Thermal Engineering
Common to Thermal Eng.(MTH), Thermal Power Eng.(MTP)
Course Objectives:

The Student will learn different mathematical concept that can be used in finding solutions to many engineering problems and in formulating mathematic models to represent engineering applications.


   06 Hours


   Roots of polynomial-Polynomials in Engineering and Science, Muller’s method, Bairstow’s Method Graeffe’s Roots Squaring Method.

   12 Hours

Differentiation Applied to Engineering problems, High Accuracy differentiation formulae

06 Hours


14 Hours

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


12 Hours

Text Books:


Reference Books:

1. Pervez Moin “Application of Numerical methods to Engineering”.


Course Outcomes:

The Student will be able to

1. Model some simple mathematical models of physical Applications.

2. Find the roots of polynomials in Science and Engineering problems.

3. Differentiate and integrate a function for a given set of tabulated data, for Engineering Applications.
Course Objectives

1. Introduce the various aspects of FEM as applied to engineering problems.

2. Apply the fundamental concepts of mathematical methods and theory of elasticity to solve simple continuum mechanics problems.

1. Introduction to Finite Element Method: Engineering Analysis, History, Advantages, Classification, Basic steps, Convergence criteria, Role of finite element analysis in computer-aided design, Mathematical Preliminaries, Differential equations formulations, Variational formulations, weighted residual methods

   6 Hours

2. One-Dimensional Elements—Analysis of Bars and Trusses, Basic Equations and Potential Energy Functional, 1D Bar Element, Admissible displacement function, Strain matrix, Stress recovery, Element equations, Stiffness matrix,
Consistent nodal force vector: Body force, Initial strain, Assembly Procedure, Boundary and Constraint Conditions, Single point constraint, Multi-point constraint, Truss Element, Shape functions for Higher Order Elements, $C^0$, $C^1$ elements


Heat Transfer /Fluid Flow: Steady state heat transfer, 1 D
heat conduction governing equation, boundary conditions, one dimensional element, Functional approach for heat conduction, Galerkin approach for heat conduction, heat flux boundary condition, 1D heat transfer in thin fins. Basic differential equation for fluid flow in pipes, around solid bodies, porous media.

5. Dynamic Considerations: Formulation for point mass and distributed masses, Consistent element mass matrix of one dimensional bar element, truss element, beam element. Lumped mass matrix, Evaluation of eigen values and eigen vectors, Applications to bars, stepped bars, and beams.

6 Hours

Text Books:


Reference Books:


4. Bathe K. J. Finite Elements Procedures, PHI.

Course Outcome:

Students will be able to

1. Define the element properties such as shape function and stiffness matrix for the various elements.

2. Formulate element properties for 1D and 2D elements.

3. Develop skill to solve simple beam problems using the steps of FEM.
Course Objective: To understand the kinematics of fluids, their governing equations, Mechanics of laminar and turbulent flow, NS Equations and Experimental Techniques.

MODULE-I
Introduction and Kinematics of Fluids: Concepts of continuum rarefied gas dynamics, magneto fluid mechanics regimes in mechanics of fluids; fluid properties. Kinematics of Fluids - Methods of describing fluid motion - Lagrangian method, Eulerian method; translation, rotation and rate of deformation; stream lines, path lines and streak line; material derivative and acceleration; vorticity.

Governing Equations for Fluid Flow: Nature of stress; transformation of stresses - nature of strains; transformation of the rate of strain; relation between stress and rate of strain; Conservation equations for mass, momentum and energy - differential and integral forms; Euler’s equations of motion, integration along the stream line; integration of steady irrotational motion; integration for two dimensional unsteady flow. 12 Hours

MODULE-II
Mechanics of Laminar Flow: Introduction; Laminar and turbulent flows; viscous flow at different Reynolds number - wake frequency; laminar plane Poiseuille flow; stokes flow; flow through a concentric annulus.

Mechanics of Turbulent Flow: structure and origin of turbulent flow - Reynolds, average concept, Reynolds equation of motion; zero equation model for fully turbulent flows; k-l, k-ε and other turbulence models; turbulent flow through pipes; losses in bends, valves etc; analysis of pipe network - Hard cross method. 8 Hours

MODULE-III
Exact and Approximate solutions of N-S Equations: Introduction; Parallel flow past a sphere; Oseen’s approximation; hydrodynamic theory of lubrication; Hele-Shaw Flow.

Boundary Layer Theory: Introduction; Boundary layer equations; displacement and momentum thickness, shape factor; flow over a flat plate – similarity transformation, integral equation for momentum and energy; skin
friction coefficient and Nusselt number; separation of boundary layer; critical Reynolds number; control of boundary layer separation. **12 Hours**

**MODULE-IV**

**Flow Around bodies:** Introduction; flow past a circular cylinder; drag on a sphere; streamlined body, lift and drag on airfoil; Drag and lift on road vehicles. **8 Hours**

**MODULE-V**

**Experimental Techniques:** Introduction; improved modeling through experiments; design of fluid flow experiments; error sources during measurement; pressure transducers; hot wire anemometer; laser - Doppler velocity meter; methods of measuring turbulence fluctuations - flow visualization techniques; wind tunnel; analysis of experimental uncertainty - types of error, estimation of uncertainty. **10 Hours**

**Text Books:**

**Reference Books:**

**Course Outcome:** Students will have a thorough knowledge about the basics of fluid flow, their kinematics and governing equations. Knowledge about types of flow, etc.
Course Objective: To enrich the knowledge of students in thermodynamics. To predict the availability and irreversibility associated with the thermodynamic processes. To analyze the properties of ideal and real gas mixtures, behavior of pure substances and to understand the basic concepts of combustion, flame propagation and types of flames.

