SIDDHARTHA ACADEMY OF HIGHER EDUCATION
(Deemed to be University) - Vijayawada
V R SIDDHARTHA SCHOOL OF ENGINEERING
Pre Ph.D List of Courses
MECHANICAL ENGINEERING

POOL I Courses:

S.No	Course Code	Title of the Course	L	T	P	C	SE
1	24ME710A	Manufacturing Machining of Composite Materials	3	0	0	3	100
2	24ME710B	Special Manufacturing Processes	3	0	0	3	100
3	24ME710C	Design for Manufacture	3	0	0	3	100
4	24ME710D	Finite Element Methods for Thermal Engineering	3	0	0	3	100
5	24ME710E	Numerical Methods for Thermal Engineering	3	0	0	3	100
6	24ME710F	Mechanics of Composite Materials	3	0	0	3	100
7	24ME710G	Renewable Energy Systems	3	0	0	3	100
8	24ME710H	Reliability Engineering	3	0	0	3	100

POOL II Courses:

S.No	Course Code	Title of the Course	L	T	P	C	SE
1	24ME720A	Finite Element Methods	3	0	0	3	100
2	24ME720B	Additive Manufacturing	3	0	0	3	100
3	24ME720C	Non- Conventional Machining	3	0	0	3	100
4	24ME720D	Characterization of Composite Materials	3	0	0	3	100
5	24ME720E	Experimental Methods for Thermal Engineering	3	0	0	3	100
6	24ME720F	Non-Destructive Testing	3	0	0	3	100
7	24ME720G	Thermal Energy Storage Technologies	3	0	0	3	100
8	24ME720H	Mechanical Vibrations	3	0	0	3	100

Legend:

L – Lecture, **T** – Tutorial, **P** – Practical, **C** – Credits, **SE** – Semester End Exam

24ME710A
Manufacturing & Machining of Composite Materials

Course Outcomes:

- CO1: Classify the types of composite materials and their characteristic features.
- CO2: Demonstrate the purpose and significance of Functions of various Composite matrix.
- CO3: Apply the methods employed in composite fabrication.
- CO4: Examine the various methods available to characterization and test the Composites through NDT methods.
- CO5: Illustrate the methods employed in composite machining and composite applications.

Unit 1: Introduction to Composites

Concept of Composite materials, Classification of Composites, various types of Reinforcements, fibers and Matrix for composite Materials, Role and Selection of fibers and matrix materials, Mechanical Properties of composite materials.

Unit 2: Functions of Matrix

Desired Properties of Thermosets and Thermoplastics, Metal matrix, Ceramic matrix, Carbon Matrix, Glass Matrix. Laminated composites, Lamina and Laminate Lay-up, Ply-orientation definition, Oxidation protection of Carbon/Carbon Composites, Properties of Carbon/Carbon Composites, and application of Carbon/Carbon Composites.

Unit 3: Manufacturing of Composites

Manufacturing of Polymer Matrix Composites (PMCs)- Spray technique, Filament winding, Pultrusion, Resin Transfer Moulding (RTM), bag moulding, Structural reaction injection moulding, Sandwich Mould Composites (SMC). Manufacturing of Metal Matrix Composites (MMCs) - Solid state, liquid state. Manufacturing of Ceramic Matrix Composites (CMCs) - hot pressing-reaction bonding process-infiltration technique, direct oxidation- interfaces.

Unit 4: Characterization and Testing of Composites

Characterization: Repairing, and Recycling: Mechanical, Physical and Chemical Characterization. Repairing, Solvolysis and Recycling of Polymer Composites. Testing of Composites: Mechanical testing of composites, tensile testing, and Compressive testing. Types of defects, NDT tests – Purpose, NDT method – Ultrasonic inspection, Radiography, Acoustic emission and Acoustic ultrasonic method.

Unit 5: Machining of Composites

Secondary Manufacturing of Polymer Composites: Conventional and Non-traditional machining of Polymer Composites, Drilling of Composites, Drilling Induced Damage, Influence of the Machining Parameters and Tool Geometry on the Machining Quality, Effects of Drilling Parameters on Mechanical Strength. Joining of Polymer Composites: Mechanical, Adhesive bonding. Applications: Aircrafts, missiles, Space hardware, automobile, Electrical and Electronics, Marine, Recreational and sports equipment- future potential of composites.

Text Books:

1. "Mechanics of Composite Materials", Jones R. M., Hemisphere Publishing Corporation, New York.

2. Fibre-Reinforced Composites, Materials, Manufacturing, and Design P.K. Mallick CRC Press, Taylor & Francis Group Third Edition.

3. "Composite materials Science and Engineering", Krishan K. Chawla, 4th Edition, published by Springer, 2019.

4. "Drilling of Polymer-Matrix Composites", Vijayan Krishnaraj, Redouane Zitoune, J. Paulo Davimd, Springer briefs in applied sciences and technology, 2013.

Reference Books:

1. "Stress analysis of fiber Reinforced Composites Materials ", Michael W, Hyer Mc-Graw Hill International 2009.

Web Reference:

1. https://link.springer.com/content/pdf/bfm%3A978-3-642-54634-1%2F1.pdf

2. http://www.ae.iitkgp.ac.in/ebooks

24ME710B
SPECIAL MANUFACTURING PROCESSES

Course Outcomes

At the end of the course, the student will be able to:

- CO1: Apply surface treatment techniques such as CVD, thermal spraying, and diffusion coating to specific manufacturing scenarios. (K3 - Apply)
- CO2: Analyze the process parameters and performance of non-traditional machining techniques like AJM, USM, WJM, and EDM. (K4 - Analyze)
- CO3: Develop insights into the operation of advanced processes such as LBM, PAM, ECM, and EBM for material machining. (K3 - Apply)
- CO4: Classify ceramic and composite processing techniques based on their characteristics and application areas. (K4 - Analyze)
- CO5: Examine microelectronics fabrication processes and nanotechnology fundamentals to evaluate their impact on modern manufacturing. (K4 - Analyze)

Course Units

Unit 1: Surface Treatment

Scope, Cleaners, Methods of cleaning, Surface coating types, and ceramic and organic methods of coating, economics of coating. Electroforming, Chemical Vapour Deposition (CVD), thermal spraying, Ion implantation, diffusion coating, Diamond coating, and cladding.

