# M Tech in Mechanical Engineering with specialization in Thermal and Design Engineering

| SUBJECT CODE | Category | SUBJECT NAME | TEACHING & EVALUATION SCHEME | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | THEORY | | | PRACTICAL | | L | T | P | CREDITS |
| | | | END SEM UNIVERSITY EXAM | TWO TERM EXAM | TEACHER ASSESSMENT* | END SEM UNIVERSITY EXAM | TEACHER ASSESSMENT* | | | | |
| MTMA101 | ODS | Advanced Mathematics | 60 | 20 | 20 | 0 | 0 | 3 | 1 | 0 | 4 |

**Legends**: **L** - Lecture; **T** - Tutorial/Teacher Guided Student Activity; **P** – Practical; C - Credit;
**Teacher Assessment** shall be based following components: Quiz/Assignment/ Project/Participation in Class, given that no component shall exceed more than 20 marks.

## Course Educational Objectives (CEOs):

To introduce the concepts of(A)solving Partial Differential equations by reducing to normal forms, finding solutions of differential equations.(B)Fourier transform using one dimensional heat conductions and Ritz methods used variation problem solve.(C)the finite element methods to related heat and mass transfer effects. (D) broad-based theoretical background of Mathematical Sciences and practical training in computing, numerical methods, and mathematical/statistical modeling(E)Reminisce the simulations related problem and efficient solutions of the Wave Equation, Non-Linear Finite Element Problems.

## Course Outcomes (COs):

After the completion of the course, students will be able to demonstrate following knowledge, skills and attitudes

The student will be able to

1. Solve fundamental mathematics equations and to solve problems of algebraic and differential equations, simultaneous equation, partial differential equations
2. To provide an overview of discovering the experimental aspect of modern applied mathematics
3. To solve finite element problems to related fluid flow and heat transfer problems
4. To solve Applications of digital computers to solutions of problems in mechanical engineering, square, roots and maxima and minima problems
5. To solve simulations problem related field and other field also.

# Syllabus

## Unit-I

**Boundary Value Problems and Applications:** Linear second order partial differential equation in two independent variables – Normal forms hyperbolic, parabolic and elliptic equations – Cauchy problem. Wave equations –Solution of initial value problem – Significance of characteristic curves, Laplace transform solutions – Displacements in a long string – long string under its weight – a bar with prescribed force on one end – Free vibrations of a string. Un-damped free vibration of 2 degrees of freedom and Principal modes of vibration; torsion vibrations; Forced, Un-damped vibrations with harmonic excitation.

**Unit-II**

**Fourier Transform methods**: one-dimensional heat conduction problems in infinite and semi-infinite rod – Laplace Equation – Poisson Equation. Concept of variation and its properties – Euler's equation – Functional dependent on first and higher order derivatives – Functional dependent on functions of several independent variables Variation problems with moving boundaries – Direct methods – Ritz and Kantorovich methods.

**Unit-III**

**Introduction to Finite Element Method:** Introduction to Finite Element Method Rules for forming interpolation functions - Shape Functions Application to fluid flow and heat transfer problems.

**Unit-IV**

**Convection Computer Methods in Mechanical Engineering:** Applications of digital computers to solutions of problems in mechanical engineering, matrices, roots of equations, solution of simultaneous equations, curve fitting by least squares, differential and integration, differential and partial differential equations.

Introduction to optimization methods: Local and global minima, Line searches, Steepest descent method, Conjugate gradient method, Quasi Newton method, Penalty function.

**Unit-V**

**FEM Simulations:** 1d/2d/3d Poisson Equation Solver, Convection-Diffusion Solver, Heat Equation Solver, Efficient solutions of the Wave Equation, Non-Linear Finite Element Problems

**References**

1. *Mitchell A.R. and Griffith D.F., The Finite difference method in partial differential*
2. *equations, John Wiley and sons, New York (1980)*
3. *Gupta, A.S., Calculus of Variations with Applications, Prentice Hall of India Pvt. Ltd., New*
4. *Delhi (1997).*
5. *DESAI, C.S., and ABEL, J. P., Introduction to Finite Element Method, Van No strand Reinhold.*
6. *ELSEGOLTS, L., Differential Equations and the Calculus of Variations, Mir Publishers.*
7. *Probability and statistics for engineers - Miller and Freund's*

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|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | THEORY | | | PRACTICAL | | L | T | P | CREDITS |
| | | | END SEM UNIVERSITY EXAM | TWO TERM EXAM | TEACHER ASSESSMENT* | END SEM UNIVERSITY EXAM | TEACHER ASSESSMENT* | | | | |
| MTME101 | DS | Advanced Computational Fluid Dynamics | 60 | 20 | 20 | 30 | 20 | 3 | 1 | 2 | 5 |

**Legends**: **L** - Lecture; **T** - Tutorial/Teacher Guided Student Activity; **P** – Practical; C - Credit;
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## Course Educational Objectives (CEOs):

This course introduces the beginning graduate and advanced undergraduate students (A)to finite difference methods as a means of solving different type of differential equations that arise in fluid dynamics. (B) fundamentals of numerical analysis, ordinary differential equations and partial differential equations related to fluid mechanics and heat transfer will be reviewed. (C) Error control and stability considerations are discussed and demonstrated. (D)Naiver-Stokes equations will be solved using commercial software.

## Course Outcomes (COs):

After the completion of the course, students will be able to demonstrate following knowledge, skills and attitudes

1. Give the student a working knowledge of a variety of computational techniques that can be used for solving engineering problems.
2. Develop a student's capability to write efficiently computer software.
3. Develop a student's ability for result presentations and data visualization of engineering problem

# Syllabus

### Unit-I

**Introduction, Classification and Overview of Numerical Methods:** mass; momentum and energy equations; convective forms of the equations and general description. Classification into various types of equation; parabolic elliptic and hyperbolic; boundary and initial conditions; over view of numerical methods.