MODULE-I
Work and heat interaction, first law of thermodynamics, steady and unsteady flows with energy transaction. Second law of thermodynamics, reversibility, corollaries of the second law and entropy. Available energy, availability analysis of open and closed systems. **12 Hours**

MODULE-II
Properties of pure substances, properties of gases and gas mixtures, combined first and second laws of thermodynamics. Phase and reaction equilibrium, equilibrium constants, calculation of equilibrium composition of multi component gaseous mixtures. **8 Hours**

MODULE-III
Equation of state and calculation of thermodynamics and transport properties of substances. Reaction rates and first, second and higher order reaction, in gaseous, liquid and solid phases. **10 Hours**

MODULE-IV
Combustion and flame velocities, laminar and turbulent flames, premixed and diffusion flames, their properties and structures. **8 Hours**

MODULE-V
Theories of flame propagation, thermal, diffusion and comprehensive theories, problems of flame stability, flashback and blow off. Combustion of solid, liquid and gaseous fuels. Combustion of fuel droplets and sprays. Combustion system combustion in closed and open systems, application to boiler, gas turbine combustors and rocket motors. **12 Hours**

Text Books:

Reference Books:

**Course Outcome:**
Students will get an enriched knowledge about the availability and irreversibility associated with the thermodynamic processes, Properties of ideal and real gas mixtures, behavior of pure substances. The basic concepts of combustion, flame propagation and types of flames will also be known.
Course Objective: To create awareness about the availability of various non-conventional energy sources, their conversion technology.

MODULE-I
Man and Energy: World's Production and reserves of commercial energy sources, India's production and reserves, Energy alternatives, Different forms of non-conventional energy source, Limitation of conventional and non-conventional sources of energy.


MODULE-II
Thermal Application: Water heating, Drying, Cooking, Desalination, Solar refrigeration, solar ponds (Basic concepts).

MODULE-III
Biomass Energy Sources: Thermo-chemical and Bio-chemical routes to biomass Utilization.


Wave energy: Wave energy conversion machine & recent advances.

MODULE-IV
Mini and micro hydro power generation: Basic concepts, Types of turbines, Hydrological analysis.

Geothermal Energy Conversion: Forms of geothermal energy sources, geothermal electric power plants.

MODULE-V
OTEC: Principle of operation, Open and Closed OTEC cycles.

Tidal Energy: Single basin and double basin tidal systems (Basic concepts), nuclear fusion energy.

Text Books:
Reference Books:

Course Outcome: Students will get an idea about the availability of Non-conventional energy sources, their conversion technologies, utilization, etc.
Course Objective: To provide in-depth knowledge on Nuclear reaction materials reprocessing techniques and also to understand nuclear waste disposal techniques and radiation protection aspects.

MODULE-I
Radioactivity, Nuclear reactions, Cross sections, Nuclear fission, Power from fission, Conversion and breeding. 10 Hours

MODULE-II
Neutron transport equation, Diffusion theory approximation, Pick's law, Solutions to diffusion equation for point source, Planar source, etc. Energy loss in elastic collisions, Collision and slowing down densities. Moderation in hydrogen, Lethargy, concept. 10 Hours

MODULE-III
Moderation in heavy nucleus, Moderation with absorption, Resonance absorption, NR and NRIM approximations. Multi-region reactors, Multi-group diffusion methods. 10 Hours

MODULE-IV
Thermal reactors, Heterogeneous reactors. Reactor kinetics, in hour equation, Coefficients of reactivity, Control, Fission product poison. Perturbation theory. 10 Hours

MODULE-V
Environmental impact; Natural and artificial radioactivity, reactions from nuclear power plant, effluents, high level wastes. 10 Hours

Reference Books:

Course Outcome: Knowledge about fundamental study of nuclear reactions, nuclear fuels cycles, characteristics. Fundamental principles governing nuclear fission chain reaction and fusion will be demonstrated by the student.
Course Objective: To give an overview on the different technologies in vogue for converting one form of energy to another. To analyze the pros and cons of conventional energy conversion techniques. Waste heat recovery, Economic Analysis.

MODULE-I
General energy problem, Energy uses patterns and scope of conversion.

Energy Management Principle: Need, Organizing and managing an energy management program.

Energy Auditing: Elements and concepts, Type of energy audits instruments used in energy auditing.

10 Hours

MODULE-II
Economic Analysis: Cash flows, Time value of money, Formulae relating present and future cash flows- single amount, uniform series.

Financial appraisal methods: Pay back periods, net present value, benefit cost ratio, internal rate of return and Life cycle cost / benefits.

10 Hours

MODULE-III
Thermodynamics of energy conservation: Energy conservation in Boilers and furnace, Energy conservation in stream and condensate system.

Cogeneration: Concepts, Type of cogeneration system, performance evaluation of a cogeneration system.

8 Hours

MODULE-IV

Space Heating, Ventilation Air Conditioning (HVAC) and water heating of building, Transfer of heat, space heating methods, Ventilation and air conditioning, Heat pumps, Insulation, Cooling load, Electric water heating systems, Electric energy conversation methods.

Industrial Insulation: Insulation materials, insulation selection, Economical thickness of insulation. Industrial Heating: Heating by indirect resistance, direct resistance heating (salt bath furnace), Heat treatment by induction heating in the electric furnace industry.

12 Hours

MODULE-V

10 Hours
Reference Books:
4. **Industrial energy conservation Manuals**: MIT Press.

Course Outcome: Knowledge about the different technologies, Waste heat recovery, Economic Analysis. Will be very well understood by the students.

**REFRIGERATION AND AIR CONDITIONING**

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**Course Objective:** To teach the students about the methods of Refrigeration and its types, Psychrometry and its principles. Teaching the cycle analysis pertaining to various Refrigeration systems, Air-conditioning systems, cooling load calculations.

**MODULE-I**

**Method of Refrigeration and Non-conventional refrigeration system:** Ice refrigeration, evaporative refrigeration, refrigeration by expansion of air, refrigeration by throttling of gas, Vapor refrigeration system, steam jet refrigeration system, refrigeration by using liquid using liquid gases, dry ice refrigeration, types of refrigerants, properties of refrigerants, thermoelectric refrigeration, vortex refrigeration, cooling by adiabatic demagnetization, pulse tube refrigeration.

