Department of Mechanical Engineering

M.E.
Specialization: CAD CAM & CAE

SYLLABUS

2024-25

Shri G. S. Institute of Technology & Science, Indore
23, Park Road, Indore-03

(An Autonomous Institution, Established in 1952)

Code	Subject Name	L	T	P	Credits			Maximum Marks				
					T	P	Total	Th.	CW	SW	Viva	Total
ME87001	Engineering Materials	4	0	0	4	0	4	70	30	0	0	100

Course Outcomes (COs)

At the end of this course the student is expected to learn:

1 Understand the different types and applications of modern materials and alloys.
2 Classify composites, its importance and properties.
3 Understand the properties of different types of polymers and plastics.
4 Analyze the mechanics of composite materials.
5 Asses the applicability and selection of testing and design concept of composites.

COURSE CONTENTS

Unit 1: Modern materials and alloys: Super alloys refractory materials, Ceramic and their applications, Low melting alloys, Shape memory alloys, Advanced Composites, Metal matrix and ceramic matrix, Carbon-Carbon composites, Ti and Ni based alloys for gas turbine applications, cryogenic applications, Steels-Newer materials and their treatment for automobile applications, materials for Naval and nuclear systems. Smart and Nano materials.

Unit 2: Composite Materials: General introduction and concept, Historical development, Concept of Composite materials, importance of composite material and its engineering potential, Comparison with metals, advantages and limitations of composites, Basic definitions and classification of composites, various types of composites, Classification based on matrix material, Classification based on reinforcements.

Unit 3: Plastics and Polymers Composites: Structure and properties of thermoplastics and thermosets, Fiber reinforced plastic processing, Engineering applications, Property modifications, Mechanical, thermal behavior of composites with polymer matrix.

Unit 4: Mechanics of Composites: Concept of Laminate, Laminate Strain-Displacement relationship based on Kirchhoff's Hypothesis, Mechanical behavior of unidirectional, cross-ply and angle-ply. Structural mechanics of laminates, Macro-mechanical failure theories, maximum stress theory, maximum strain theory, Tsai-Hill theory, Tsai-Wu theory.

Unit 5: Testing and Design Concept: Mechanical testing of composites, Tensile testing, Compressive testing, Intra-laminar shear testing, Inter-laminar shear testing, Fracture testing etc. Design issues, Typical structural component design process, Laminate analysis/design software, Composite codes and standards, Manufacturing processes.

BOOKS:

1. Engineering Materials and Applications P Flinn and P.K. Trojan MIR Publications.
2. Engineering Materials: Polymers, Ceramics and Composites. A.K. Bhargava, Prentice Hall of India.
3. Advances in Materials and their applications, P. Rama Rao, Wiley Eastern.
4. Fiber Reinforced Composites, P.K. Mallick, CRC Press.
5. Mechanics of Composite Materials, Auter Jaw.
6. Mechanics of Composite Materials, R. Jones, Taylor and Francis.

Code	Subject Name	L	T	P	Credits			Maximum Marks				
					T	P	Total	Th.	CW	SW	Viva	Total
ME87002	Advanced Machine Design	4	0	2	4	2	6	70	30	40	60	200

Course Outcomes

At the end of this course the student is expected to learn:

1 Students will demonstrate the ability to identify needs of the customer and convert them in to technical specifications of a product.
2 Students will realize that creativity, manufacturability, assembly, maintainability, reliability are also important aspects of design other than finding dimensions and stresses
3 Students will be able to solve problems in unsymmetrical bending and shear center.
4 Students will be able to analyse torsion in solid and thin section
5 Students will be able to design the components considering strength based reliability.

COURSE CONTENTS

Unit 1: Mechanical design process, Phases and interactions of design process, design for sustainability, use of standards and codes in design. Tribological considerations in design, Human factors in design.

Unit 2: Design for manufacturing & assembly: Design consideration and recommendation for machining, casting, extrusion, etc. design consideration and recommendation for assembly processes.

Unit 3: Unsymmetrical Bending and Shear Centre: Concept of shear center in symmetrical and unsymmetrical bending, stress and deflections in beams subjected to unsymmetrical bending, shear center for thin wall beam cross section, open section with one axis of symmetry, general open section, and closed section.