### Unit-II

**Finite Difference Technique and Finite Volume Technique:** Finite difference methods; different means for formulating finite difference equation; Taylor series expansion, integration over element, local function method; treatment of boundary conditions; boundary layer treatment; variable property, interface and free surface treatment; accuracy of cfd method. Finite volume methods, different types of finite volume grids, approximation of surface and volume integrals; interpolation methods, central, upwind and hybrid formulations and comparison for convection-diffusion problem.

**Unit-III**

**Finite Element Methods and Methods of Solution:** Finite element methods; Rayleigh-Ritz, Galerkin and Least square methods; interpolation functions; one and two dimensional elements; applications, Solution of finite difference equations; iterative methods; matrix inversion methods; ADI method; operator splitting; fast Fourier transform.

**Unit-IV**

**Time integration Methods and Numerical Grid Generation:** Single and multilevel methods; predictor corrector methods; stability analysis; Applications to transient conduction and advection-diffusion problems, Numerical grid generation; basic ideas; transformation and mapping.

**Unit-V**

**Navier-Stokes Equations and Turbulence modeling:** Explicit and implicit methods; SIMPLE type methods; fractional step methods, Reynolds averaged Navier-Stokes equations, RANS modeling, DNS and LES.

**References**

1. *Dale A. Anderson, John C. Tannehill and Richard H. Platcher. Computational Fluid Mechanics and Heat Transfer; McGraw Hill Book Company.*
2. *K. Muralidhar and T. Sundarajan. Computational Fluid Flow and Heat Transfer, Narosa Publishing House.*
3. *W.F. Ames. Numerical Method for Partial Differential Equation, Academic Press.*
4. *C.A.J. Fletcher. Computational Techniques for Fluid dynamics: Vol – I & II, Springer-Verlag, Berlin.*

**List of Experiments**

1. Simulate and solve, two problems, each 2-d and 3-d steady and unsteady flows using any commercial CFD package like Ansys-FLUENT, STAR CCM, FLUIDYNE, Ansys-CFX, etc.
2. Write codes for, at least one each, 1-d and 2-d steady conduction with and without source and do the post processing to verify with analytical results.
3. Write codes, at least one, for steady, 2-d conduction-advection problems and do the post processing to verify with analytical results.
4. Perform Analytical and Numerical analysis on Pin-Fin to calculate temperature distribution.
5. Perform Analytical and Numerical analysis on 1-D steady state heat conduction to calculate temperature distribution along wall thickness.
6. Perform Analytical and Numerical analysis on 2-D steady state heat conduction to calculate temperature distribution along wall thickness.
7. Perform Analytical and Numerical analysis on 1-D unsteady state heat conduction along the wall thickness.
8. Perform Analytical and Numerical analysis on 2-D unsteady state heat conduction along the wall thickness.
9. Perform Analytical and Numerical analysis on unsteady state heat transfer by convection.
10. Perform Numerical analysis on flow through pipe with varying Reynold's number.

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| | | | THEORY | | | PRACTICAL | | L | T | P | CREDITS |
| | | | END SEM UNIVERSITY EXAM | TWO TERM EXAM | TEACHER ASSESSTMENT* | END SEM UNIVERSITY EXAM | TEACHER ASSESSTMENT* | | | | |
| MTME102 | DS | Advanced Machine Design | 60 | 20 | 20 | 30 | 20 | 3 | 1 | 2 | 5 |

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## Course Educational Objectives (CEOs):

The objective of the subject is to deal (A)with failure analysis and advanced areas of design of machine elements based on reliability, fatigue, creep, (B)also with the fracture mechanics approach to design. Pre requisites are Material science, Machine Design I and Machine Design II.

## Course Outcomes (COs):

1. Students will be able to understand Case studies of mechanical engineering design failures, theories of failure and will be able to analyze static strength failure.
2. Student will be able to apply knowledge of mathematics, science and engineering to design Equipment's and Elements, Design of shaft and gear under fatigue, design of rolling contact bearings including linear bearings.
3. Student will be able to analyze various types of failures produced in Mechanical equipment's and interpret data for Reliability and optimization.
4. Student will be able to Design for Dynamic Loading High cycle and low cycle fatigue, Fatigue strength, Design for Creep, Combined creep and fatigue failure prevention, Design for low temperature (Brittle failure). Design for corrosion, wear, hydrogen embrittlement, fretting fatigue and other combined modes of mechanical failure.
5. Student will be able to understand ethics and responsibility while designing Mechanical components under creep, Dynamic loading fatigue, fretting fatigue and other combined modes of mechanical failure.
6. Student will be able to evaluate better design selection by choosing appropriate material and will be able to work in a team to design various mechanical components during project work and will be able to explain in team during project work.
7. Student will able to understand fracture mechanics and its approach to design and the energy criterion and the effects of stress concentration.

# Syllabus

### Unit-I

Introduction to Advanced Mechanical Engineering Design Review of materials and processes for machine elements. Case studies of mechanical engineering design failures. Review of static strength failure analysis – theories of failure.

**Unit-II**

Reliability and Optimum based Design Introduction to optimum design, analysis of simple machine members based on optimum design. Fundamentals of reliability, System concepts in Reliability engineering. Failure distributions, Statistical analysis of failure data, Weibull analysis, dimensioning

**Unit-III**

Design for Dynamic Loading High cycle and low cycle fatigue, Fatigue strength. Design of Mechanical Equipment Elements. Exercises of fatigue design of shafting and gears. Exercises of surface fatigue design of rolling contact bearings including linear bearings.