**Air refrigeration system:** Bell Coleman air refrigerator, advantages and disadvantages of air refrigeration system, necessity of cooling the aero plane, factors considered in selecting the refrigeration system for aero plane, simple cooling with simple evaporative type aero plane air conditioning, bootstrap and bootstrap evaporative type, regenerative type, reduced ambient type, comparison of different systems, actual air conditioning system with control, limitations, merits and comparisons.

**MODULE-II**

**Vapor compression refrigeration system:** Simple vapor refrigeration system, T-s, h-s, p-h diagrams for vapor compression refrigeration system, wet versus dry compression, vapor compression refrigeration systems with multiple evaporators and compressors.

**Absorption refrigeration system:** Basic- absorption system, actual ammonia absorption system, Electrolux refrigeration system, lithium bromide.
absorption refrigeration system, analysis of ammonia refrigeration system, comparison of compression and absorption refrigeration system. 

**MODULE-III**

**Psychometry:** Psychometry and psychometric properties, psychometric relations, psychometric chart, psychometric processes, requirements of comfort air conditioning, comfort chart, design consideration, summer air conditioning system, winter air conditioning.

**Cooling load calculations and design of air conditioning system:** Different heat sources, conduction heat load, radiation load of sun, occupants load, equipment load, infiltration air load, miscellaneous heat sources, fresh air load, design of air conditioning system, bypass factor consideration, effective sensible heat factor, cooling coils and dehumidifying air washers. 

**MODULE-IV**

**Air conditioning systems:** Air conditioning systems central station air conditioning system, unitary air conditioning system, direct air conditioning system, self contained air conditioning units, direct expansion system, all eater system, all air system air water system, arrangement of the components of some air conditioned systems used in practice, factory air conditioning.

**MODULE-V**

**Refrigeration and air conditioning equipments:** Refrigeration equipments- Compressors, condensers and cooling towers, evaporators, expansion devices, electric motors air conditioning equipments- air cleaning and air filters, humidifiers, dehumidifiers from different reputed companies, fans and blower. 

**Reference Books:**


**Course Outcome:** Students will be in a position to have a knowledge about the various refrigeration techniques, Psychrometry principles, cooling load calculations. Good understanding about components and equipments, etc.
Thermal Engineering Measurement Laboratory - Lab 1

Subject Code: 14MTP16  IA Marks : 25
Hours/Week : 6  Exam Hours : 03
Total Hours : 84  Exam Marks : 50

Note:

- These are independent laboratory exercises
- A student may be given one or two problems stated herein
- Student must submit a comprehensive report on the problem solved and give a presentation on the same.

1. Develop a Diaphragm Gauge using steel diaphragm and electrical strain gauges mounted on the diaphragm to measure pressure of a gaseous source. Calibrate the gauge using a standard source of pressure. Enumerate the range of pressure measurement by such gauges and draw the calibration curves for loading and un-loading conditions.

2. Develop manometers to measure pressure of gaseous sources of the order of 1 atm to 3 atm pressure. Choose proper size of glass tube, the multiple loops of tube and various manometric fluids to achieve the pressure ranges indicated. Also conduct the sensitivity test to assess the dynamic response of this gauge.

3. Develop a diaphragm Gauge with LVDT to measure low pressures. Calibrate the instrument against a standard pressure source of means and draw the calibration curves.
4. Design a venturimeter to measure the flow rate of a fluid of specific gravity 0.85 to measure flow rate up to 2 litres per second at atmospheric temperature of 30 degrees centigrade. Use standard charts for determining the coefficient of discharge of venturimeter. Suppose the differential pressure gauge used to measure the pressure difference across the throat and convergent portion has an accuracy of 0.3% of full scale, determine the percentage error of measurement of mass flow through the venturimeter at maximum flow rate.

5. Design a rotameter to measure the flow rate of water with a maximum flow rate of 0.25 litres per second. Obtain the calibration curve for the scale fixed on the rotameter for entire range of flow. Suppose a liquid of specific gravity 0.85 used instead of water, obtain the correction factor for the same.

6. Using a hot wire anemometer obtain the mean velocity profile in the test section of a laboratory wind tunnel and measure the turbulence intensity across the depth of the test section. The work should include the critical analysis of hot wire technique for measurement of velocity including design parameters and limitations of this technique.

7. Develop a shadowgraph and Schlieren to obtain the first order and second order density variation in the flow field. Using these techniques obtain the images of two fluid flow fields such as a jet of salt water flowing into distilled water, smoke coming out a insane-stick, thermal plumes raising from hot objects etc. Critical analysis of both techniques is a must.

8. Develop Mach-Zehnder interferometer and obtain the iso-temperature contours from a heated ball losing heat.
to ambient by natural convection. For these fringe lines obtained in free-convection boundary layers, obtain the expression for number of fringes and related density change in the temperature field.

9. For subsonic flows through an experimental wind tunnel, develop smoke visualisation technique and obtain the flow visualisation photographs for flow past a sharp edged flat plate at various angles of attack at different wind speeds and show the regimes of flow through photographs captured. Critical analysis of the image is essential to explain the phenomena of boundary layer separation.

10. Conduct a series of tests to obtain the stagnation pressure response of pitot probe in a wind tunnel for varied yaw angle of the stagnation pitot and obtain the response curve in terms of error, (percentage of velocity head) to yaw angle. Repeat the experiment for other any two different type of stagnation pitot probes of various c/s and obtain the response curves for varying yaw angle. Critical analysis of curves obtained is desired.

11. Conduct a series of tests to obtain the static pressure response of pitot probe in a wind tunnel for varied yaw angle of the static pitot and obtain the response curve in terms of error, (static percentage head) to yaw angle. Repeat the experiment for other any two different types of static pitot probes of different c/s and obtain the response curves for varying yaw angle. Critical analysis of curves obtained is desired.

12. Develop a simple constantan-iron or other suitable combination of thermocouple and calibrate it at freezing point and boiling point of water and draw the calibration curves. Integrate this instrument with a computer to log-
in the data of changing temperature of a source and develop a code to obtain the temperature values which would automatically take care of changing atmospheric temperature for compensation of cold junction. Obtain the time constant of this thermocouple depending on the bead diameter of the tip of the thermocouple.