Unit 4. Theory of Torsion: Torsion of prismatic bars of solid section and thin walled section. Analogies for torsion, membrane analogy, fluid flow analogy and electrical analogy. Torsion of conical shaft, bar of variable diameter, thin walled members of open cross section in which some sections are prevented from warping, Torsion of noncircular shaft.

Unit 5: Design based on Reliability: Design for Reliability, strength based reliability, approach to robust design. Experimental Stress Analysis: Strain gauges, photo elasticity, non-destructive testing, brittle coating.

References:

1. Mechanical Design Process, D G Ullman, McGraw Hill Book Company
2. Design of Machine Elements, V B Bhandari McGraw Hill
3. Design for Manufacturing and Assembly, O Molloy, E A Warman, S Tilley, Springer
4. Advance Strength of Materials, Sandhu Singh, Khanna Publishers
5. Strength of Materials, S S Ratan, McGraw Hill
6. Experimental Stress Analysis, J W Dally, W F Riley, McGraw Hill

Code	Subject Name	L	T	P	Credits			Maximum Marks				
					T	P	Total	Th.	CW	SW	Viva	Total
ME87004	Finite Element Analysis	4	0	2	4	2	6	70	30	40	60	200

Course Outcomes

At the end of this course the student is expected to:

1 The student will be able to classify a given problem on the basis of its dimensionality as 1- D, 2-D, or 3-D, time-dependence as Static or Dynamic, Linear or Non-linear. Student will also understand deriving governing differential equations for axial bar problems.
2 Student will be able to derive the shape functions and element level governing equations for solving axial bar problem. They will also understand criterion to select proper number of elements in finite element analysis.
3 Student will be able to solve beam problems by finite element method and will also learn to extend bar and beam elements to solve truss and frame problems.
4 Students will be able to write shape functions for lower and higher order two dimensional and quadrilateral elements and will also learn writing governing differential equations for two dimensional problems.
5 Students will be able to write equations of motion of dynamic systems using finite element method. They will also learn solving eigen value and force vibration problem using finite element method.

COURSE CONTENTS

Unit 1: Introduction to approximate methods of solving mathematical models of physical systems. Method of weighted residuals and variational approach for solving differential equations. Galerkin method. Weak form of weighted residual statement.

Unit 2: Basic aspects of the finite element method. Principle of minimum potential energy. Rayleigh-Ritz method. Introduction to finite element modelling of one dimensional problems in statics. Finite element for bar problems, Linear and quadratic shape functions. Convergence criterion.

Unit 3: Finite element formulation for truss and frame problems. Formulation of Beam problems. Numerical integration, Coordinate transformation

Unit 4: Plane stress and plane strain problems, Axisymmetric Formulation, Two dimensional problems using constant strain triangles and higher order elements, iso-parametric formulation.

Unit 5: Dynamic analysis, Equations of motion, Mass Matrices, Free vibration analysis, Natural frequencies of longitudinal, transverse and torsional vibration, Introduction to transient field problems.

Books

1. Textbook of Finite Element Analysis, P. Seshu, Eastern Economy Edition
2. Finite Element Analysis, C S Krishnamoorthy, Tata McGraw-Hill
3. Finite Element Method, J. N. Reddy, Tata Mc Graw-Hill
4. Finite Elements in Engineering, Chandrupatla and Belegundu, Prentice Hall India

Code	Subject Name	L	T	P	Credits			Maximum Marks				
					T	P	Total	Th.	CW	SW	Viva	Total
ME87006	Computer Aided Design	4	0	4	4	4	8	70	30	40	60	200

Course Outcomes

At the end of this course the student is expected to learn:

1 Student will understand the fundamental of CAD Graphic standards and their modes
2 Student will be able to understand the concept of geometric modelling
3 Student will be able to solve the surface modelling and their engineering application
4 Students will be able to analysis of solid models of engineering applications
5 Students will be get idea of strategic plan f CAD system Design & development

UNIT1 Review of basic fundamentals of CAD, CAD data exchange, Graphics standards, modes of graphics operation

UNIT 2 Geometric Modelling: Types of mathematical representation of curves, parametric representation of analytic and synthetic curves, wire frame modeling. Introduction of transformation of geometric models, visual realism.