**Unit-IV**

Design for Creep Introduction to Design for creep. Combined creep and fatigue failure prevention. Design for low temperature (Brittle failure). Design for corrosion, wear, hydrogen embrittlement, fretting fatigue and other combined modes of mechanical failure

**Unit-V**

Fracture mechanics Introduction: Fracture mechanics approach to design, the energy criterion, the stress intensity approach, effect of material properties on fracture, dimensional analysis in fracture mechanics. Fundamental concepts: Stress concentration effect of flaws, the Grifith energy balance, the energy release rate, instability and the R curve, stress analysis of cracks, K as a failure criterion. Fracture toughness testing of metals

*Note: Only Mechanical Engineer's Handbook, Data-books and certified notes are allowed in the examination hall.*

**References**

1. *Shingley J.E., Mechanical Engineering Design, McGraw-Hill*
2. *Dieter G.E., Engineering Design, McGraw-Hill*
3. *Spotts M.F., Shoup T.E., Hrnberger L.E., Design of Machine Elements, Pearson Education*
4. *Shariff A., Design of Machine, Elements, Dhanpat Rai Publications (P)*
5. *Mubeen., Machine Design, Khanna Publications (P)*

**List of experiments**

1. Problem based on theories of failures.
2. Problem based on Reliability Criterion.
3. Problem based on Optimum Criterion.
4. Problem on Design of parts subjected to Fatigue Loading.
5. Problem on Design of parts subjected to Dynamic Loading
6. Problem on Design of parts subjected to Creep.
7. Problem on Design of shafts and gears subjected to fatigue loading.
8. Problem on Design of rolling contact bearings including linear bearings subjected to surface fatigue

9. Experimental analysis of fracture mechanism for different materials.
10. Experimental analysis of Creep mechanism for different materials.

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| | | | THEORY | | | PRACTICAL | | L | T | P | CREDITS |
| | | | END SEM UNIVERSITY EXAM | TWO TERM EXAM | TEACHER ASSESSTMENT* | END SEM UNIVERSITY EXAM | TEACHER ASSESSTMENT* | | | | |
| MTME114 | DS | Energy Systems & Management | 60 | 20 | 20 | 0 | 0 | 3 | 1 | 0 | 4 |

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**Course Educational Objectives (CEOs):**

To explain (A)energy conversions systems and classification, energy management, renewable energy technologies etc.(B) to classify various trends of energy systems and management

**Course Outcomes:**

1. Students will be able to memories the energy conversion system and their classification, project management, renewable energy technologies and way of sustainable growth of energy.
2. Students will able to classify the various trends of energy systems and Management.
3. Students will be able to compare various energy systems each other.
4. Students will be able to solve various problems of energy systems and Management.
5. Students will be able to interpret advanced energy conversion systems, project management, energy policies and sustainable development.

# Syllabus

## Unit-I

**Advanced Energy Conservation Systems**: Classification of energy sources- Utilization, economics and growth rates- Fossil fuels, nuclear fuels and solar energy, Gas turbine and combined cycle analysis – Inter-cooling, reheating and regeneration-gas turbine cooling, Nuclear energy conversion – Chemical and nuclear equations – Nuclear reactions – Fission and fusion, Fuel rod design – Steam cycles for nuclear power plants – reactor heat removal – Coolant channel orificing – Core thermal design – Thermal shields.

## Unit-II

**Energy modelling, Project Management**: Interdependence of energy-economy-environment; Modeling concept, and application, Methodology of energy demand analysis; Methodology for energy forecasting; Sectoral energy demand forecasting; Interfuel substitution models; SIMA model, and I-O model for energy policy analysis; Simulation and forecasting of future energy demand consistent with macroeconomic parameters in India, Project Evaluation & Management: Financial analysis: Project cash flows, time value of money, life cycle approach & analysis, conception, definition, planning, feasibility and analysis; Project appraisal criteria; Risk analysis; Project planning matrix; Aims oriented project planning; Social cost benefit analysis.

**Unit-III**

**Electrical Energy Systems and Management**: Overall structure of electrical systems – Supply and demand side – Economic operation – Input-output curves – Load sharing – Industrial Distribution, Energy efficiency – Energy accounting, monitoring and control – Electricity audit instruments – Energy consumption models – Specific Energy Consumption – ECO assessment and Evaluation methods, Electric loads of air conditioning and refrigeration – Energy conservation – Power consumption in compressors – Energy conservation measures – Electrolytic process – Electric heating, Optimal operation.

**Unit-IV**

**Renewable Energy Technologies**: Power in wind - Availability – Types of wind turbines - Aerodynamics of Wind turbine, Bio fuel classification- Biomass production for Energy farming- Direct combustion for heat- Paralysis- Thermo chemical process Anaerobic digestion, Concept of energy and power from waves – Wave characteristics – period and wave velocities - Different wave energy conversion devices (Tapchan, oscillating water column type), OTEC Principle - Lambert's law of absorption - Open cycle and closed cycle, The Hydrogen economy – Advantages of hydrogen as an energy carrier.

**Unit-V**

**Energy Policies for Sustainable Development**: Supply focus approach and its limitations – Energy paradigms – DEFENDUS approach – End use orientation – Energy policies and development, Energy conservation schemes – Statutory requirements of energy audit – Economic aspects of energy audit, Social cost benefit analysis – Computation of IRR and ERR – Advance models in energy planning – Dynamic programming models in integrated energy planning – Energy planning case studies.

