basics of computational fluid dynamics<br>2. To learn different methods for discretization of Navier Stokes Equations<br>3. To implement various algorithms to solve Navier Stokes Equations for Simple Flows over flat plates and flows with heat transfer in 1D and 2D. |
| **Course Outcomes** | 1. Students will be able to discretize PDEs using different methods<br>2. Students will develop understanding about selection of different methods available for solving Navier Stokes Equations according to different boundary conditions. |

## SYLLABUS

***Note for Examiner**- The examiner shall set 8 questions i.e., 4 from each part and students shall be required to attempt a total of 5 questions with at least 2 questions from each part.*

## SECTION-A

**Introduction:**History of CFD; Computational Fluid Dynamics: What, When, and Why?, CFD Applications, Numerical vs Analytical vs Experimental, Modeling vs Experimentation, Fundamental principles of conservation, Reynolds transport theorem, Conservation of mass, Conservation of linear momentum: Navier-Stokes equation, Conservation of Energy, General scalar transport equation (5 hrs)

**Problem Formulation:** The standard procedure for formulating a problem Physical and Mathematical classification of problems; Types of governing Differential equations and Boundary conditions. Mathematical classification of Partial Differential Equation, Illustrative examples of elliptic, parabolic and hyperbolic equations, Physical examples of elliptic, parabolic and hyperbolic partial differential equations (6 hrs)

**Methods of Discretisation:** Discretization principles: Pre-processing, Solution, Post-processing, Finite Element Method, Finite difference method, Well posed boundary value problem, Possible types of boundary conditions, Conservativeness, Boundedness, Transportiveness, Finite volume method (FVM), Illustrative examples: 1-D steady state heat conduction without and with constant source term (5 hrs)

**Finite Volume Method:** Some Conceptual Basics and Illustrations through 1-D Steady State Diffusion Problems: Physical consistency, Overall balance, FV Discretization of a 1-D steady state diffusion type problem, Composite material with position dependent thermal conductivity, Four basic rules for FV Discretization of 1-D steady state diffusion type problem, Source term linearization, Implementation of boundary conditions (4hrs )

**SECTION-B**

**Numerical Solution to Heat Conduction Problems:** Steady-state Problems: (i) One-dimensional Heat Con conduction Transfer through a Pin-fin (ii) Two-dimensional Conduction through a plate Unsteady-state Problem: One-dimensional Transient Heat Conduction. Explicit and Implicit Methods, Stability of numerical Methods. (10 hrs)

**Numerical Solution to Fluid Flow Problems:**Types of fluid flow and their governing equations; Viscous Incompressible flows Calculation of flow field using the stream function-vorticity method; Calculation of boundary layer flow over a flat plate; Numerical algorithms for solving complete Navier- Stokes equations- MAC method; SIMPLE algorithm; Project problem. (12hrs)

| **TEXT BOOKS** | | | |
|---|---|---|---|
| **S. No.** | **NAME** | **AUTHOR(S)** | **PUBLISHER** |
| 1 | Numerical Heat Transfer and Fluid Flow, | S. V. Patankar | Mc. Graw Hill (2007) |
| 2 | Computational Fluid Dynamics | T. J. Chung, | Cambridge University Press |
| **RECOMMENDED BOOKS** | | | |
| 1 | | | |
| 2 | | | |

| | |
|---|---|
| **Course Code** | **MME302(d)** |
| **Course Title** | **Vibration Testing** |
| **Type of Course** | Elective |
| **L T P** | 3 1 0 |
| **Credits** | 4 |
| **Course Assessment Methods**<br>End Semester Assessment (University Exam.)<br>Continuous Assessment (Sessional, Assignments, Quiz) | <br>50<br>50 |
| **Course Prerequisites** | Introductory course on mechanical vibrations |
| **Course Objectives** | Introduction of various techniques that can be used to measure and analyze mechanical vibrations. |
| **Course Outcomes** | Ability to test a structure for vibrations and ability to extract modal parameters from vibration signals. |

## SYLLABUS

***Note for Examiner****- Examiner will set 7 questions of equal marks. First question will cover whole syllabus, having 10 conceptual questions of 1 mark each or 5 questions of 2 mark each and is compulsory. Rest of the paper will be divided into two parts having three questions each and the candidate is required to attempt at least two questions from each part.*

### SECTION-A

**Overview**: Introduction and basic philosophy of modal testing; Historical development of modal testing; Practical applications of modal testing; Basic terminology and notations related to modal testing.