13. Develop a system to measure the thermal conductivity of liquid. Use either guarded hot-plate apparatus or concentric cylinder concept for the same. Develop the equations for determining the thermal conductivity of liquids. Using this instrument measure the thermal conductivity of water, alcohol and any liquid fuel.

14. Conduct performance test on IC engine and obtain the characteristic curves of mass flow of fuel to brake power (BP) at various operating loads and brake mean effective pressure (bmep) show that for same BP and bmep, two distinct values of mass flow of fuel is possible.

15. Conduct performance test on any IC engine and draw the conclusions on the effect of variation of load on the engine to its emission of pollution in terms of particulate matter (in case of diesel engine), CO, and NOX. Draw conclusions suitably.

16. Conduct performance test on any IC engine to evaluate the performance and emission characteristics of engine for various blends of bio-fuel with petroleum fuel and draw the conclusions. Critical analysis of performance and emission is essential.

17. Establish the effect of Exhaust Gas Recirculation (EGR) in IC engine to reduce the NOX formation. Draw the emission curves at various percentage of exhaust recirculation and also comment on the relative change in the performance of engine in terms of Brake Power.
Course Objective: To develop the ability to use the heat transfer concepts for various applications like finned systems, turbulence flows, high speed flows. To analyze the thermal analysis and sizing of heat exchangers and to learn the heat transfer coefficient for compact heat exchanges. To achieve an understanding of the basic concepts of fluid flow, phase change processes and radiation heat transfer.

MODULE-I
Introduction and one-dimensional heat transfer: The modes of heat transfer, the laws of heat transfer, problems Heat conduction in solids: Simple steady state problems in heat conduction, concept of thermal resistance, the critical radius problem, the differential equation of heat conduction, heat generation, two dimensional steady state heat conduction, unsteady state processes, extended surfaces-fins, other techniques for solving heat conduction problems, the finite difference method for steady state situations, the finite difference method for unsteady state situations, problems.

Steady state conduction in multiple dimensions: Mathematical analysis of 2-D heat conduction, graphical analysis, the conduction shape factor, numerical method of analysis, Gauss-Siedel iteration, electrical analogy for 2-D conduction. 12 Hours

MODULE-II
Thermal radiation: basic concepts, emission characteristics and laws of black body radiation, radiation incident on a surface, solid angle and radiation intensity, heat exchange by radiation between two black surface elements, heat exchange by radiation between two finite black surfaces, the shape factor, radiant heat exchange in an enclosure having black surfaces, heat exchange by radiation between two finite parallel diffuse-gray surfaces, heat exchange by radiation in an annular space between two infinitely long concentric cylinders, radiant heat exchange in an enclosure having diffuse gray surfaces, problems. 8 Hours

MODULE-III
Principles of fluid flow: the law of conservation of mass—the differential equation of continuity, differential equations of motion in fluid flow—Navier-Stokes equations, laminar flow in a circular pipe, turbulent flow in a pipe, the velocity boundary layer, laminar flow over a flat plate, the integral method—
an appropriate technique for solving boundary layer problems, turbulent flow over a flat plate, problems.

**MODULE-III**

**Heat transfer by forced convection:** the differential equation of heat convection, laminar flow heat transfer in circular pipe, turbulent flow heat transfer in a pipe, the thermal boundary layer, heat transfer in laminar flow over a flat plate, the integral method, analogy between heat and momentum transfer, heat transfer in turbulent flow over a flat plate, flow across a cylinder, flow across a bank of tubes, problems.

**Heat transfer by natural convection:** natural convection heat transfer from a vertical plate, correlations for a horizontal cylinder and a horizontal plate, correlations for enclosed spaces, problems.

**MODULE-IV**

**Heat exchangers:** types of heat exchangers, direct transfer type of heat exchangers, classification according to flow arrangement, fouling factor, logarithmic mean temperature difference, the effectiveness-NTU method, other design consideration, Compact heat exchangers.

**MODULE-V**

**Condensation and boiling:** film and drop condensation, film condensation on a vertical plate, condensation on horizontal tubes, bank of tubes, effect of superheated vapor and of non-condensable gases, types of boiling: correlations in pool boiling heat transfer, forced convection boiling, problems.

**Reference Books:**


**Course Outcome:** Students will have a good understanding and the ability to use the heat transfer concepts for various applications like finned systems, turbulence flows, high speed flows. Ability to analyze and size heat exchangers.
Course Objective: To learn the working principle, operations and analysis of nozzles, diffusers, steam and gas turbines.

**MODULE-I**


10 Hours

**MODULE-II**

**Steam Turbines Types and Flow of Steam through Impulse Blades**

Principal of operation of turbine, Comparison of Steam Engines and Turbines, Classifications of Steam Turbine, The Simple Impulse Turbine, Compounding of Impulse Turbine, Pressure Compounded Impels Turbine, Simple Velocity –Compounded Impulse Turbine, Pressure Velocity – Compounded Impulse Turbine, Impulse –Reaction Turbine, Combination Turbines, Difference between Impulse and Reaction Turbines. Velocity Diagram for Impulse Turbines, Combination of Vector Diagram, Forces on the Blade and Work done by Blades, Blade or Diagram Efficiency, Axial Thrust or end thrust on the rotor, Gross Stage Efficiency, Energy Converted heat by blade friction, Influence of ratio of blade speed to steam speed on blade efficiency in single stage impulse turbine, Efficiency of multistage impulse turbine with single row wheel, Velocity diagram for three row velocity compound wheel, Most economical ratio of blade speed for a two row velocity compounded impulse wheel, Impulse blade suctions, Choice of
blade angle, Inlet blade angles, Blade heights in velocity compounded impulse turbine.

**MODULE-III**

*Flow of Steam Through Impulse-Reaction Turbine Blades:* Velocity diagram, degree of reaction, impulse-reaction turbine with similar blade section and half degree reaction turbine, height of reaction turbine blading, effect of working steam on the stage efficiency of Parson’s turbine, operation of impulse blading with varying heat drop or variable speed, impulse-reaction turbine section.