**References**

1. *IEEE Bronze Book: IEEE Standard 739-1984 – Recommended Practice for Energy Conservation and Cost Effective Planning in Industrial Facilities, IEEE Publications, 1996.*
2. *Nag PK; Power plant Engg; TMH*
3. *Energy Policy Analysis and Modeling, M. Munasinghe and P. Meier Cambridge University Press, 1993.*
4. *Renewable Energy Resources Basic Principles and Applications / G.N. Tiwari and M.K. Ghosal / Narosa*
5. *J. Goldemberg, T.B. Johansson, A.K.N. Reddy and R.H. Williams: Energy for a Sustainable World, Wiley Eastern, 1990.*

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|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | THEORY | | | PRACTICAL | | L | T | P | CREDITS |
| | | | END SEM UNIVERSITY EXAM | TWO TERM EXAM | TEACHER ASSESSMENT* | END SEM UNIVERSITY EXAM | TEACHER ASSESSMENT* | | | | |
| MTME124 | DS | Advanced Refrigeration & Air- Conditioning | 60 | 20 | 20 | 0 | 0 | 3 | 1 | 0 | 4 |

**Legends**: **L** - Lecture; **T** - Tutorial/Teacher Guided Student Activity; **P** – Practical; C - Credit;
**Teacher Assessment** shall be based following components: Quiz/Assignment/ Project/Participation in Class, given that no component shall exceed more than 20 marks.

### Course Educational Objectives (CEOs):

The basic objective of the subject is to impart the(A) basics of refrigeration and Air conditioning equipment design and theory. Fundamentals of thermodynamics, refrigeration cycles Psychometry. Pre requisites are Refrigeration & Air Conditioning. (B) to introduced the fundamentals Properties of Moist air- Psychrometric relations Psychrometric chart, (C)To classify the Construction Details of Room Air Conditioner, Duct Design – Equal Friction Methods. (D) to introduced the fundamentals of fan, blower and compressor types and working.

### Course Outcomes (COs):

After the completion of the course, students will be able to

1. Acquire an overview of various common refrigeration systems.
2. Estimate the refrigeration compressor types and design.
3. Able to understand simple Applied Psychrometry
4. Student able to understand the Fundamentals of thermodynamics, refrigeration cycles Psychometry. Pre requisites are Refrigeration & Air Conditioning
5. Develop the skills to analyze the multi pressure refrigeration systems.

## Syllabus

### Unit- I

**Refrigeration Cycles:** Vapor compression cycle, multi-pressure systems, air refrigeration cycles, systems equilibrium and cycling controls, classification of refrigerants, refrigerant properties, oil compatibility, blends, ecofriendly refrigerants. Vapor absorption systems, steam jet refrigeration, thermo electric refrigeration

### Unit - II

**Compressors and Expanders:** Refrigeration compressors, compressors types and control, expansion devices, valves, receivers, oil trap, oil regenerators, driers and strainers, accumulator, functional aspects of the above components & accessories

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**Unit - III**

**Applied Psychrometry**: psychrometry: properties of moist air- psychrometric relations psychrometric chart – psychrometric processes in air-conditioning equipment – bypass factor –sensible heat factor, effective and grand sensible heat factors- selection of air- conditioning apparatus for cooling and dehumidification-high latent cooling load applications- all outdoor air application.

**Unit - IV**

**Design of air-conditioning systems:** Moist air, psychrometric chart and processes, cooling load estimation, controls of temperature, humidity and airflow, flow through ducts, losses, duct design – equal friction methods. Indoor air quality, thermal insulation, water piping in chilled water systems, construction details of room air conditioner – window type, package type, split type central units – air distribution devices – air circuits – air supply system.

**Unit - V**

**Fans, blowers and compressors:** Turbo machines, performance characteristics, fan laws, dimensionless parameters, specific speed, centrifugal, axial, mixed flow, axial flow machines. Centrifugal blowers: characteristic curves, velocity triangles, losses and efficiency, flow through impellers, casing, diffusers, cross-flow fans. Axial flow fans: rotor design, airfoil theory, vortex theory, cascade effects, degree of reaction, surge and stall, stator and casing, mixed flow impellers.

**References**

1. *Refrigeration and air conditioning, C P Arora, McGraw Hill.*
2. *Refrigeration and air conditioning, stocker, McGraw Hill.*
3. *Thermal Environmental Engineering, Threlked J L, Prentice Hall, N. Y.*
4. *Ozisik, M.N., Design of Heat exchangers, condensers and evaporators, John Wiley, New York, 1e, 1985.*
5. *Nicholas Cheremisioff, Cooling tower, Ann Arbor Science pub., 1e, 1981.*
6. *Austin H. Church, Centrifugal pumps and blowers, John Wiley and Sons, 1e, 1980.*
7. *Carrier Air Conditioning Co., Handbook of Air conditioning systems design, McGraw-Hill, 1e, 1985.*
8. *C.P. Arora, Refrigeration and Air conditioning, Tata McGraw-Hill Pub. Company, New Delhi, 4e, 2006.*

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|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | THEORY | | | PRACTICAL | | L | T | P | CREDITS |
| | | | END SEM UNIVERSITY EXAM | TWO TERM EXAM | TEACHER ASSESSMENT* | END SEM UNIVERSITY EXAM | TEACHER ASSESSMENT* | | | | |
| MTME134 | DS | Advance Thermodynamics & Combustion Engineering | 60 | 20 | 20 | 0 | 0 | 3 | 1 | 0 | 4 |

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## Course Educational Objectives (CEOs):

To make the student understand(A)the principle of entropy, and entropy generation in closed and open system, (B)the concepts of availability and irreversible Properties of gases and gas mixtures, and thermodynamic relations (C)thermodynamics of reactive systems and chemical equilibrium, (D)Certain advanced power cycles. Concepts of statistical thermodynamics. (E)Engine operating parameters like fuel-air mixtures, temperature and cycles Supercharging, turbo charging and flow through ports and valves Combustion process in SI engine and CI engine and emissions Formation during the combustion cycle and their treatment, (F)Metering and flow of charge in SI engines Modern trends in IC engines