Unit 2: Non-Traditional Machining

Introduction, need, AJM - Principle, Process capabilities, USM - Mechanics of cutting, models, Parametric Analysis, WJM - Principle, equipment, process characteristics, performance.

Unit 3: EDM and Advanced Machining

EDM - principles, equipment, generators, analysis of R-C circuits, MRR, WEDM. LBM - working, equipment, process parameters. PAM - working, equipment, process parameters. EBM - working, equipment, process parameters. ECM - working, equipment, process parameters.

Unit 4: Processing of Ceramics and Composites

Processing of Ceramics: Applications, characteristics, classification, Processing of particulate ceramics, Powder preparations, consolidation, Drying, sintering, Hot compaction, Area of application, finishing of ceramics.

Processing of Composites: Composite Layers, Particulate and fiber reinforced composites, Elastomers, Reinforced plastics, MMC, CMC, Polymer matrix composites.

Unit 5: Microelectronic Devices and Nanotechnology

Fabrication of Microelectronic devices: Crystal growth and wafer preparation, Film Deposition oxidation, lithography, bonding and packaging, reliability and yield, Printed Circuit Boards (PCBs), computer-aided design in microelectronics, surface mount technology, Integrated circuit economics. **Nanotechnology:** Properties of nano-materials, introduction to micromachining, High-Speed Machining, and rapid prototyping processes.

Text Books

1. Manufacturing Engineering and Technology / Kalpakijian / Adisson Wesley.
2. Process and Materials of Manufacturing / R. A. Lindburg / PHI.

References

1. Microelectronic packaging handbook / Rao. R. Thummala and Eugene, J. Rymaszewski / Van Nostrand Renihold.
2. MEMS & Micro Systems Design and manufacture / Tai - Run Hsu / TMGH.
3. Advanced Machining Processes / V.K. Jain / Allied Publications.
4. Introduction to Manufacturing Processes / John A Schey / McGraw Hill.

24ME710C: Design for Manufacture

Course Outcomes:

- CO-1: Apply the principles of design for economic production and material selection, and process selection.
- CO-2: Analyze design rules for machining, dimensional tolerance and specify design recommendation for machine parts.
- CO-3: Evaluate and integrate advanced casting and welding processes into product design.
- CO-4: Design and optimize forging processes, and material flow to enhance manufacturability and component integrity.
- CO-5: Integrate the knowledge of compliance analysis and interference analysis for assembly.

Course Content:

UNIT I:

Design philosophy, steps in design process, general design rules for manufacturability, basic principles of designing for economical production.
Materials: Selection of materials for design, developments in material technology, criteria for material selection, material selection.

UNIT II:

Machining Processes: Overview of various machining processes, general design rules for machining, dimensional tolerance and surface roughness, design for machining ease, redesigning of components for machining ease with suitable examples, general design recommendations for machined parts.

UNIT III:

Metal Casting: Appraisal of various casting processes, selection of casting process, general design considerations for casting, casting tolerance, use of solidification simulation in casting design, product design rules for sand casting.
Metal Joining: Appraisal of various welding processes, factors in design of weldments, general design guidelines, pre and post treatment of welds, effects of thermal stresses in weld joints, design of brazed joints.

UNIT IV:

Forging: Design factors for forging, closed die forging design, parting lines of dies, drop forging die design, general design recommendations.
Extrusion and Sheet Metal Work: Design guidelines for extruded sections, design principles for punching, blanking, bending, and deep drawing.

UNIT V:

Assembly: Compliance analysis and interference analysis for the design of assembly, design and development of features for automatic assembly, liaison diagrams.
Environment: Introduction to environment, motivations for environmental principles, eco-efficiency, product life cycle perspective, environmental tools and processes, environmental design guidelines.

Text Books:

- Design for Manufacture by Geoffrey Boothroyd.
- Design for Manufacture, John Cobert, Adisson Wesley, 1995.

References:

- Product Design for Manufacturing and Assembly by Geoffrey Boothroyd, Peter Dewhurst, Winston Knight, Marcel Dekker, Inc.
- ASM Handbook, Vol.20.
- Product Design and Manufacturing by A.K Chitale and R.C Gupta, Prentice-Hall of India, New Delhi, 2003.
- Design and Manufacturing by Surender Kumar
  Goutham Sutradhar, Oxford
  IBH Publishing Co. Pvt. Ltd., New Delhi, 1998.

24ME710D: Finite Element Method for Thermal Engineering

Course Outcomes:

- CO1: Differentiating numerical methods and evaluation of FEM solution with analytical solution.
- CO2: Analyze 1-D steady state and transient heat transfer problems.
- CO3: Analyze 2-D steady state heat transfer problems.
- CO4: Formulate 1-D and 2-D fluid kinematics problems.
- CO5: Evaluation of Gauss quadrature numerical integration for 1-D and apply to 2-D integrals.

Course Content:

UNIT I:

Basic Concepts of the Finite Element Method: Introduction, working of finite element method, Comparison of Finite Element and Exact Solutions, Comparison of Finite Element and Finite Difference Methods, General Procedure for Finite Element Analysis, Compatibility and Completeness requirements, Polynomial forms for 1-D linear and quadratic elements, geometric isotropy, Polynomial forms for linear triangular and rectangular elements, Iso-parametric formulation.

UNIT II:

1-D Steady-State Heat Transfer: FE Formulation using Galerkin's approach for one-dimensional heat conduction using linear and quadratic elements, FE Formulation for one-dimensional fins of uniform cross-section using linear elements. Numerical problems in composite walls and fins with specified temperature, heat flux, and convection boundary conditions.
1-D Transient Heat Transfer: FE Formulation using Galerkin's approach, Derivation of element matrices for linear elements, Application of Finite Difference Methods for the Transient Response- Forward, Central, and Backward Difference Schemes, Numerical problems with two linear elements.

UNIT III:

2-D Steady-State Heat Transfer: FE Formulation using Galerkin's approach with linear triangle elements, problem modeling and boundary conditions.
2-D Steady-State Axisymmetric Heat Transfer: Finite element formulation using

Galerkin's approach with linear triangular elements, problem modeling and boundary conditions.

UNIT IV:

Fluid Kinematics: Finite Element formulation for kinematics of 1-D and 2-D steady, incompressible, inviscid, irrotational fluid flows, Problem modeling and boundary conditions for kinematics part of fluid flow, Heat transfer analogy for fluid kinematics problems.