UNIT 3 Surface Modelling: Parametric representation of analytic and synthetic curves, surface manipulation, Design and engineering applications. Solid Modelling: Boundary representation, constructive solid geometry, sweep representation, analytical solid modelling, Design and engineering applications.

UNIT 4 Engineering analysis of solid model.

UNIT 5 Strategic plan of CAD system design & development, Graphic exchange, features recovery etc.

Reference Books:

1. Chris McMohan and Jimmi Browne ,"CAD/CAM Principles, practice and manufacturing management ", Pearson Education Asia , Ltd, 2000
2. Donald Hearn and M.Pauline Baker"Computer Graphics",Prentice Hall, Inc. 1992
3. Ibrahim Zeid"CAD/CAM- Theory and practice"-Mcgraw Hill, International edition,1998

Code	Subject Name	L	T	P	Credits			Maximum Marks				
					T	P	Total	Th.	CW	SW	Pr.	Total
ME87501	Mechatronics and Automations	4	0	4	4	4	8	70	30	40	60	200

Course Outcomes

At the end of this course the student is expected to learn:

1 Student will understand the fundamental of control systems
2 Student will be able to analyze mathematical models and transient response analysis
3 Student will be able to understand the basic control action and response of control system
4 Students will be able to analyze frequency response and design control system
5 Students will be solve PID control system and robust control systems

UNIT 1. Introduction to Control System

Introduction to control system, Open loop control system and close loop control system, Examples of control system and their aspects. Laplace Transform, Application of Laplace transform solving Linear, Time invariant, Differential Equation

UNIT 2. Mathematical modeling and Transient Response Analysis

Transfer Function and Impulse Response Function, Block Diagram, Mechanical System, Electrical System, Modelling in state Space. First Order System, Second Order System, Transient Response Analysis

UNIT 3. (a) Basic Control Action and Response of Control Systems

Basic Control Actions, Effect of Integral and derivative control actions on systems, Higher Order Systems, Routh stability criterion, Pneumatic, Hydraulic, and Electronic Controller, Steady State Errors.

(b) Root Locus Analysis

Root locus plots, Root locus analysis of control systems, Control system design by Root Locus Method, preliminary design considerations, Lead compensation, Lag compensation, Lag-lead compensation

UNIT 4. Frequency Response analysis and Designing of Control System

Bode Diagram, polar Plots, Nyquist Plots, Nyquist Stability Criterion, Stability analysis, Closed loop frequency response.

UNIT 5. (a) PID Controls and Introduction to Robust Control: Tuning rules for PID Controllers, Modifications of PID control system, Design consideration for robust control.

(b) Introduction to Analysis of Control system in state space

Reference Books

1. Ogata K., Modern Control Engineering, PHI

2. Kuo B. C. Automatic Control System, John Wiley

3. Raven F.H, Automatic Control Engineering, McGraw Hill

Code	Subject Name	L	T	P	Credits			Maximum Marks				
					T	P	Total	Th.	CW	SW	PR.	Total
ME87502	Optimization Technique	4	0	0	4	0	4	70	30	0	0	100

Course Outcomes

At the end of this course the student is expected to:

1 Understand basic technology and applying classical optimization technique to a given problem.
2 Solve optimization problem using linear programming techniques.
3 Apply single variable optimization search technique to given problem.
4 Understand and apply various methods for non-linear programming problem.
5 Understand application of some other techniques of optimization like genetic algorithms, artificial neural network, simulated annealing etc.

COURSE CONTENTS

Unit 1: Introduction to Optimization and Classical Optimization Techniques, Statement of an Optimization Problem, Basic Terminology. Classification of Optimization Problems.
Classification of Optimization Techniques: Single-Variable Optimization, Multivariable Optimization without Constraints, Multivariable Optimization with Equality Constraints: Solution by the Method of Lagrange Multipliers. Multivariable Optimization with Inequality Constraints: Kuhn–Tucker Conditions, Constraint Qualification.

Unit 2: Introduction to Linear Programming, Standard Form of a Linear Programming Problem, Formulation of Problems, Solution of a System of Linear Simultaneous Equations, Algebraic method, Graphical Method, Simplex Algorithm, Big-M Method, Two Phases of the Simplex Method, Revised Simplex Method.