## Course Outcomes (COs):

1. The student will be able to
2. Apply the principles of entropy and irreversibility to solve practical problems
3. Explain the equations of state for ideal and real gases and gas mixtures
4. Use thermodynamic relations to predict latent heats and other properties of substances
5. Explain combined power cycles
6. Explain thermodynamic distribution function and partition function in classical thermodynamics
7. design parameters like fuel-air mixtures and cycle analysis
8. Gas exchange processes and motion of charge in the cylinder and its effects on combustion process in SI and CI engines and control the pollutant formation
9. Flow in carburetor and Intake manifolds
10. Modern concepts like Lean burn, HCCI, GDI

# Syllabus

### Unit – I

**Entropy:** Claudius theorem - the property of entropy, the inequality of Claudius, entropy change in an irreversible process, entropy principle, applications of entropy principle to the processes of transfer of heat through a finite temperature difference, and mixing of two fluids maximum work obtainable from a finite body and a thermal energy reservoir, entropy transfer with heat flow, entropy generation in a closed system, entropy generation in an open system.

**Unit - II**

**Availability & Pure Substances:** Available energy referred to cycle, available energy from a finite energy source, maximum work in a reversible process, availability in a steady flow process, availability in non-flow process.

**P-V-T Relationships for pure substances:** P-v diagram for a pure substance, triple point line, critical point, saturated liquid and vapor lines, P-T diagram for a pure substance, T-s diagram for a pure substance, h-s diagram (Mollie diagram) for a pure substance, dryness fraction, problems using steam tables.

**Properties of Gases:** Equations of state – Vander Waal's equation, law of corresponding states, Beattie-Bridgeman equation, Redlich-Kong equation.

**Gas Mixtures:** Dalton's law of partial pressures – enthalpy and entropy

**Unit - III**

**Thermodynamic Relations:** Maxwell's equations –Tads equations – difference in heat capacities – ratio of heat capacities – Joule-Kelvin effect – Clausius-Clapeyron equation.

**Power Cycles:** Brayton cycle – comparison between Brayton cycle and Rankine cycle – effect of regeneration & reheat on Rankine cycle efficiency – Brayton-Rankine combined cycle, Carnot Cycle,

**Statistical Thermodynamics-II:** Maxwell-Boltzmann statistics and distribution, Fermi-Dirac statistics and distribution, Bose-Einstein statistics and distribution, phase space, Lowville equation, equilibrium constant by statistical thermodynamic approach

**Unit - IV**

**Engine types and their operation**- engine design and operating parameters, Fuel-air mixtures and cycle analysis- thermo chemistry of fuel-air mixtures, properties of working fluids, fuel-air cycle analysis, and availability analysis of engine processes.

**Gas Exchange Processes -** Volumetric efficiency, flow through valves, residual gas fraction, exhaust gas flow rate and temperature variation, supercharging and turbo charging.

**Charge motion-** Mean velocity and turbulence characteristics, swirl, squish, pre-chamber engine flows, crevice flows and blowy.

**Fuel metering and manifold phenomenon-**SI engine mixture requirements, carburetors, fuel injection systems, flow past throttle plate, and flow in intake manifolds.

**Unit - V**

**SI Engine combustion-** Thermodynamic analysis of SI engine combustion, flame structure and speed, cyclic variations in combustion, and abnormal combustion.

**Pollutant formation and control-** Nature and extent of problem, nitrogen oxides, carbon monoxide, unburned hydrocarbon emissions, particulate emissions, exhaust gas treatment.

**Modern trends in I.C. engines-** lean burning engines-rotary engines, modification in I.C engines to suit Bio – fuels.**CI Engine combustion-** Essential features, types of diesel combustion systems, analysis of cylinder pressure data, fuel spray behavior, ignition delay, and mixing-controlled combustion.

**References**

1. *Heinz Heisler, "Advanced Engine Technology", Trafalgar Square, 1997.*

2. *V. Ganesan, "Internal Combustion Engines", 2ndEdition, Tata McGraw Hill, 2002.*
3. *M. L. Mathur and R. P. Sharma, "Internal Combustion Engines", Dhanpat Rai, 2008.Y.A. Cengel and M.A. Boles, "Thermodynamics – An Engineering Approach", 5th Edition in SI Units, Tata McGraw Hill Publishing Company Limited, New Delhi, 2006.*
4. *C. Borganakke and R. E. Sonntag, "Fundamentals of Thermodynamics", 7th Edition, Wiley India, Delhi, 2012.*
5. *Van P. Carey, "Statistical thermodynamics and micro scale thermo physics", Cambridge University Press, 1999*
6. *John B. Heywood, "Internal Combustion Engine Fundamental", 1st Edition, Tata McGraw-Hill Education, 2011.*
7. *P.K. Nag, "Engineering Thermodynamics", 4th Edition, Tata McGraw-Hill Education Private Limited, 2010.*
8. *S.S. These, "Advanced Thermodynamics", Narosa Publishing House, New Delhi, 2013.*

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|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | THEORY | | | PRACTICAL | | L | T | P | CREDITS |
| | | | END SEM UNIVERSITY EXAM | TWO TERM EXAM | TEACHER ASSESSMENT* | END SEM UNIVERSITY EXAM | TEACHER ASSESSMENT* | | | | |
| MTME115 | DS | Optimization Methods in Engineering | 60 | 20 | 20 | 0 | 0 | 3 | 1 | 0 | 4 |

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## Course Educational Objectives (CEOs):

(A)Introduce methods of optimization to engineering students, including linear programming, network flow algorithms, integer programming, interior point methods, quadratic programming, nonlinear programming, and heuristic methods. (B)Advanced optimization techniques such as Evolutionary search algorithms, Multi objective optimization are briefly introduced. (C)Numerous applications are presented in civil, environmental, electrical (control) engineering, and industrial engineering. The goal is to maintain a balance between theory, numerical computation, problem setup for solution by optimization software, and applications to engineering systems.