*State Point Locus Reheat Factor and Design Procedure:* Introduction, stage efficiency of impulse turbines, state point locus of an impulse turbine, reheat factor, internal and other efficiencies, increase in isentropic heat drop in a stage due to friction in proceeding stage, correction for terminal velocity, reheat factor for an expansion with the uniform adiabatic index and a constant stage efficiency, correction of reheat factor for finite number of stages, design procedure of impulse turbine, design procedure for impulse-reaction turbines.

**10 Hours**

**MODULE-IV**

*Axial Flow and Centrifugal Compressors:* Elementary theory, compressibility effects, factors affecting stage pressure ratio, blockage in compressor annulus, degree of reaction, 3-dimensional flow, design process and blade design, off design performance, compressor characteristics.


**10 Hours**

**MODULE-V**

*Axial and Radial Flow Gas Turbines and Prediction of performance:* Elementary theory of axial flow turbine, vortex theory, choice of blade profile, pitch and chord, estimation of blade performance, overall turbine performance, the tooled turbine, the radial flow turbine. Component characteristics, off-design operation of the single-shaft gas turbine, equilibrium running of a gas generator, off-design operation of free turbine engine, off-design operation of the jet engine, methods of displacing the equilibrium running line, incorporation of variable pressure losses.

*Jet and Rocket Propulsion:* The ram jet engine, pulse jet engine, turbo prop engine, turbo jet engine, thrust equation, specific thrust, principles of rocket propulsion, ideal chemical rocket, advantages of liquid over solid propellants, free radical propulsion, nuclear propulsion, electro dynamics propulsion, photon propulsion.

**10 Hours**

**Reference Books:**

31

**Course Outcome:**
Students will get a good understanding about the working of nozzles, diffusers, flow of steam in steam turbine, compressors and rocket and jet propulsion.

**ADVANCED POWER PLANT CYCLES**

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**Course Objective:**
To provide a knowledge about the analysis of various cycles used for power generation, Combustion, kinetics involved in combustion. To impart knowledge about feed water circulation, working of FWH.

**MODULE-I**

**Analysis of Steam cycles:** Rankine cycle, Carnot cycle, mean temperature of heat addition, effect of variation of steam condition on thermal efficiency of steam power plant, reheating of steam, regeneration, regenerative feed water heating, feed water heaters, carnotization of Rankine cycle, optimum degree of regeneration, Super critical pressure cycle, steam power plant appraisal, Deaerator, typical layout of steam power plant, efficiencies in a steam power plant, Cogeneration of Power and Process Heat, Numerical Problems.

**Combined cycle power generation:** Flaws of steam as working fluid in Power Cycle, Characteristics of ideal working fluid in vapor power cycle, Binary vapor cycles, coupled cycles, combined cycle plants, gas turbine-steam turbine power plant, MHD-steam power plant, Thermionic- Steam power plant, Numerical problems. **12 Hours**

**MODULE-II**

**Fuels and combustion:** Coal, fuel oil, natural and petroleum gas, emulsion firing, coal – oil and coal – water mixtures, synthetic fuels, bio-mass, combustion reactions, heat of combustion and enthalpy of combustion, theoretical flame temperature, free energy of formation, equilibrium constant, effect of dissociation, Numerical problems.

**Combustion Mechanisms:** Kinetics of combustion, mechanisms of solid fuel combustion, kinetic and diffusion control, pulverized coal firing system, fuel-bed combustion, fluidized bed combustion, coal gasifiers, combustion of
fuel oil, combustion of gas, combined gas fuel oil burners, Numerical problems. **12 Hours**

**MODULE-III**

**Steam Generators:** Basic type of steam generators, fire tube boilers, water tube boilers. Economizers, superheaters, reheaters, steam generator control, air preheater, fluidized bed boilers, electrostatic precipitator, fabric filters and bag houses, ash handling system, feed water treatment, de-aeration, evaporation, internal treatment, boiler blow down, steam purity, Numerical problems.

**Condenser, feed water and circulating water systems:** Need of condenser, direct contact condensers, feed water heaters, circulating water system, cooling towers, calculations, Numerical Problems. **10 Hours**

**MODULE-IV**

**Nuclear Power Plants:** Chemical and nuclear reactions, nuclear stability and binding energy, radioactive decay and half life, nuclear fission, chain reaction, neutron energies. Neutron flux and reaction rates, moderating power and moderating ratio, variation of neutron cross sections with neutron energy, neutron life cycle. Reflectors, Types of Reactor, PWR, BWR, gas cooled reactors. Liquid metal fast breeder reactor, heavy water reactors, Fusion Power reactors, Numerical problems. **8 Hours**

**MODULE-V**

**Hydro Electric Power Plant:** Introduction, advantages and disadvantages of water power, optimization of hydro – thermal mix, hydrological cycles, storage and pondage, essential elements of hydro electric power plant, classification, hydraulic turbines – Pelton wheel, Francis turbine, propeller and Kaplan turbines, Deriaz turbine, bulb turbine, comparisons of turbines, selection of turbines, Numerical problems. **8 Hours**

**Reference Books:**


**Course Outcome:** Students will have an idea about the use of various cycles for power generation. The types of turbine tom be selected for power generation, etc.
THEORY OF IC ENGINES

Course Objective: To impart the knowledge of working cycle, Engine design and operating conditions, combustion phenomena, Engine emission and control, use of alternate fuels in IC engines.

MODULE-I
Engine Design and Operating Parameters: Engine characteristics, geometrical properties of reciprocating engines, brake torque, indicated work, road load power, M.E.P., S.F.C. and efficiency, specific emissions and emission index, relationships between performance parameters, Engine design and performance data.

Ideal models for engine cycles: Thermodynamic relation for engine process, Ideal Cycle analysis, fuel-air cycle analysis, over expanded engine cycles, Availability analysis of engine processes, comparison with real engine cycle. 10 Hours

MODULE-II
SI Engines fuel metering, manifold phenomena: S.I. Engine mixture requirements, carburetors, fundamentals and design, fuel injection systems, feed back systems, flow past throttle plate, flow in in-take manifold.