UNIT V:

Numerical Integration: Gauss quadrature formula, One-dimensional Integration with one-point, two-point, and three-point formulas, Two-dimensional numerical integration with two-point formula for linear triangular and linear quadrilateral regions.

Text Books:

- Fundamentals of Finite Element Analysis - David V. Hutton, Tata McGraw Hill.
- Introduction to Finite Elements in Engineering – T. R. Chandraputla A. D. Belegundu, Prentice Hall / PHI.

Reference Books:

- Applied Finite Element Analysis – Larry J. Segerlind, John Wiley and Sons.
- The Finite Element Method in Engineering - Singiresu S. Rao, Butterworth–Heinemann, an imprint of Elsevier.

Web Resources:

- https://www.youtube.com/watch?v=xBgWqy49Z_8
- http://www.nptelvideos.in/2012/11/finite-element-analysis.html
- http://ocw.mit.edu/courses/mechanical-engineering/2-092-finite-element-analysis-of-solids-and-fluids-i-fall-2009/

24ME710E
Numerical Methods in Thermal Engineering

Course Outcomes

- CO1: Apply different methods to solve systems of linear equations.
- CO2: Evaluate the use of linear regression and fitting a straight line for solving problems.
- CO3: Compare the different integration techniques.
- CO4: Analyze the numerical stability and convergence of single-step and multi-step methods.
- CO5: Apply the Finite Difference Method (FDM) to solve Poisson's equation and interpret the numerical results.

Unit I:

NUMERICAL SOLUTIONS OF SYSTEM OF LINEAR AND NON-LINEAR EQUATIONS: System of linear equation: Gauss Elimination Method, Gauss Jordan Method, Choleski Method, Gauss-Seidel Method – System of Non-Linear equations : Method of Iteration, Newton-Raphson Method.

Unit II:

EIGEN VALUE PROBLEMS AND CURVE FITTING: Eigen value problem: Power Method – Curve fitting: Least Square approximations – Fitting a straight line – Regression Lines – Non-Linear curve fitting – Method of least square for continuous functions.

Unit III:

NUMERICAL INTEGRATION: Trapezoidal Rule - Simpson's Rules-Adaptive Quadrature Method – Gaussian Quadrature-Double integrals using Trapezoidal and Simpson's rule.

Unit IV:

NUMERICAL SOLUTIONS OF ORDINARY DIFFERENTIAL EQUATIONS : Single step methods: Euler's Methods – Modified Euler's Method - Runge-Kutta Method of fourth order – Multi Step methods: Milne's and Adam's Predictor and Corrector Methods. Numerical solution of Ordinary Differential Equation by Finite Difference Method.

Unit V:

NUMERICAL SOLUTIONS OF PARTIAL DIFFERENTIAL EQUATIONS: Laplace Equation: Gauss Jacobi Method, Gauss Seidel Method – Poisson Equation: Finite difference method. Parabolic Equation: Crank Nicholson Method – Hyperbolic Equation: Explicit method.

Text Books

1. P.Kandasamy, K.Thilagavathy, K.Gunavathy, "Numerical Methods", S.Chand and Company Ltd., 2010.

2. Veerarajan.T and Ramachandran.T., "Numerical Methods with Programming C", Tata McGraw Hill Publishers, 2007.

Reference Books

1. S.S.Sastry, "Introductory Methods of Numerical Analysis", Prentice Hall of India, 2005.

2. Balagurusamy .E., "Numerical Methods", Tata McGraw Hill Publishers, 1999, reprint 2007.

3. S.R.K.Iyengar, R.K.Jain, "Numerical Methods", New Age International Publishers, 2009.

4. Grewal. B. S., and Grewal. J.S., "Numerical Methods in Engineering and Science", Seventh Edition, Khanna Publishers, 2007.

5. C.F. Gerald and Wheatley. P.O., "Applied Numerical Analysis", Sixth Edition, Pearson Education, 2006.

6. M.K.Jain, S.R.K. Iyengar and R.K.Jain, "Numerical Methods for Scientific and Engineering Computation", Wiley Eastern Limited, 2004.

24ME710F
Mechanics of Composite Materials

Course Outcomes

- CO1: Comprehend the types, benefits, limitations, and applications of composite materials.
- CO2: Analyze problems on macro mechanical behavior of lamina and interpret different manufacturing methods of composites.
- CO3: Analyze problems on micromechanical behavior of lamina.
- CO4: Apply failure criteria and critically evaluate their behavior.
- CO5: Analyze problems on macro mechanical behavior of laminate.

Unit I:

BASIC CONCEPTS AND CHARACTERISTICS: Definition and Characteristics, Applications, Advantages and Limitations of Composite Materials, Current Status and Future Prospects. Geometric and Physical definitions, material response under load, types and classification of composite materials. Reinforcements: Fiber's – Glass, carbon, Aramid, natural, Silica, Kevlar, boron and ceramic fibers. Matrix: Polymer matrix Thermoplastics, Thermosets, Metal matrix and ceramic matrix composites.

Unit II:

MATERIALS AND PROCESSES: Lamina and Laminate-Characteristics and Configurations, Scales of Analysis-Micromechanics and Macro mechanics, Basic Lamina Properties, Degrees of Anisotropy Manufacturing Methods for Composite Materials: Hand Lay up process, Pultrusion, Compression Molding, Injection Molding, Autoclave Molding, Filament Winding, Resin Transfer Molding. STRENGTH OF UNIDIRECTIONAL LAMINA: Longitudinal Tension-Failure Mechanisms and Strength, Longitudinal Compression, Transverse Tension, Transverse Compression, In Plane Shear, Out-of-Plane Loading, General Micromechanics Approach.

Unit III:

ELASTIC BEHAVIOR OF UNIDIRECTIONAL LAMINA: Stress-Strain Relations-General Anisotropic Material, Specially Orthotropic Material, Transversely Isotropic Material, Orthotropic Material Under Plane Stress, Isotropic Material, Relations Between Mathematical and Engineering Constants, Stress-Strain Relations for a Thin Lamina (Two-Dimensional), Transformation of Stress and Strain (Two-Dimensional), Transformation of Elastic Parameters (Two-Dimensional), Relations in Terms of Engineering Constants (Two-Dimensional).