## Course Outcomes (COs):

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

1. basic theoretical principles in optimization
2. formulation of optimization models
3. solution methods in optimization
4. methods of sensitivity analysis and post processing of results
5. applications to a wide range of engineering problems

# Syllabus

### Unit-I

Introduction and Basic Concepts - Historical Development; Engineering applications of Optimization; Art of Modeling; Objective function; Constraints and Constraint surface; Formulation of design problems as mathematical programming problems Classification of optimization problems Optimization techniques – classical and advanced techniques

### Unit-II

Optimization using Calculus - Stationary points; Functions of single and two variables; Global Optimum; Convexity and concavity of functions of one and two variables; Optimization of function of one variable and multiple variables; Gradient vectors; Examples; Optimization of function of multiple variables subject to equality constraints; Varangian function Optimization of function of multiple variables subject to equality constraints; Hessian matrix formulation; Eigen values Kuhn-Tucker

Conditions; Examples

**Unit-III**

Linear Programming - Standard form of linear programming (LP) problem; Canonical form of LP problem; Assumptions in LP Models; Elementary operations; Graphical method for two variable optimization problem; Motivation of simplex method, Simplex algorithm and construction of simplex tableau; Simplex criterion; Minimization versus maximization problems; Revised simplex method; Duality in LP;Primaldual relations; Dual Simplex method; Sensitivity or post optimality analysis Other algorithms for solving LP problems – Karmarkar's projective scaling method

Linear Programming Applications- Use of software for solving linear optimization problems using graphical and simplex method; Examples for transportation, assignment and other optimization problems

**Unit-IV**

Dynamic Programming- Sequential optimization; Representation of multistage decision process; Types of multistage decision problems; Concept of sub optimization and the principle of optimality; Recursive equations – Forward and backward recursions; Computational procedure in dynamic programming (DP) Discrete versus continuous dynamic programming; Multiple state variables; curse of dimensionality in DP.

Dynamic Programming Applications - Problem formulation and application in Design of continuous beam and Optimal geometric layout of a truss; Water allocation as a sequential process; Capacity expansion and Reservoir operation

**Unit-V**

Integer Programming - Integer linear programming; Concept of cutting plane method; Mixed integer programming; Solution algorithms.

Advanced Topics in Optimization - Piecewise linear approximation of a nonlinear function; Multi objective optimization – Weighted and constrained methods; Multi level optimization; Direct and indirect search methods; Evolutionary algorithms for optimization

**References**

1. *S.S. Rao, "Engineering Optimization: Theory and Practice", New Age International P) Ltd., New Delhi, 2000.*
2. *G. Hadley, "Linear programming", Narosa Publishing House, New Delhi, 1990.*
3. *H.A. Tasha, "Operations Research: An Introduction", 5th Edition, Macmillan, New York, 1992.*
4. *K. Deb,"Optimization for Engineering Design Algorithms and Examples", Prentice-Hall of India Pvt. Ltd., New Delhi, 1995.*
5. *K. Srinivasa Raju and D. Nags Kumar, "Multicriterion Analysis in Engineering and Management", PHI Learning Pvt. Ltd., New Delhi, India, ISBN 978-81-203-3976-7, pp.288*

| SUBJECT CODE | Category | SUBJECT NAME | TEACHING & EVALUATION SCHEME | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | THEORY | | | PRACTICAL | | L | T | P | CREDITS |
| | | | END SEM UNIVERSITY EXAM | TWO TERM EXAM | TEACHER ASSESSMENT* | END SEM UNIVERSITY EXAM | TEACHER ASSESSMENT* | | | | |
| MTME125 | DS | Micro & Smart Systems | 60 | 20 | 20 | 0 | 0 | 3 | 1 | 0 | 4 |

**Legends**: **L** - Lecture; **T** - Tutorial/Teacher Guided Student Activity; **P** – Practical; C - Credit;
**Teacher Assessment** shall be based following components: Quiz/Assignment/ Project/Participation in Class, given that no component shall exceed more than 20 marks.

**Course Educational Objectives (CEOs): -**

(A)Introduce various aspects of micro systems and scaling effects. (B)Familiarize the students with micro fabrication, modeling and simulation. (C)Reminisce electronic amplifiers, signal conditioning and control theory. (D) Create awareness about some of the MEMs applications.

**Course Outcomes (COs):**

1. Classify the presently available micro sensors and actuators available in the market.
2. Understand the conventional and silicon based micro machining technologies for smart structure development.
3. Compute the coupled response of an electro mechanical smart system using finite element method.
4. Identify the credibility of various electronic circuits and control methods used to develop micro and smart systems.
5. Describe the methodology for micro and smart system integration.

# Syllabus

**Unit-I**

**Introduction:** Smart materials and systems: an overview and Introduction of Micro and smart systems, Processing of Sensors, Actuators and micro structures, Applications in diverse fields including Biomedical, Defense, Automobile and Aerospace Engineering and Examples of smart systems: structural health monitoring and vibration control

**Unit-II**

**Micro Fabrication Processes:** Introduction of Micro Machining Technologies, conventional and silicon micro machining techniques, Ultrasonic machining, sandblasting, laser ablation, spark erosion and photo lithography and Smart material processing.

**Unit-III**

**Modeling and Mechanics:** Stresses and deformation: bars and beams and Solid mechanics concepts for Micro and smart systems, Solid Modeling in Micro systems and Frequency response; damping; quality factor.