Unit 3: Nonlinear Programming of Single variable One-Dimensional: Unimodal Function, Elimination Methods: Unrestricted Search with Fixed Step Size and Accelerated Step Size, Exhaustive Search, Dichotomous Search, Interval Halving Method, Fibonacci Method, Golden Section Method, Comparison of Elimination Methods. Interpolation Methods: Quadratic Interpolation Method, Cubic Interpolation Method, Direct Root Methods, Newton Method, Quasi-Newton Method, Secant Method.

Unit 4: Nonlinear Unconstrained Optimization Techniques: Introduction, Standard form of problems and basic terminology, Direct Search Method: Random Search Methods, Univariate Method, Pattern Directions Method, Simplex Method. Indirect Search (Descent) Methods: Steepest Descent (Cauchy) Method, Conjugate Gradient Method, Newton's Method, Application to engineering Problems.
Nonlinear Constrained Optimization Techniques: Introduction, Standard form of problems and basic terminology, Direct Search Method: Sequential Linear Programming, Basic Approach in the Methods of Feasible Directions, Generalized Reduced Gradient Method. Indirect Methods: Basic Approach of the Penalty Function Method, Interior Penalty Function Method, Convex Programming Problem, Exterior Penalty Function Method.

Unit 5: Introduction to Non-traditional Methods: Genetic Algorithms: Introduction, Representation of Design Variables, Representation of Objective Function and Constraints, Genetic Operators and Numerical Results. Introduction to Neural-Network-Based Optimization.

TAXT BOOK:

7. Engineering Optimization (Theory and Practice) by Singiresu S. Rao, New Age Int. (P) Ltd. 2002.

REFERENCE BOOK:

1. "Optimization Methods in Operations Research and systems Analysis" – by K. V. Mital and C. Mohan , New Age Int. Publishers, 1996.
2. "Operations Research: An Introduction " by H. A. Taha PHI Pvt. Ltd.
3. Introductory Operation Research by H. S. Kasene & K. D. Kumar, Springer (India).

Code	Subject Name	L	T	P	Credits			Maximum Marks				
					T	P	Total	Th.	CW	SW	Pr	Total
ME87506	Rapid Prototyping and Rapid Tooling	4	0	4	4	4	8	70	30	40	60	200

Course Outcomes

At the end of this course the student is expected to:

1 Understanding working principal and process parameters of RP processes,
2 Exploring applications of RP processes in various fields,
3 Selecting suitable material & process for given product build up,
4 Applying knowledge in material science in RP parts, &
5 Design and develop a product with RP process

COURSE CONTENTS

Unit 1: Introduction of Rapid Prototyping (RP),Technology Description, Definition of RP, Overview of RP, Classification of RP, Benefits and types of materials for RP.

Unit 2: RP Processes: Process overviews, STL file Generation, File Verification and Repair, Build File Creation, Part Building, Part Cleaning and finishing, Process Strength and limitations.

Unit 3: Liquid and Solid based RP processes, Principal of working, parameters that affect surface finish of RP parts, Photo Polimerization, Stereo lithography, Fused deposition modeling (FDM), Laminated Object manufacturing (LOM), Laser in RP, Selective Laser Sintering.

Unit 4: Prototype properties: Material properties, color, dimensional accuracy, stability, surface finish, machinability, environmental resistance, operational properties. RP Applications, Form & fit checking, Ergonomic Studies, Functional testing

Unit 5: Rapid Tooling, application in Medicine, miniaturization Reverse Engineering.