Unit IV:

STRENGTH OF UNIDIRECTIONAL LAMINA: Longitudinal Tension-Failure Mechanisms and Strength, Longitudinal Compression, Transverse Tension, Transverse Compression, In Plane Shear, Out-of-Plane Loading, General Micromechanics Approach. STRENGTH OF COMPOSITE LAMINA: Failure theories, maximum stress theory, maximum strain theory, Tsai- hill, Tsai- Wu theory.

Unit V:

ELASTIC BEHAVIOR OF MULTIDIRECTIONAL LAMINATES: Basic assumptions, Strain-Displacement Relations, Stress-Strain Relations of a Layer Within a Laminate, Force and Moment Resultants, General Load-Deformation Relations: Laminate Stiffness, Inversion of Load-Deformation Relations: Laminate Compliances. Symmetric Laminates: Symmetric Laminates with Isotropic Layers, Symmetric Laminates with specially Orthotropic Layers (Symmetric Cross-ply laminates), Symmetric Angle-Ply Laminates

Text Books

1. Isaac M. Daniel and Ori Ishai, "Engineering Mechanics of Composite Materials", Oxford University Press, 2006.
2. R. M. Jones, "Mechanics of Composite Materials", Taylor & Francis Group, 2015.
3. Madhujit Mukhopadhyay, "Mechanics of Composite Materials", Universities Press.

References

1. B. D. Agarwal and L. J. Broutman, "Analysis and Performance of Fibre Composites", Wiley Inter-science, 2006.
2. Autar K. Kaw, "Mechanics of Composite Materials (2nd Edition)", CRC Taylor and Francis.

E-Resources

- http://nptel.ac.in/courses/Webcourse-contents/IISc-BANG/CompositeMaterials

24ME710G
Renewable Energy Systems

Course Outcomes

- CO1: Compare the efficiency, design considerations and suitability of the collectors.
- CO2: Design and analysis of wind and geothermal energy systems.
- CO3: Analyse the ocean thermal, tidal and wave energy power plant.
- CO4: Apply the basic concepts of various fuel cells.
- CO5: Evaluate the principles of biogas technology.

UNIT I: Solar Energy

Availability of solar energy, Measurement of sunshine, solar radiation data, estimation of average solar radiation, solar energy selection, selective surfaces, Construction of solar flat plate and evacuated tube collectors, Solar heating and cooling. **Photo Voltaic Energy**: Solar cells - Photovoltaic conversion efficiency, Performance characteristics of solar cells as a function of light intensity, temperature and cell area, Solar cell response under normal condition, solar cell arrays.

UNIT II: Wind and Geothermal Energy

Wind mills and wind turbine systems, Classification of wind machines: Horizontal & Vertical axis configuration. High and low solidity rotors, Elements of wind mills and wind turbine systems, Aerodynamic models, Rankine Froud Actuator disc model.
Geothermal Energy: Earth as source of heat energy, stored heat and renewability of earth's heat, Nature and occurrence of geothermal field, Classification of thermal fields, Model of Hyperthermal fields & Semi-thermal fields.

UNIT III: Ocean, Tidal and Wave Energy

Ocean Thermal Energy: Ocean thermal energy sources, Ocean thermal energy power plant development, Closed and open cycles, advantages and operating difficulties.
Tidal & Wave Energy: Tidal power sources, Conventional and latest design of tidal power system, the ocean wave, oscillating water column (Japanese) and the Dam.

UNIT IV: Fuel Cell Energy

Description, properties and operation of fuel cells, Major components & general characteristics of fuel cells, Description of low power fuel cell systems and molten carbonate fuel cell systems.

UNIT V: Biomass Energy

Types of conversion techniques for the production of solid, liquid and gaseous fuels by chemical and biochemical methods - Technology of biogas, - Principles and feed stock Design of bio-gas plants.

Text Books

- Renewable Energy Sources - Twidell J.W. & Weir, A., EFN Spon Ltd., UK., 2nd Edition, 1986.
- Non-Conventional Energy Sources - G.D. Rai, Khanna Publishers, New Delhi, 4th edition, 2009.

References

- Solar Energy - S.P. Sukhatme, Tata McGraw Hill Pub. Co. Ltd., 3rd Edition, 2008.
- Wind Energy Systems - Johnson Gary L., Prentice Hall, New York., 2nd Edition, 1995.
- Biomass Regenerable energy - Hall D.D. & Grover R.P., John Wiley., 1st edition,1989.
- Renewable energy sources & conversion technology - Leemann & Meliss, TMH., 4th edition,1993.
- Non –conventional energy Resources-S.Hasan Saeed, D.K.Sharma, Publishers-S.K.Kataria & Sons, 3rd Edition, 2012.

Web Resources

- www.renewable-energy-sources.com/

24ME710H
Reliability Engineering

Course Outcomes

- CO1: Comprehend the various concepts of mortality curve.
- CO2: Apply different types of failure distributions.
- CO3: Develop the methods of improving the reliability.
- CO4: Apply the concept of reliability management.
- CO5: Analyze the Objectives and Scope of Risk Assessment.

UNIT I: Reliability Concept

Reliability function - failure rate - Mean time between failures (MTBF) - Mean time to failure (MTTF) – a priori and a posteriori concept - mortality curve - useful life availability - maintainability – system effectiveness.

UNIT II: Reliability Data Analysis

Time to failure distributions - Exponential, normal, Gamma, Weibull, ranking of data - probability plotting techniques.

UNIT III: Reliability Prediction Models

Series and parallel systems - RBD approach - Standby systems - m/n configuration - Application of Baye's theorem - cut and tie set method - Markov analysis - FTA - Limitations.

UNIT IV: Reliability Management

Reliability testing - Reliability growth monitoring - Non parametric methods - Reliability and life cycle costs –Reliability allocation - Replacement model.

UNIT V: Risk Assessment

Concept of risk- objective and scope of risk assessment- probabilistic Risk- risk perception and acceptability- PRA management- preliminary hazard analysis- HAZOP and HAZAN, FMEA and FMECA analysis, Fault tree Analysis.

Text Books

- Modarres, "Reliability and Risk analysis ", Mara Dekker Inc., 1993.

References

- John Davidson, “The Reliability of Mechanical system “, published by the Institution of Mechanical Engineers, London, 1988.
- Smith C.O.” Introduction to Reliability in Design “, McGraw Hill, London, 1976.