**Unit-IV**

**Finite Element Method:** Types of Numerical Methods for solving partial differential equations, FEM applications for modeling and analysis of Coupled Electromechanical Systems

**Unit-V**

**Electronics and Packaging:** Integration of mechanical components with electronics, Electronic circuits and control for micro and smart systems, scaling effects and Case-study Pressure sensor and Accelerometer

**References**

1. *G. K. Ananta Suresh, Micro and Smart Systems, Wiley India Pvt. Ltd., 2010*
2. *G. K. Ananta Suresh, K. J. Vanoy, S. Gopala Krishnan, K. N. Bhat, V.*
3. *KasudevAatre, Micro and Smart Systems: Technology and Modeling, John Wiley & Sons, 2012.*
4. *Tai-Ran Hsu, MEMS and Microsystems: Design and Manufacture, Tata McGraw Hill Education Private Limited, 2002.*

| SUBJECT CODE | Category | SUBJECT NAME | TEACHING & EVALUATION SCHEME | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | THEORY | | | PRACTICAL | | L | T | P | CREDITS |
| | | | END SEM UNIVERSITY EXAM | TWO TERM EXAM | TEACHER ASSESSMENT* | END SEM UNIVERSITY EXAM | TEACHER ASSESSMENT* | | | | |
| MTME135 | DS | Computer Application in Design | 60 | 20 | 20 | 0 | 0 | 3 | 1 | 0 | 4 |

**Legends**: **L** - Lecture; **T** - Tutorial/Teacher Guided Student Activity; **P** – Practical; C - Credit;
**Teacher Assessment** shall be based following components: Quiz/Assignment/ Project/Participation in Class, given that no component shall exceed more than 20 marks.

**Course Educational Objectives (CEOs):**

(A)The primary objective of the course is to describe the Design Concepts with the help of Computer Application. (B)This course Provides Comprehensive Knowledge of computer applications including geometric, solid, surface & wireframe modeling and Assemblies of parts & Graphics Standards.

**Course Outcomes (COs):**

1. Student will be able to understand the various Design concepts with the help of computer application.
2. Students would be able to get familiarized with the computer graphics application in design and understand the basic 2D & 3D commands of CAD and distinguish the CAD from manual paper drafting, in current industrial & product development scenarios.
3. Students would be able to understand the Solid, Surface & Wireframe modeling to develop product to use in various experiments & real life.
4. On completion of this course the students will be able to acquire knowledge of the applications of computers in design, parts creation & assembling, mechanism and manufacturing activity.

## Syllabus

**Unit–I**

**Introduction to Design Concepts with Computer Application:** Introduction to CAD, Why CAD Software, Scope, objective, benefit, limitation & evaluation Engineering design, Engineering Design process, Types of designs, Considerations of a good design, Formulation of the design problem, Importance, Regulatory and social issues in Indian context, Conceptual Design, Product Design Cycle, Total life cycle, Digital Prototyping, Product development today.

**Unit–II**

**Computer Graphics Fundamentals:** Definition, Software configuration of a Graphic system, Functions of a Graphics package, CAD Interface , Coordinate system ,Create Objects, Linear Objects lines , Polylines, Multiline, Rectangle & Polygons, Freehand Sketches Curved Objects Arcs Circles Donuts Ellipses Splines, Helixes, Construction and Reference Geometry, Utility Commands, Modify Objects, Move or Rotate Objects, Copy, Array, Offset, Mirror, Change the Size and Shape of Objects

Chairperson
Board of Studies
Shri Vaishnav Vidyapeeth Vishwavidyalaya
Indore

Deputy Registrar
Shri Vaishnav Vidyapeeth Vishwavidyalaya
Indore

Fillet, Chamfer, Break, or Join Objects, Layers & Blocks, Text, Table & Dimensions , Introducing Printing, Plotting, and Layouts .

**Unit-III**

**Geometric Modelling:** Introduction of Geometric Modeling, Types of models, Construction of 3D Solid Primitives, create 3D Solids from Objects, Extrude, Revolve, Sweep, Loft, Combine or Slice 3D Objects, Move Rotate& Scale 3D Objects, Object Sectioning, Save and Publish Section Objects Wire Frame Models, Wire frame Entities, Curve Representation. Parametric Representation of Analytic Curves - Review of Vector Algebra, Lines, Circles, Ellipses, Parabolas, Hyperbolas, Conics. Parametric Representation of Synthetic Curves - Hermite Cubic Splines, Bezier Curves, B-Spline Curves, Rational Curves. Curve Manipulations.

**Unit-IV**

**Surfaces & Mesh**

Introduction Surface Models, Surface Entities, Surface Representation, Parametric Representation of Analytic Surfaces - Plane Surface, Ruled Surface, Surface of Revolution, Tabulated Cylinder. Parametric Representation of Synthetic Surfaces - Hermit Cubic Surface, Bezier Surface, B-Spline Surface, Coons Surface, Blending Surface, Offset Surface, Triangular Patches, Sculptured Surface, Rational Parametric Surface, Trim and Antrim Surfaces, Create &Edit NURBS& Control Vertices. Create 3D Mesh Primitives, Modify Mesh Objects, Change Mesh Smoothness Levels. Modify Mesh Faces. Meshing algorithms,

**Unit-V**

**Parts Assembly, Visualization & Graphics Standards:** Mechanical Assembly: Introduction, Assembly Creation Methods, Design for Assembly (DFA)

Assembly Modeling - Parts Modeling & Representation, Hierarchical Relationships, Generation of Assembling Sequences - Precedence Diagram, Assembly Constraints, Mechanism & Mechanism Analysis, Connections, Servo & Force Motors, Mass Properties, Representation schemes - Graph, Creating Visual styles, Materials and Texture, Light Effect, Camera & Animation.

Data exchange standards – IGES – STEP – CALS – DXF – STL

Communication standards – LAN, WAN.