Combustion in IC Engines: Combustion in SI Engines – Flame front propagation, flame speed, rate of pressure rise, knock in SI engines; combustion in CI engines – ignition delay period, rapid and controlled combustion, factors affecting delay period, knock in CI engines. 10 Hours

MODULE-III
Engine Operating Characteristics: Engine performance parameters, Effect of spark-timing, Mixture composition, load and speed and compression ratio on engine performance, efficiency and emissions, SI engine combustion chamber design and optimization strategy, Testing of SI engine. 10 Hours

MODULE-IV
Instrumentation: Pressure measurement in engines, recording pressure and crank angle diagram, measurement of pollutants.

Engine emissions and their control: Air pollution due to IC engines, Euro norms I & II, engine emissions, emission control methods – thermal converters, catalytic converters, particulate traps, Ammonia injection systems, exhaust gas recirculation. 10 Hours

MODULE-V
Alternate fuels for I.C engines: Vegetable oils, alcohol’s, L.P.G, C.N.G, properties, Fuel Air ratio, emission characteristics. 10 Hours
Reference Books:

Course Outcome: A good understanding about combustion and emissions from IC engine, Engine instrumentation, Fuels, Alternate fuel usage, etc
Elective-II
THERMAL POWER STATION – I

Sub Code : 14MTP251  IA Marks : 50
Hrs/ Week : 04  Exam Hours : 03
Total Hrs. : 50  Exam Marks : 100

Course Objective: To impart knowledge about various components and equipments used in a thermal power plant, their maintenance and performance analysis.

MODULE-I
Steam Generator and Auxiliaries: High pressure boilers, classification, schemes, circulation, nature of fuels and its influence on design, furnaces, PF burners, PF milling plant, oil and gas burner types and location, arrangement of oil handling plant.
Waste heat recovery systems: Furnace circuit, steam side and waterside corrosion, pressure parts, super heater, re-heater, and economizer, de-super heater, air heater, on-load cleaning of boilers. **12 Hours**

MODULE-II
Dust Extraction Equipment: Bag house, electrostatic precipitator, draught systems, FD, ID and PA fans, chimneys, flue and ducts, dampers, thermal insulation and line tracing, FBC boilers and types, waste heat recovery boilers. **8 Hours**

MODULE-III
Feed Water system: Impurities in water and its effects, feed and boiler water corrosion, quality of feed water, boiler drum water treatment and steam purity, water treatment, clarification, demineralization, evaporation and reverse osmosis plant.
Circulating water system: Introduction, System classification, The circulation system, Wet-Cooling towers, Wet-cooling tower calculations, Dry cooling towers, Dry-cooling towers and plant efficiency and economics, wet-dry cooling towers, cooling-tower icing, Cooling lakes and ponds, Spray ponds and canals. **12 Hours**

MODULE-IV
Operation and Maintenance of Steam Generators and auxiliaries: Pre commissioning activities, Boiler start up and shut down procedures, emergencies in boiler operation, Maintenance of Steam generator and auxiliaries. **8 Hours**

MODULE-V
Performance: Boiler efficiency and optimization, coal mill, fans, ESP.
EIA study: Pollutants emitted, particulate matter, SOx and NOx and ground level concentration, basic study of stack sizing. **10 Hours**
Reference Books:

Course Outcome: The students will have a good understanding about the components used, their operation and maintenance and performance of it.
Course Objective: To impart the idea of various alternate fuels available for IC Engine, Engine classification depending upon the fuel used.

MODULE-I
Fuels: Introduction, Structure of petroleum, Refining process, Products of refining process, Fuels for spark ignition, Knock rating of SI engine fuels, Octane number requirement, Diesel fuels.
Properties of petroleum products: Specific gravity, Density, Molecular weight, Vapour pressure, Viscosity, Flash point, Fire point, Cloud point, Pour point, Freezing point, Smoke point & Char value, Aniline point, Octane Number, Performance Number, Cetane Number, Emulsification, Oxidation Stability, Acid Value/Number, Distillation Range, and Sulphur content.
12 Hours

MODULE-II
Alternative fuels for I.C. engines: Need for alternative fuels such as Ethanol, Methanol, LPG, CNG, Hydrogen, Biogas and Producer gas and their methods of manufacturing.
Single Fuel Engines: Properties of alternative fuels, Use of alternative fuels in SI engines, Engine modifications required, Performance and emission characteristics of alternative fuels in SI mode of operation v/s gasoline operation. 12 Hours

MODULE-III
Bio-diesels: What are bio-diesels Need of bio-diesels, Properties of bio-diesels v/s petro-diesel, Performance and emission characteristics of bio-diesels v/s Petro diesel operation. 12 Hours

MODULE-IV
Availability: Suitability & Future prospects of these gaseous fuels in Indian context. 7 Hours

MODULE-V
Environmental pollution: with conventional and alternate fuels, Pollution control methods and packages. 7 Hours
Reference Books:

Course Outcome: Various fuels available, their usage in IC Engines, Emissions, performance analysis will be very well understood by the students.

MODELING & SIMULATION OF THERMAL SYSTEMS

<table>
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<th>Sub Code</th>
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<th>Exam Hours</th>
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<td>04</td>
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Course Objective: To provide review and use knowledge from thermodynamics, heat transfer and fluid mechanics, modeling and simulation techniques for thermal system component analysis and their synthesis in integral engineering systems and processes

MODULE-I

Principle Of Computer Modeling And Simulation: Monte Carlo simulation, Nature of computer modeling and simulation, limitations of simulation, areas of application.

System And Environment: components of a system —discrete and continuous systems. Models of a system-a variety of modeling approaches.

12 Hours

MODULE-II

Random Number Generation: technique for generating random numbers — mid square method- The mid product method- constant multiplier technique-additive congruential method —linear congruential method —tests for random numbers —the kolmogorov-simrnov test-the Chi-square test.