Web Resources

- http://LifeDataAnalysis.com
- http://nptel.ac.in/courses/10567/reliability
- www.ReliabilityGrowthAnalysis.com
- www.FMEAandFMECAAnalysis.com

24ME720A
Finite Element Method

Course Outcomes:

Upon successful completion of the course, the student will be able to:

- CO1: Analysis of 1-D bar problems using variational and finite element methods.
- CO2: Analysis of planar truss, beam and frame problems using FEM.
- CO3: Analysis of 2-D plane-stress, plane-strain and axisymmetric problems using FEM.
- CO4: Analysis of natural frequencies of 1-D bar using FEM.
- CO5: Evaluation of Gauss quadrature numerical integration for 1-D and apply to 2-D integrals.

UNIT I:

Fundamental concepts: Introduction, stresses and equilibrium, boundary conditions, strain- displacement relations, stress-strain relations for plane stress, plane strain, 2-D axisymmetric and three-dimensional cases, potential energy and equilibrium; the Rayleigh-Ritz method, Galerkin's method. Basic concepts of FEM and one dimensional problems: Fundamental concepts, Finite Element Modeling using linear 1-D elements, coordinates and shape functions, the potential energy approach, element stiffness matrix and element load vector, assembly of the global stiffness matrix and load vector, properties of global stiffness matrix, the Finite Element equations; treatment of boundary conditions, examples of axially loaded members. Quadratic bar element applied to one- dimensional bar problem.

UNIT II:

Analysis of one-dimensional structures: Plane trusses: Introduction, plane trusses, local and global coordinate systems, element stiffness matrix, treatment of boundary conditions, stress calculations, example of plane truss with three members. Planar beams: Introduction, potential energy approach, element stiffness matrix for two node planar beam element, load vector for uniformly distributed load, boundary conditions, simple beam problems. Plane frames: Introduction, potential energy approach, element stiffness matrix for two node planar frame element, load vector for uniformly distributed load, boundary conditions, simple frame problems.

UNIT III:

Two dimensional problems: Introduction, plane stress and plane strain, Finite Element Modeling, Constant Strain Triangle (CST); potential energy approach, derivation of element stiffness matrix, derivation of force vector for body forces and linearly varying pressure load, problem modeling and boundary conditions. simple problems. Finite element formulation for an axisymmetric linear triangular element, potential energy approach, derivation of element stiffness matrix, derivation of force vector for body forces and uniformly distributed pressure load, simple problems.

UNIT IV:

Dynamic Analysis: Dynamic equations of motion, consistent and lumped mass matrices, mass matrices of a space truss, space frame, planar frame, beam, and tetrahedron elements. Lumped mass matrices, Evaluation of Eigenvalues and eigenvectors using characteristic polynomial technique. Free longitudinal vibrations of a stepped bar.

UNIT V:

Numerical Integration: Gauss quadrature formula, One-dimensional Integration with one-point formula, two point formula, three-point formula. Two-dimensional numerical integration with two- point formula for linear triangular and linear quadrilateral regions.

Text Books:

- Introduction to Finite Elements in Engineering by T. R. Chandrupatla and A. D.Belegundu, 3rd Edition, PHI Learning Private Limited, 2011.

Reference Books:

- Singiresu S. Rao, "The Finite Element Method in Engineering", Fifth edition, Butterworth-Heinemann, 2011.
- Applied Finite Element Analysis – Larry J. Segerlind, John Wiley and Sons, Second Edition, 1984.

E-Resources:

- https://en.wikipedia.org/wiki/Finite_element_method
- http://reference.wolfram.com/applications/structural/FiniteElementMethod.html
- https://www.youtube.com/watch?v=oNqSzzycRhw

24ME720B
Additive Manufacturing

Course Outcomes:

At the End of the course the student will be able to:

- CO1: Apply the fundamentals of additive manufacturing to differentiate it from conventional manufacturing techniques.
- CO2: Develop prototypes using liquid-based additive manufacturing techniques like SLA, SGC, and PolyJet.
- CO3: Construct solid-based AM models by utilizing processes such as FDM, MJM, and LOM.
- CO4: Analyze powder-based rapid prototyping systems, including SLS and 3DP, for their applications and advantages.
- CO5: Evaluate additive manufacturing data formats and software for domain-specific applications like aerospace and automotive.

UNIT I:

Introduction to Additive Manufacturing Techniques: Introduction, Prototyping Fundamentals-Definition, Types and roles of Prototypes, Historical development, Fundamentals of Additive Manufacturing, AM Process Chain, Advantages and Limitations of AM, Commonly used Terms. Additive Manufacturing: Classification of AM process, Fundamental Automated Processes, Process chain, Distinction between AM and CNC other related technologies.

UNIT II:

Liquid Based Additive Manufacturing: Liquid-based AM Systems: Stereo lithography Apparatus (SLA): Models and specifications, Process, working principle, photopolymers, photo polymerization, Layering technology, laser and laser scanning, Applications, Advantages and Disadvantages. Solid ground curing (SGC): Models and specifications, Process, working principle, Applications, Advantages and Disadvantages. Poly jet: Models and specifications, Process, working principle, Applications, Advantages and Disadvantages.

UNIT III:

Solid-Based AM Systems: Laminated Object Manufacturing (LOM): Models and specifications, Process, working principle, Applications, Advantages and Disadvantages. Fused Deposition Modeling (FDM): Models and specifications, Process, working principle, Applications, Advantages and Disadvantages. Multi-Jet Modelling (MJM): Models and specifications, Process, working principle, Applications, Advantages and Disadvantages.

UNIT IV:

Powder Based Rapid Proto Typing Systems and Tooling: Powder Based Rapid Prototyping Systems: Selective laser sintering (SLS): Models and specifications, Process, working principle, Applications, Advantages and Disadvantages. Three dimensional

Printing (3DP): Models and specifications, Process, working principle, Applications, Advantages and Disadvantages. Laser Engineered Net Shaping (LENS): Models and specifications, Process, working principle, Applications, Advantages and Disadvantages. Rapid Tooling: Classification and Definition of terms, Properties of AM tools, Indirect Rapid Tooling Processes, Direct Rapid Tooling Processes.