**Methods of Vibration Testing:** Impulse hammer method of modal testing; Roving accelerometer method; Roving hammer method; Shaker method of modal testing; Types of shakers and their relative merits and demerits; Comparison of hammer and shaker method of modal testing.

**Basic Hardware for Vibration Testing:** Working, comparison and selection criterion for different types of accelerometers, mountings of accelerometers, impulse hammers, exciters, connecting cables, charge amplifiers, filters, windows, FFT analyzers.

**FRF Measurement:** Preparation of test structure; Effects of double hitting; Methods of avoiding double hitting effects; Effects of mass loading; Methods of avoiding mass loading effects; Different types of windows and their use in FRF measurements; Different estimates of FRF and effects of noise; Methods of dealing with incomplete measured data; Repeatability of measured FRF data; Reciprocity of measured FRF data.

## SECTION-B

**Verification of Experimental Results:** Visual checks; Low-frequency asymptotes; High-frequency asymptotes; Incidence of anti-resonances; Overall shape of FRF skeleton; Nyquist plot inspection; Repeated modes.

**Modal Parameter Extraction Methods:** Frequency domain methods; Time domain methods; SDOF methods; MDOF methods; Single-FRF methods; Multi-FRF methods; Difficulties in modal parameter extraction due to damping and model order.

**Display of Modal Models:** Static displays; Deflected shapes; Multiple frames; Argand diagram; Dynamic displays; Interpretation of displays of modal models.

**Applications of Vibration Testing:**
Practical applications of vibration testing on following real life structures:

Cantilever beam
Fixed-fixed beam
Drilling machine skeleton (F-structure)
Lathe
I.C. Engine Structure

| **TEXT BOOKS** | | | |
|---|---|---|---|
| **S. No.** | **NAME** | **AUTHOR(S)** | **PUBLISHER** |
| 1 | Modal Testing: Theory, Practice and Application | D.J. Ewins | Second edition, Research Studies Press Limited, England, 2000 |
| 2 | Theoretical and Experimental Modal Analysis | N.M.M. Maia and J.M. Silva | Research Studies Press Limited, England, 1997 |
| **RECOMMENDED BOOKS** | | | |
| 1 | Modal Analysis | He and Fu | Butterworth Heinemann Publisher, Oxford, 2001, ISBN 0 7506 5079 6 |

| | |
|---|---|
| **Course Code** | **MME302(e)** |
| **Course Title** | **Optimization Techniques** |
| **Type of Course** | Elective |
| **L T P** | 3 1 0 |
| **Credits** | 4 |
| **Course Assessment Methods**<br>End Semester Assessment (University Exam.)<br>Continuous Assessment (Sessional, Assignments, Quiz) | <br>50<br>50 |
| **Course Prerequisites** | Calculus, Linear Algebra, Operations Research |
| **Course Objectives** | 1. To understand the theory of optimization methods and algorithms developed for solving various types of optimization problems<br>2. To develop and promote research interest in applying optimization techniques in problems of Engineering and Technology<br>3. To apply the mathematical results and numerical techniques of optimization theory to concrete Engineering problems. |
| **Course Outcomes** | 1. Understanding the need and importance of optimization<br>2. Understanding and Practice of the different Linear Optimization techniques<br>3. Understanding and Practice of the different Non Linear Optimization techniques |

## SYLLABUS

*Note: The examiner shall set 8 questions i.e., 4 from each part and students shall be required to attempt a total of 5 questions with at least 2 questions from each part.*