REFERENCES

1. T.A. Grimm & Associates, Users Guide to Rapid Prototyping, Society of Manufacturing Engineers (SME) ISBN0872636976
2. Frank W. Liou, Rapid Prototyping &engineering applications, CRC Press, ISBN 978-0-8493-3409-2
3. Rapid Prototyping theory & practice, Manufacturing System Engineering Series,
4. 1\Ji K. Kamarani, SpringerVerlag '/.1<.apid Prototyping- case book, J. A. McDonalds, C. J. RyaJI, Wiley Eastern.
5. Rapid & Virtual Prototyping & applications, C. E. Bocking, AEW Rennie, Wiley J (astern)

WEBSITES

http://www_ipl.stanford.edu, http://home.utah.edu/

http://www.me.psu.edu, http://itri.loyola.edu/rp/025, http://www.udri.udayton.edu/

Code	Subject Name	L	T	P	Credits			Maximum Marks				
					T	P	Total	Th.	CW	SW	Pr	Total
ME87701	Computational Fluid Dynamics	4	0	0	4	0	4	70	30	-	-	100

Course Outcomes (At the end of this course the student is expected to learn):

1 Understand the governing differential equation and finite difference methods
2 Solve conduction heat transfer problems in steady and transient one, two and three dimension
3 Derive governing equation of incompressible fluid flow
4 Solve convection heat transfer problems and understand the FEM solution
5 Understand turbulence models in engineering

UNIT1: GOVERNING DIFFERENTIAL EQUATION AND FINITE DIFFERENCE METHOD

Classification, Initial and Boundary conditions, Initial and Boundary value problems. Finite difference method, Central, Forward, Backward difference, Uniform and non-uniform Grids, Numerical Errors, Grid Independence Test

UNIT2: CONDUCTION HEAT TRANSFER

Steady one-dimensional conduction, two and three dimensional steady problems, Transient one-dimensional problem, Two-dimensional Transient Problems

UNIT3: INCOMPRESSIBLE FLUID FLOW

Governing Equations, Stream Function- Vorticity method, Determination of pressure for viscous flow, Simple Procedure of patankar and Spalding, Computation of Boundary Layer flow, Finite deference approach.

UNIT4: CONVECTION HEAT TRANSFER AND FEM

Steady One- Dimensional and Two- Dimensional Convective-Diffusion, Unsteady one-dimensional convection- Diffusion, Unsteady two-dimensional convection-Diffusion- Introduction to finite element- Solution of steady heat conduction by FEM- Incompressible flow -Simulation by FEM.

UNIT5: TURBULENCE MODELS

Algebraic Models- One equation model, K-I Models, Standard and High and Low Reynolds number models, Prediction of fluid flow and heat transfer using standard codes.

References:

1. Muralidar,K and Sundararajan,T., "Computational Fluid Flow and Heat Transfer", Narosa Publishing House New Delhi 1995
2. Ghoshdasdidar,P.S,"Computer Simulation of flow and heat transfer " Tata McGraw-Hill Publishing Company Ltd., 1998
3. Subas, V.patankar " Numerical heat transfer fluid flow " Hemisphere Publishing Corporation.,1980
4. Taylor, C and Hughes J.B.'Finite Element Programming of the Navier Stock Equation Pineridge Press Ltd ., U.K.1981

5. Anderson,D.A., Tannehill, I.I.,and Pletchar,.R.H., Computational Fluid Mechanics and Heat Transfer ,Hemisphere Publishing Corporation, New York USA.1984
6. Fletcher, C.A.J, "Computational Techniques for Fluid Dynamics I " Fundamental and General Techniques, springer-Verlag,1987
7. Fletcher, C.A.J, "Computational Techniques for Different Flow Categories, springer-Verlag,1987
8. Bose,T.K., "Numerical Fluid dynamics" Narosa Publishing House 1997.

Code	Subject Name	L	T	P	Credits			Maximum Marks				
					T	P	Total	Th.	CW	SW	Pr	Total
ME86**	INSTRUMENTATION AND CONTROL SYSTEM	4	0	0	4	0	4	70	30	-	-	100

Course Outcomes

At the end of this course the student is expected to:

1 Understand basic principles of measurement and various types of errors
2 Understand various types of displacement sensors and temperature sensors and their application
3 Understand various types of pressure measuring instruments and their application.
4 Understand various types of pressure, level, flow, speed, stress-strain, humidity measurement instruments and apply them to measure various parameters
5 Analyze different element of control system

UNIT 1 Definition- Basic principles of measurement-Measurement systems, generalized configuration and functional descriptions of measuring instruments-examples, Dynamics performance characteristics-source of error, Classification and elimination of error.

UNIT 2 Measurement of Displacement: Theory and construction of various transducers to measure displacement-Piezo electric, Inductive, capacitance, resistance, ionization and Photo electric transducers and Calibration.