UNIT V:

ADDITIVE MANUFACTURING DATA FORMAT AND SOFTWARE: STL format, STL File Problems, Consequences of Building Valid and Invalid Tessellated Models, STL File Repair ADDITIVE MANUFACTURING APPLICATIONS: Applications in Design, Engineering, Analysis and Planning, Manufacturing and Tooling, Aerospace Industry, Automotive Industry, Jewelry Industry, Coin Industry, Arts and Architecture

Text Books:

- Chua C.K., Leong K.F, LIM C.S, "Rapid Prototyping: Principles and Applications", World Scientific publications, 3rd Edition, 2010.

Reference Books:

- Andreas Gebhardt, Jan-Steffen Hötter, "Additive Manufacturing 3D Printing for Prototyping and Manufacturing" Hanser Publications, Cincinnati, 2016.
- Paul F Jacobs, "Rapid Prototyping Manufacturing", Wohlers Associates, ASME Press, 1st Edition, 1996.
- D.T Pham, S. S. Dimov, "Rapid Manufacturing", Springer, 1st Edition, 2001.

Web References:

- http://nptel.ac.in/courses/112107077/38
- http://web.iitd.ac.in/~pmpandey/MEL120_html/RP_document.pdf

24ME720C
NON-CONVENTIONAL MACHINING

Course Outcomes:

- CO1: Comprehend the principles and significance of non-conventional machining processes, and evaluate their applications, advantages, and limitations.
- CO2: Analyze the operational principles, process parameters, and performance characteristics of Ultrasonic Machining and Abrasive Jet Machining.
- CO3: Evaluate the mechanism, equipment, process parameters, and operational configurations of Electrical Discharge Machining.
- CO4: Analyze the principles, mechanisms, equipment, and process parameters of Laser Beam Machining, Plasma Arc Machining, and Electron Beam Machining.
- CO5: Analyze the principles, mechanisms, equipment, and process parameters of Electro Chemical Machining and Chemical Machining.

UNIT-I:

Introduction: Introduction to Non-Conventional machining, Need for Non-Conventional machining process, Comparison between Conventional and Non-Conventional machining, general classification Non-Conventional machining processes, classification based on nature of energy employed in machining, selection of Non-Conventional machining processes, Specific advantages, limitations and applications of Non-Conventional machining processes.

UNIT-II:

Mechanical processes: Ultrasonic Machining (USM): Introduction, Equipment and material process, Effect of process parameters: Effect of amplitude and frequency, Effect of abrasive grain diameter, effect of slurry, tool work material. Process characteristics: Material removal rate, tool wear, accuracy, surface finish, applications, advantages limitations of USM. Abrasive Jet Machining (AJM): Introduction, Equipment and process of material removal, process variables: carrier gas, type of abrasive, work material, stand-off distance (SOD). Process characteristics-Material removal rate, Nozzle wear, accuracy surface finish. Applications, advantages limitations of AJM.

UNIT-III:

Electrical discharge machining (EDM): Introduction, mechanism of metal removal, EDM equipment: spark erosion generator (relaxation type), dielectric medium-its functions desirable properties, electrode feed control system. Flushing types; pressure flushing, suction flushing, side flushing, pulsed flushing. EDM process parameters: Spark frequency, current spark gap, surface finish, Heat Affected Zone. Advantages, limitations applications of EDM, Electrical discharge grinding, Traveling wire EDM.

UNIT-IV:

Laser beam machining (LBM): Introduction, generation of LASER, Equipment and mechanism of metal removal, LBM parameters and characteristics, Applications, Advantages limitations.

Plasma arc machining (PAM): Introduction, non-thermal generation of plasma, equipment mechanism of metal removal, Plasma torch, process parameters, process characteristics. Safety precautions. Safety precautions, applications, advantages and limitations. Electron beam machining (EBM): Introduction, Principle, equipment and mechanism of metal removal, applications, advantages and limitations.

UNIT-V:

ELECTROCHEMICAL MACHINING (ECM): Introduction, Principle of Electro Chemical Machining, ECM equipment, elements of ECM operation, Chemistry of ECM. ECM Process characteristics: Material removal rate, accuracy, surface finish. Process parameters: Current density, Tool feed rate, Gap between tool work piece, velocity of electrolyte flow, type of electrolyte, its concentration temperature, and choice of electrolytes. ECM Tooling: ECM tooling technique example, Tool insulation materials. Applications ECM: Electrochemical grinding and electrochemical honing process. Advantages, disadvantages and application of ECG, ECH.

CHEMICAL MACHINING (CHM): Elements of the process, Resists (maskants), Etchants. Types of chemical machining process- chemical blanking process, chemical milling process. Process characteristics of CHM: material removal rate, accuracy, surface finish, advantages, limitations and applications of chemical machining process.

Text Books:

1. Advanced Machining Processes by V.K. Jain. Allied Publishers Pvt Ltd.
2. Modern Machining Processes by P.C. Pandey and H.S. Shan. Tata McGraw-Hill.

Reference Books:

1. Production technology HMT McGraw Hill Education India Pvt. Ltd 2001.
2. Benedict, G.F., "Non-traditional Manufacturing Processes", Marcel Dekker Inc., New York 1987.
3. Carl Sommer, "Non-Traditional Machining Handbook", Advance Publishing, United States, 2000.

4. Jagadeesha T., "Non-Traditional Machining Processes", I.K. International Publishing House Pvt. Ltd., New Delhi, India, 2017.

24ME720D
CHARACTERISATION OF COMPOSITE MATERIALS

Course Outcomes:

1. Analyze the various properties of composites.
2. Perform mechanical testing on composite materials by applying standard procedures and interpret the results.
3. Apply techniques for Thermophysical Characterization of composites.
4. Evaluate the dielectric properties of composites in varying frequency ranges.
5. Apply acoustic characterization methods to assess sound properties and analyze morphology of composites.

UNIT-I: Introduction

Introduction to testing of Composites,Standards organizations (BIS, ASTM, BS, DIN, ISO). Preparation of test pieces and conditioning. Properties of composites: Mechanical, Thermal, Electrical, and Acoustic properties.

UNIT-II: Mechanical Characterization of Composites

Mechanical testing including tensile, flexural, compressive, shear, fracture, fatigue, and impact testing.

UNIT-III: Thermophysical Characterization

Measurement of Thermal conductivity of composites using guarded heat flow meter, Laser Flash Method. Measurement of Specific heat of composites using Differential calorimeter, Thermal diffusivity, Density, Thermal degradation of composites using Thermo gravimetric analyzer.