## PART A

**Linear programming:** Modelling of linear programming problem – a few examples; Solution of linear programming problem – Graphical Method, simplex method, two-phase method, Big-M method; Sensitivity analysis using Graphical technique (12 Hrs)

**Nonlinear programming:** Convex and non-convex search space, Kuhn-Tucker conditions, Hessian matrix; Transformation of constrained optimization problems into unconstrained ones – penalty function approach; Direct search – variable elimination method, random search method (12 Hrs)

## PART B

**Integer Programming:** Modelling of integer programming problem – a few examples; Solution of integer programming problem – branch & bound algorithm, cutting-plane algorithm; Travelling salesman problem – formulation, solution and practical applications (12 Hrs)

**Heuristic models:** Limitations of traditional optimization approaches to solve real world problems, Population based optimization techniques, Simple genetic algorithms – introduction, representation of variables, fitness function, genetic operators – reproduction, crossover, mutation; Advantages and limitations of population based optimization techniques over the point-to-point based ones (12Hrs)

**Recommended Books:**

| Title | Author(s) | Publisher |
|---|---|---|
| Operations Research | Taha, H. A. | |
| PHI | | |
| Optimization of EngineeringDesign | Deb, K. | |
| PHI | | |
| Operations Research | D.S. Hira, P. K. Gupta | S. Chand |

| | |
|---|---|
| **Course Code** | **MME302(f)** |
| **Course Title** | **Materials Design** |
| **Type of Course** | Elective |
| **L T P** | 3 1 0 |
| **Credits** | 4 |
| **Course Assessment Methods**<br>End Semester Assessment (University Exam.)<br>Continuous Assessment (Sessional, Assignments, Quiz) | <br>50<br>50 |
| **Course Prerequisites** | Mechanics of Materials, Materials and Heat Treatment |
| **Course Objectives** | 1. To introduce applications of composite materials<br>2. To educate students about various material characterization techniques<br>3. To familiarize students on the effects of using nano-materials in composites<br>4. To educate students about the uses of modelling in micro and nano scale characterization |
| **Course Outcome** | 1. Evaluate the uses and applications of different types of materials and composites<br>2. Analyze and characterize variety of materials for different types of applications<br>3. Model structures comprising of different types of materials<br>4. Learn various techniques for composite fabrication |

**SYLLABUS**

*Note: The examiner shall set 8 questions i.e., 4 from each part and students shall be required*
*to attempt a total of 5 questions with at least 2 questions from each part.*

**SECTION-A**

Principles of designing components for various engineering applications. Basic Introduction to various types of engineering, dental and bio-materials: Types of engineering materials, properties, glass transition temperatures, mechanical properties, characterization of polymers and ceramic materials (6 hrs)

Introduction to fabrication techniques and methodologies for different types of composite materials: Processing of plastics, extrusion, blow molding, compression moulding, mechanical behavior of ceramics, solvent mixing, melt blending, types of composite materials, laminates, dispersion, particle and fibre strengthening of composites (13 hrs)

**SECTION-B**

Simulation and Finite Element modeling techniques for characterization (10 hrs)
Material analysis and testing techniques: Electron Microscopy, Raman and IR spectroscopy, interpretation of various spectra, crack identification and propagation, Weibull equation and distribution (5 hrs)
Material applications for engineering, dental and surface coatings: use of ceramics in body implants, material requirements for biocompatibility, ceramic compounds and their biomedical applications. Rapid prototyping methods and applications. (5 hrs)

| **TEXT BOOKS** | | | |
|---|---|---|---|
| **S. No.** | **NAME** | **AUTHOR(S)** | **PUBLISHER** |
| 1 | Mechanical Behavior of Materials(3E) | Norman Dowling | Pearson Publishers |
| 2 | Mechanical Behavior of Materials | Bowman | John Wiley &Sons |
| **RECOMMENDED BOOKS** | | | |
| 3 | Mechanical Behavior of Engineering Materials | Roesler, Harders, Baeker | Springer |