Measurement of Temperature: Classification-Ranges-Various principles of measurement-Expansion, Electrical Resistance-Thermistor-Thermocouple Pyrometers, temperature indicators.

UNIT 3 Measurement of Pressure: Classification, Different principles used, Manometer, Piston, Bourdon Pressure Gauge, Bellows, Diaphragm gauge, Low pressure measurement, Thermal conductive gauge, Ionization pressure gauge, Mcload pressure gauge

UNIT 4 Measurement of LEVEL: Direct methods, indirect method, capacitative, ultrasonic, magnetic, cryogenic fuel level indicator, Bubler level indicators

Flow Measurement: Rotameter, magnetic, Ultrasonic, Turbine flow meter, Hot Wire, anemometer, Laser Doppler Anemometer (LDA)

Measurement of speed: mechanical Tachometer-Electrical tachometer, stroboscope, noncontact tyoe tachometer, Measurement of acceleration, and vibration: Different simple instrument-Principles of Seismic instruments- Vibrometer and accelerometer using this principles

Stress-strain Measurement: Various types of stress and strain measurement-Electrical strain gauge, gauge factor, method of usage of resistance strain gauge for bending compressive and tensile, strains-usage of measuring torque, strain gauge, Rosettes.

Measurement of HUMIDITY: Moisture content of gases, sling psychrometer, absorption psychrometer, Dew point meter

Measurement of Force, Torque, and Power-Elastic force meter, load cells, Torsion meter, Dynamometers

UNIT 5 ELEMENTS OF CONTROL SYSTEMS: Introduction, importance classification Open and closed system, servomechanism –Examples with block diagrams, temperature, speed and position control systems

References Books:

1. Measurement System: Application & Design by D S Kumar

2. Mechanical Measurement, Beckwith, Marangoni, linehard, PHI/PE

3. Measurement System: Application & Design, Doeblin, Earnest. Adoption by Manik and Dhanesh/TMH

4. Instrumentation and Control system/S Bhaskar/Anuradha Agengies

5. Experimental methods for Engineers/Holman

6. Instrumentation, measurement and Analysis by B C Nakra & K K Choudhary, TMH

Code	Subject Name	L	T	P	Credits			Maximum Marks				
					T	P	Total	Th.	CW	SW	Viva	Total
ME86*	Product Design and Development	4	0	0	4	0	6	70	30			100

Course Outcomes

At the end of this course the student is expected to:

1 Understand the development process of the product.
2 Gain knowledge in understanding the tools and techniques for studying the customer need.
3 Asses the need for industrial design and estimate the various cost required in manufacturing process.
4 Build an expertise in prototype and product development.
5 Understanding and managing economics of product development projects.

COURSE CONTENTS

Unit 1: Introduction: Characteristics of successful product development, the challenges of product development, structural methodology, industrial examples, organizational realities.
Development process and Organizations: A generic development process, technology push products, plateform products, process intensive products, customized products.

Unit 2: Identifying customer need: Define the scope of the effort, gather raw data from the customers, interpret raw data in terms of customer needs, organize the need into hierarchy, establish the relative importance of the needs establish the relative importance of the needs, reflection on the results and the processes.
Establishing product specifications: Establishing target specifications, refining the specifications. Concept generation: Clarity the problem, search externally, search internally, explore systematically, reflection on solutions and process.
Concept selection: Overview of methodology, concept screening, concept scoring.
Product Architecture: Implications of the architecture, establishing the architecture, related system level design issues.

Unit 3: Industrial design: Assessing the need for industrial design, the impact of industrial design, the industrial design process, management of industrial design process, assessing the quality of industrial design.
Design for manufacturing: Estimate the manufacturing cost, reduce the component cost, reduce the assembly cost, reduce the support cost, consider the impact of such decisions on other factors.

Unit 4: Effective prototyping: Principal of prototyping, planning for prototype, experiments on prototype.

Unit 5: Economics of product development projects: Elements of economic analysis, methodology.
Managing product development projects, Understanding and representing tasks, baseline project planning, accelerating the project, project execution.

BOOK: Product Design and Development by Karl T Ulrich, McGraw, Hill, Inc.