UNIT-IV: Dielectric Characterization

Dielectric Characterization of composites in the high and very high frequency fields (a.c field), ultra high frequency field (Microwave field). Dielectric constant, dielectric loss and absorption property of composites in the a.c and microwave fields.

UNIT-V: Acoustic and Morphology Characterization

Acoustic characterization of composite materials: Methods for measuring the sound absorption coefficient (SACs) of material samples: Two- microphone impedance tube method and reverberation room method. Two-microphone impedance tube method as per ISO 10534–2 (ISO (International Organization for Standardization) 1998) and ASTM E1050 (ASTM (American Society for Testing and Materials) 2019a) standards. The reverberation room method is as per ISO 354 (ISO (International Organization for Standardization) 2003) and ASTM C423 (ASTM (American Society for Testing and Materials) 2017) standards. Morphology study of composites: Preparation of samples for morphology analysis. Study of morphology of composites using Scanning Electronic Microscope (SEM) and Transmission electron microscope (TEM).

Text Books:

1. Hand Book of Plastic Test Methods, R.P. Brown (Ed.), George Godwin, London 1981.
2. ASTM, BS, BIS, ISO, and DIN Standards for Plastics & Rubber tests.
3. Hand Book of Plastics Test Methods, G.C. Ives, J.A. Mead, M.N. Riley, Iliffe, London, 1971.
4. Hand Book of Plastics Testing Technology, Vishu Shah, Wiley, 1998.
5. Engineered Materials Handbook vol. 3 Adhesives and Sealants, C.A. Dostal et al., ASM International, 1990.
6. Conductive Polymers and Plastics, James Margolis (Editor), 2011.

24ME720E
Experimental Methods in Thermal Engineering

Course Outcomes

- CO1: Apply experimental planning techniques for selecting and configuring measuring instruments.
- CO2: Analyze temperature measurement techniques based on radiation and evaluate their applicability in different industrial environments.
- CO3: Analyze the principles and applications of hot-wire anemometers for measuring fluid velocity.
- CO4: Evaluate convection heat transfer measurements and determine the heat transfer coefficients in various fluid flow conditions.
- CO5: Apply chemical, thermal, magnetic, and optical gas analyzers to measure the concentration of gases in different applications.

Unit I: Measurement Characteristics

Instrument Classification, Characteristics of Instruments – Static and dynamic, experimental error analysis, Systematic and random errors, Statistical analysis, Uncertainty, Experimental planning and selection of measuring instruments, Reliability of instruments, Variable resistance transducers, capacitive transducers, piezoelectric transducers, photoconductive transducers, photovoltaic cells, ionization transducers, Hall effect transducers.

Unit II: Temperature Measurement

Temperature measurement by mechanical effect, temperature measurement by radiation, transient response of thermal systems, thermocouple compensation, temperature measurements in high-speed flow.

Unit III: Flow Measurement

Flow measurement by drag effects; hot-wire anemometers, magnetic flow meters, flow visualization methods, interferometer, Laser Doppler anemometer.

Unit IV: Thermal Conductivity and Radiation Measurements

Thermal conductivity measurement of solids, liquids, and gases, measurement of gas diffusion, convection heat transfer measurements, humidity measurements, and heat-flux meters. Detection of thermal radiation, measurement of emissivity, reflectivity, and transmissivity, solar radiation measurement.

Unit V: Measurement Analysis

Chemical, thermal, magnetic, and optical gas analyzers, measurement of smoke, dust, and moisture, gas chromatography, spectrometry, measurement of pH, Review of basic measurement techniques.

Textbooks

1. Holman, J.P., Experimental Methods for Engineers, McGraw-Hill, 1988.
2. Barney, Intelligent Instrumentation, Prentice Hall of India, 1988.

Reference Books

1. Prebrashensky, V., Measurements and Instrumentation in Heat Engineering, Vol.1 and 2, MIR Publishers, 1980.
2. Raman, C.S., Sharma, G.R., Mani, V.S.V., Instrumentation Devices and Systems, Tata McGraw Hill, New Delhi, 1983.
3. Doeblin, Measurement System Application and Design, McGraw Hill, 1978.
4. Morris A.S, Principles of Measurements and Instrumentation, Prentice Hall of India, 1998.

24ME720F
Non-Destructive Testing

Course Outcomes

- CO1: Apply the fundamentals of non-destructive testing and Liquid Penetration testing.
- CO2: Analyze Magnetic Particle Testing and Ultrasonic testing methods.
- CO3: Analyze Acoustic Emission Testing, Thermography, and Codes, Standards, Specification, and Procedures used for NDT.
- CO4: Evaluate the procedures to detect different flaws in composite materials.
- CO5: Apply X-ray tomography principles to the non-destructive testing of high-performance polymer composites.

Unit I: Introduction

INTRODUCTION: Various methods, advantages, disadvantages and applications. Visual Examination: Basic principle, the eye- defects which can be detected by unaided, visual inspection, optical aids used for visual inspection- microscope, bore scope, endoscope, telescope, holography; applications. LIQUID PENETRANT TESTING: Physical principles, Procedure for Penetrant testing- cleaning, penetrant application, removal of excess penetrant, application of developer, inspection and evaluation; Penetrant testing materials: penetrants, cleaners and emulsifiers, developers, special requirements, test blocks; penetrant testing methods: water washable method, post-emulsifiable method, solvent removal method; sensitivity, applications limitations.

Unit II: Magnetic Particle and Ultrasonic Testing

Principle of MPT, Magnetizing techniques- magnetization using a magnet, magnetization using an electro magnet, constant current flow method. Procedure used for testing a component: Equipment used for MPT-simple equipment, large portable equipment, stationary magnetizing equipment; sensitivity, limitations.

ULTRASONIC TESTING: Basic properties of sound beam- sound waves, velocity of ultrasonic waves, acoustic impedance, behavior of ultrasonic waves. Inspection methods: Normal incident pulse-echo inspection, normal incident through-transmission testing, angle beam pulse-echo testing, criteria for probe selection, flaw sensitivity, beam divergence, penetration and resolution.

Unit III: Acoustic Emission Testing and Thermography

Principles, techniques, instrumentation, and applications. Thermography principles, detectors, techniques, and applications.