**References**

1. *Introduction to Engineering Design, McGraw Hill.*
2. *Mastering CAD George Omura with Brian Benton Autodesk.*
3. *CAD/CAM: Principles and Applications 3rd Edition, Tata McGraw Hill, India, 2010.*
4. *Ibrahim Zeid and R. Sivasubramaniam, 2nd Edition, Tata McGraw Hill, India, 2009*
5. *Michael E. Mortenson, Geometric Modeling, Wiley, 1997.*
6. *Gerald E. Farin, Hans Hagen, Hartmut Noltemeier and Walter Knödel, Geometric Modeling, Springer-Verlag,199*
7. *Anupam Saxena, Birendra Sahay, Computer aided Engineering design, Springer, 2010.*

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|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | THEORY | | | PRACTICAL | | L | T | P | CREDITS |
| | | | END SEM UNIVERSITY EXAM | TWO TERM EXAM | TEACHER ASSESSMENT* | END SEM UNIVERSITY EXAM | TEACHER ASSESSMENT* | | | | |
| MTME106 | DS | Stimulation Modelling Lab (FEA, FEM & CFD) | 0 | 0 | 0 | 30 | 20 | 0 | 0 | 4 | 2 |

**Legends**: **L** - Lecture; **T** - Tutorial/Teacher Guided Student Activity; **P** – Practical; C - Credit;
**Teacher Assessment** shall be based following components: Quiz/Assignment/ Project/Participation in Class, given that no component shall exceed more than 20 marks.

## Course Educational Objectives (CEOs):

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

## Course Outcomes (COs):

1. Student are able to solve problems related to finite element formulation for engineering purpose.
2. Define the element properties such as shape function and stiffness matrix for the various elements.
3. Formulate element properties for 1D and 2D elements.
4. Develop skill to solve simple Heat Transfer problems using the steps of FEM Syllabus
5. Understand the governing of fluid flow, heat transfer and numerical solution.
6. Numerically solve the fluid flow field using some popular CFD techniques.\

**Unit-I**

**Introduction to Finite Element Method &Finite Element Techniques:** Basic Concept, Historical Background, Engineering applications, general Description, comparison with other methods. Module boundary value problem, finite element decentralization, element shapes, sizes and node locations, interpolation functions, derivation of element equations, connectivity, boundary conditions, FEM solutions, post processing, Compatibility and completeness requirements, convergence criteria, higher order and is parametric elements, natural coordinates, Lagrange and Hermit Polynomials

**Unit-II**

**Applications to Solid and Structural Mechanics & Heat Transfer Problems:** External and internal equilibrium equations, one-dimensional stress-strain relations, plane stress and strain problems, axis symmetric and three dimensional stress strain problems, strain displacement relations, boundary conditions compatibility equations, analysis of trusses, frames and solid of revolution, computer programs.
Variation approach, Galerkin approach, one dimensional and two dimensional steady state problems for conduction, convection and radiation, transient problems.

**Unit-III**

**Stimulation:** Monte Carlo simulation, generation of stochastic variates, continuous and discrete probability distributions, application of Monte Carlo methods for production systems, computer simulation models, Marco dynamic model.

**Unit-IV**

**Finite Element Methods:** Introduction, Calculus of variation, Ritz method, weighted residual methods., Fundamental concepts of the FEM, discretization of the domain, one and two and three dimensional elements and interpolation functions, compatibility and completeness requirements. Assembly and boundry conditions, formulation of FEM solutions., application to simple boundry value problems, computer implementation.

**Unit-V**

**Computation Fluid Dynamics:** Mathematical modeling: Governing equations of fluid flow and heat transfer; Introduction to discretization methods: Finite difference and finite volume methods for heat transfer problems; Time stepping methods for unsteady problems; Solution techniques for system of algebraic equations; Grid generation techniques; Solution techniques for Navier-Stokes equation; Finite element method for heat transfer and fluid flow problems; Turbulence modeling.

**References**

1. *Finite Element Analysis – Theory & Practice by Fagan (Longman Scientific & Technical)*
2. *Fundamentals of Finite Element Analysis, David Hutton, TMH*
3. *Finite Element Method versus Classical Methods, - H.S. Govinda Rao, New Age International Publishers*
4. *An Introduction to Finite Element Analysis by J. N. Reddy, (Tata McGraw- Hill Pub. Co.)*
5. *Introduction to Finite element analysis, Martin and Carey Tata McGraw Hill*
6. *The finite element method for engg. Huebner, John willey.*
7. *Furzier, J. H. and Peril, M. (2003). Computational Methods for Fluid Dynamics. Third Edition, Springer-Verlag, Berlin.*
8. *Versteeg, H. K. and Malalasekara, W. (2008). Introduction to Computational Fluid Dynamics: The Finite Volume Method. Second Edition (Indian Reprint) Pearson Education.*
9. *Anderson, D.A., Tannehill, J.C. and Pletcher, R.H. (1997). Computational Fluid Mechanics and Heat Transfer. Taylor & Francis.*
10. *K. Muralidhar, T. Sundarajan, Computational Fluid Flow and Heat Transfer, Narosa Publishing House, New Delhi, 1997.*

**List of experiments.**

1. Modeling and analysis of periodic and heat transfer over a bank of tubes
2. Modeling and analysis of external compressible flow over an aero foil blade
3. Analysis of unsteady compressible flow through a nozzle
4. Analysis of flow pattern inside Turbomachines applications
5. Analysis of air quality inside a passenger car
6. Analysis of varies nose body configuration
7. Quantitative description of flow phenomena using measurements
8. Quantitative prediction of flow phenomena using CFD software

9. Identify the forces which cause and influence the fluid motion.
10. Choose a suitable flow model (viewpoint) and reference frame.
11. Use a comprehensive model for combustion of fuel at atmospheric pressure and develop a computer programme to estimate the heat released assuming a single step reaction.