**12 Hours**

**MODULE-III**


Design And Evaluation Of Simulation Experiments: variance reduction techniques—antithetic variables—variables-verification and validation of simulation models.

**12 Hours**

**MODULE-IV**


**7 Hours**

**MODULE-V**

Introduction to GPSS: Programming for discrete event systems in GPSS, case studies.

**7 Hours**

**Reference Books:**


**Course Outcome:**

Students will be in a position to learn basic principles underlying piping, pumping, heat exchangers; modeling and optimization in design of thermal systems. They can also develop representational modes of real processes and systems. Optimization concerning design of thermal systems will also be dealt with.
Course Objective: To impart the knowledge of computational methods in heat transfer and fluid flow, Finite volume method, various techniques, boundary conditions.

MODULE-I

Finite difference: Discretization, consistency, stability and fundamentals of fluid flow modeling, application in heat conduction and convection, steady and unsteady flow. 12 Hours

MODULE-II

Finite Volume Method: application to transient Heat Transfer. 12 Hours

MODULE-III
Finite Volume Method: application to Convective Heat Transfer.

Finite Volume Method: application to Computation of Fluid Flow SIMPLE algorithms. 12 Hours

MODULE-IV
Solution of viscous incompressible flow: Stream function and vorticity formulation. Solution of N S equations for incompressible flow using MAC algorithm. 8 Hours

MODULE-V
Compressible flows via Finite Difference Methods 6 Hours

Reference Books:
Course Outcome: Students will have a good knowledge about the computational methods to be used in heat transfer and fluid flow problems. Good knowledge about Finite Volume Methods.

Simulation Laboratory Projects on Thermal Engineering - Lab 2

Subject Code: 14MDE26 IA Marks : 25
Hours/Week : 6 Exam Hours : 03
Total Hours : 84 Exam Marks : 50

Note:

- These are independent laboratory exercises
- A student may be given one or two problems stated herein
- Student must submit a comprehensive report on the problem solved and give a presentation on the same.
- Computer programme can be developed in ‘C’ or MATLAB.
- MATLAB Simulink can be used wherever applicable.

1. Build a generic IC engine (petrol /diesel) Model in MATLAB Simulink and draw the performance curves (a) torque v/s speed, (b) power v/s speed, (c) overall efficiency v/s brake power (d) specific fuel consumption v/s brake power and analyse the curves for varied Air:Fuel ratio.
2. 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.

3. Develop computer programme to estimate adiabatic flame temperature of simple fuels such as methane. Use Gibb’s Free Energy principle for determining the adiabatic flame temperature.

4. Using MATLAB Simulink environment SIMDRIVELINE, import a four-wheeler model and run this model at various acceleration and speed and obtain the fuel consumption report. The report must be comprehensive and critical analysis of the result is essential.

5. Develop programmes in C or MATLAB to solve \( \frac{\partial T}{\partial t} = \alpha \frac{\partial^2 T}{\partial x^2} \) and draw the characteristic curves for various boundary conditions. Use Forward Time Central Space (FTCS) scheme.

6. Develop programmes in C or MATLAB to solve \( \frac{\partial T}{\partial t} = \alpha \frac{\partial^2 T}{\partial x^2} \) and draw the characteristic curves for various boundary conditions. Use Dufort-Frankel Model.

7. Develop programmes in C or MATLAB to solve \( \frac{\partial T}{\partial t} = \alpha \frac{\partial^2 T}{\partial x^2} \) and draw the characteristic curves for various boundary conditions. Use Lasoonen Model.

8. Develop programmes in C or MATLAB to solve \( \frac{\partial T}{\partial t} = \alpha \frac{\partial^2 T}{\partial x^2} \) and draw the characteristic curves for various boundary conditions. Use Crank-Nicholsen Model.
IV Sem

DESIGN OF HEAT TRANSFER EQUIPMENTS FOR THERMAL POWER PLANT

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Course Objective: To impart the idea of design of heat transfer equipment for thermal power stations,

SECTION – I

1. **Design of Double Pipe Heat Exchanger**
2. **Design of Shell and Tube Heat Exchanger**
3. **Design of Recuperative Air Pre Heater**
4. **Design of Economizer:** Estimation of Sulphur acid due point.

6. **Superheater and Reheater Design:** Estimation of flow in each element of a tube assembly. Estimation of attenuation factor and direct radiation from furnace, flame, or cavity Qr.

25 Hours

SECTION – II

1. **Design of Steam Condenser:** Effect of tube side velocity on surface area and pressure drop for various tube sizes (It involves estimation of tube side velocity, surface area and pressure drop for various tube sizes & Plot the graph) and estimation of shell diameter of steam condenser.

2. **Design of Fuel Oil Suction Heater**

3. **Design of Fuel Oil Heater**

4. **Design of Cooling Tower**
25 Hours
Reference Books:

QUESTION PAPER PATTERN

1. Three questions to be set in Section I each carrying 25 Marks, and the students are required to answer any two full questions.

2. Two questions are to be set in Section II each carrying 50 marks and students are required to answer any one full question.

Use of design data hand book prepared by the tutor using the prescribed reference books, steam tables charts and standards are permitted in the examination.

**Course Outcome:** At the end of the course students will have an idea about various design aspects and considerations about the equipment used for thermal power plants.
Course Objective: To impart knowledge in momentum transfer. Various PDE’s, Solutions to practical problems, convective mass transfer.

MODUL-I
Introduction, Conservation Principles and Fluid Stresses and Flux Laws.
The Differential Equations Of The Laminar Boundary Layer, The Integral Equations Of The Boundary Layer, The Differential Equations Of The Turbulent Boundary Layer. 12 Hours

MODULE-II
Momentum transfer and Heat transfer for Laminar Flow inside Tubes. Momentum transfer and Heat transfer in Laminar External Boundary layer.