Unit IV: Eddy Current and Radiography Testing

Eddy current testing principles, instrumentation, sensitivity, applications, limitations. Radiography principles, radiation sources, imaging, applications, limitations.

Unit V: Codes, Standards, Specification, and Procedures

Indian and International Standards for Non-Destructive Testing.

Textbooks

1. Practical Non-Destructive Testing, (2nd Edition) by Baldev Raj, T. Jayakumar, M. Thavasimuthu, Woodhead Publishing Limited.
2. Non-Destructive Testing of Fibre-Reinforced Plastics Composites by J. Summerscales, Springer.

Reference Books

1. Damage Detection in Composite Materials by Masters JE, ASTM STP 1128.
2. Non-destructive evaluation and flaw criticality for composite materials by R. Byron Pipes, ASTM International, 1979.

24ME720G
Thermal Energy Storage Technologies

Course Outcomes:

- CO1: Analyze the necessity of thermal storage systems in energy management and sustainability.
- CO2: Analyse thermal storage systems knowledge through modelling and simulation.
- CO3: Apply the concepts of parallel flow and counter flow heat exchangers to analyse and design heat exchange systems.
- CO4: Apply temperature-based and enthalpy models to simulate phase change phenomena in engineering applications.
- CO5: Evaluate solar energy storage systems for various applications.

UNIT I: Introduction

Thermal Storage necessity, classification of energy storage devices, various energy storage technologies & their comparison, storage materials, Seasonal thermal energy storage.

UNIT II: Basic Concept of Sensible Heat Storage System

Modelling of heat storage units, simple water and rock bed storage systems- use of TRNSYS packed beds and pressurized water storage system for power plant applications.

UNIT III: Regenerators

Types – parallel flow and counter flow – finite conductivity model & nonlinear model, transient performance, step changes in inlet gas temperature, step changes in gas flow rate, parameterization of transient response-recuperative and regenerative heat exchangers.

UNIT IV: Latent Heat Storage Systems

Modelling of phase change problems- temperature based model-enthalpy model porous medium approach-conduction dominated phase change convection dominated phase change.

UNIT V: Applications

Specific areas of application of energy storage – food storage - food preservation - waste heat recovery. Solar energy storage - green house heating - power plant applications-drying and heating for process industries.

Text Books:

1. Thermal Energy Storage Systems and Applications - Ibrahim Dincer & Mark A. Rosen, John Wiley & Sons.
2. Solar Engineering of Thermal Processes - J. Duffie, W. A. Beckman, John Wiley & Sons Inc.
3. Energy Conversion Systems - H.A. Sorenson, John Wiley & Sons.

References:

1. Thermal Storage and Regeneration - Schmidt F.W. & Willnot A.J., Hemisphere Pub. Corp.
2. Heat Transfer in Cold Climates - Lunadini V.J., John Wiley & Sons.
3. Sustainable Thermal Storage Systems: Planning, Design, and Operations - Hyman, Lucas B., McGraw-Hill.
4. Renewable Energy Sources & Conversion Technology - Bansal, K. Leeman & Mellis.

Web Resources:

- https://www.irena.org/DocumentDownloads
- http://arena.gov.au/project/advanced-solar-thermal-energy-storage-technologies/

24ME720H
Mechanical Vibrations

Course Outcomes:

- CO1: Apply the knowledge of mathematics and science to solve the free vibration problems of Single-Degree-of-Freedom Systems.
- CO2: Develop the mathematical models, analyze, and solve to find the response of Single-Degree-of-Freedom Systems subjected to harmonic excitation.
- CO3: Develop the mathematical models, analyze, and solve to find the free/forced vibration response of Two-Degrees-of-Freedom Systems and continuous systems.
- CO4: Apply the Fundamentals of Predictive Maintenance.
- CO5: Apply Maintenance and Condition Monitoring Techniques to machinery and Diagnose Machinery faults.

UNIT I: Free Vibration of Single-Degree-of-Freedom Systems

Importance of the Study of Vibration, Elementary Parts of Vibrating Systems, Number of Degrees of Freedom, Discrete and Continuous Systems, Classification of Vibration, Vibration Analysis Procedure, Harmonic Motion, Harmonic Analysis, Free Vibration of an Undamped Translational and Torsional Systems, Rayleigh's Energy Method, Free Vibration with Viscous Damping and Coulomb Damping.

UNIT II: Harmonically Excited Vibration

Equation of Motion, an Undamped System Under Harmonic Force, Damped System Under Harmonic Force, Damped System Under the Harmonic Motion of the Base, Damped System Under Rotating Unbalance, Transfer-Function Approach, Solutions using Laplace Transform, Frequency Transfer Functions, Representation of Frequency-Response Characteristics.

UNIT III: Two-Degree-of-Freedom Systems

Free Vibration Analysis of an Undamped System, Coordinate Coupling and Principal Coordinates, Forced-Vibration Analysis, Dynamic Vibration Absorber.
Multi-Degree-of-Freedom Systems: Influence Coefficients, Potential and Kinetic Energy Expressions, Generalized Coordinates and Generalized Forces Using Lagrange's Equations to Derive Equations of Motion, Free Vibration of Multi-Degree-of-Freedom Systems.

UNIT IV: Predictive Maintenance Techniques

Basics, maintenance philosophies, Bathtub curve, Classification of maintenance, advantages, and disadvantages of maintenance, plant machinery classifications, and recommendations. Introduction to Condition Monitoring, Definition, Types of Condition Monitoring.

UNIT V: Machinery Fault Diagnosis Using Vibration Analysis

Unbalance, Bent Shaft, Eccentricity, Misalignment, Looseness, Belt Drive Problems, Gear Defects, Bearing Defects.

Text Books:

1. Mechanical Vibrations (5th edition) by Singiresu S. Rao, Pearson Education.
2. Machinery Vibration Analysis & Predictive Maintenance by Paresh Girdhar, Elsevier Publishers.

References:

1. Elements of Vibration Analysis (2nd edition) by Leonard Meirovitch, McGraw-Hill.
2. Mechanical Fault Diagnosis and Condition Monitoring by R. A. Collacott.
3. Mechanical Vibrations: Theory and Applications (1st edition) by S. Graham Kelly, Cengage Learning.
4. Vibrations (2nd edition) by Balakumar Balachandran and Edward B. Magrab.