12 Hours

MODULE-III

12 Hours

MODULE-IV
The Influence of Temperature-Dependent Fluid Properties, Free-Convection Boundary Layers. 7 Hours

MODULE-V

7 Hours

Reference Books:

Course Outcome: Good knowledge in momentum heat transfer, solutions to practical problems will be very well be received.
ENGINE FLOW & COMBUSTION

Course Objective: To impart the knowledge of gas exchange process, movement of fuel, combustion and pollution formation. Knowledge about engine heat transfer

MODULE-I
Gas exchange process: Inlet & exhaust processes in four stroke cycle, volumetric efficiency, flow through valves, residual gas fraction, exhaust gas flow rate and temperature variation, super charging, turbo charging. Charge motion within the cylinder: Intake jet flow, mean velocity turbulence characteristics, swirl, squish, pre chamber engine flows, crevice flow and blow by, flows generated by piston cylinder wall interaction. **12 Hours**

MODULE-II
Combustion in SI engines: Essential features of the process, thermodynamics analysis, burned and unburned mixture states, analysis of cylinder pressure data, combustion processes characterization, flame structure and speed, cyclic variations in combustion, partial burning and misfire, spark ignition and alternative approaches, abnormal combustion, knock and surface ignition.

Combustion in CI engines: Essential features of the process, types of diesel combustion systems, fuel spray behavior, and ignition delay, mixing controlled combustion. **12 Hours**

MODULE-III
Pollutant formation and control: Nature of the problem, nitrogen oxide, carbon monoxide, un-burnt hydrocarbon emissions, particulate emissions, exhaust gas treatment. **8 Hours**

MODULE-IV
Engine heat transfer: Model of heat transfer, engine energy balance, intake and exhaust heat transfer, radiations from gases, flame radiation component, temperature distributions, effect of engine variables. **8 Hours**

MODULE-V
Super Charging, Engine Performance **10 Hours**

Reference Books:

**Course Outcome:**
Students get exposure to knowledge about gas exchange and combustion in IC engine.
**Course Objective:** To provide an introduction to thermal system design, Exergy analysis. Design of piping and pumping systems. Thermo Economic analysis.

**MODULE-I**

**Introduction to Thermal System Design:** Introduction; Workable, optimal and nearly optimal design; Thermal system design aspects; concept creation and assessment; Computer aided thermal system design.

**Thermodynamic modeling and design analysis:** First and second law of thermodynamics as applied to systems and control volumes, Entropy generation; Thermodynamic model – Cogeneration system. **12 Hours**

**MODULE-II**

**Exergy Analysis:** Exergy definition, dead state and exergy components; Physical Exergy – Exergy balance; Chemical Exergy; Applications of exergy analysis; Guidelines for evaluating and improving thermodynamic effectiveness.

**Heat transfer modeling and design analysis:** Objective of heat transfer processes; Review of heat transfer processes involving conduction, convection and radiation and the corresponding heat transfer equations used in the design. **12 Hours**

**MODULE-III**

**Design of piping and pump systems:** Head loss representation; Piping networks; Hardy – Cross method; Generalized Hardy – Cross analysis; Pump testing methods; Cavitation considerations; Dimensional analysis of pumps; piping system design practice. **8 Hours**

**MODULE-IV**

**Thermo-economic analysis and evaluation:** Fundamentals of thermo-economics, Thermo-economic variables for component
evaluation; thermo-economic evaluation; additional costing considerations. **8 Hours**

**MODULE-V**

**Thermo-economic optimization**:- Introduction; optimization of heat exchanger networks; analytical and numerical optimization techniques; design optimization for the co-generation system—a case study; thermo-economic optimization of complex systems. **10 Hours**

**Reference Books:**

**Course Outcome:** To learn basic principles underlying piping, pumping, heat exchangers; modeling and optimization in design of thermal systems. To develop representational modes of real processes and systems. To develop thermo economic optimization concerning design of thermal systems.
**Course Objective:** To enhance the knowledge of the students about various measuring instruments, techniques and importance of error and uncertainty analysis.

**MODULE-I**

**Introduction:** Basic concepts of measurement methods, single and multi point measurement Min space and time. Processing of experimental data, curve fitting and regression analysis. Data Acquisition systems: Fundamentals of digital signals and their transmission, A/D-and D/A converters, Basic components of data acquisition system. Computer interfacing of digital instrument and data acquisition systems; Digital multiplexes, Data acquisition board (DAQ), Digital image processing fundamentals.

**Design and Construction of Experimental facilities:** wind tunnel, general test rigs, Test cells for flow visualization and temperature mapping.

**12 Hours**

**MODULE-II**

**Modeling and Simulation of Measurement System:** Lumped analysis, first order and second order systems: Frequency response and time constant calculation. Response of a generalized instrument to random data input, FFT analysis.

**Temperature Measurement:** Measurement Design, Construction and Analysis of liquid and gas thermometers, resistance thermometer with wheat stone bridge, Thermo-electric effect, Construction, testing and calibration of thermocouples and thermopiles, Analysis of effect of bead size and shielding on time constant and frequency response characteristics of thermocouple, pyrometers, radiation thermometers.

**12 Hours**

**MODULE-III**

**Interferometry & Humidity measurement:** interferometers, Humidity measurement: Conventional methods, electrical transducers, Dunmox humidity and microprocessor based dew point instrument, Calibration of humidity sensors.

**Flow and Velocity Measurement:** industrial flow measuring devices, design, selection and calibration, velocity measurements, pitot tubes, yaw tubes, pitot static tubes; frequency response and time constant calculation. Hot-wire anemometer; 2d/3d flow measurement and turbulence measurement, Laser application in flow measurement, Flow visualization techniques, Combustion photography.

**12 Hours**

**MODULE-IV**
Measurement of Pressure, Force, and Torque: Analysis of liquid manometer, dynamics of variable area and inclined manometer, Pressure transducers, Speed and torque measurement: r speed and torque measurement of rotating system. 7 Hours

MODULE-V
Air Pollution sampling and measurement; Units for pollution measurement, gas sampling technique s, particulate sampling technique, gas chromatography. 7 Hours

Reference Books:

Course Outcome: Knowledge on various measuring instruments will be very well understood. Knowledge on advance measurement techniques. Good understanding about the various steps involved in error analysis and uncertainty analysis.