ISEMESTERM.TECH. THERMAL ENGINEERING.

APPLIED MATHEMATICS

(Common to MDE,MMD,MEA,CAE,MCM,MAR,IAE,MTP,MTH,MTE,MST,MTR)

Sub Code: 16MDE11 IA Marks: 20

Hrs/ Week: 04 Exam Hours: 03

Total Hrs: 50 Exam Marks: 80

CourseObjectives

The main objectives of the course are to enhance the knowledge of various methods in finding the roots of an algebraic, transcendental or simultaneous system of equations and to evaluate integrals numerically and differentiation of complex functions with a greater accuracy. These concepts occur frequently in their subjects like finite element method and other design application oriented subjects.

Module 1: Approximationsandroundofferrors:Significantfigures,accuracyandprecision,errordefinitions,roundofferrorsandtruncationerrors. MathematicalmodelingandEngineeringproblemsolving:Simplemathematicalmodel,ConservationLawsof Engineering. **06Hours**

Module 2: Roots of Equations: Bracketing methods-Graphical method, Bisection method, False position method, Newton-Raphson method, Secant Method. Multiple roots, Simple fixed point iteration. Roots of polynomial-Polynomials in Engineering and Science, Muller's method, Bairstow's Method Graeffe's Roots Squaring Method.

12 Hours

Module 3: Numerical Differentiation and Numerical Integration: Newton –Cotes and Guass Quadrature Integration formulae, Integration of Equations, Romberg integration, Numerical Differentiation Applied to Engineering problems, High Accuracy differentiation formulae.

06 Hours

Module 4: System of Linear Algebraic Equations And Eigen Value Problems: Introduction, Direct methods, Cramer's Rule, Gauss Elimination Method, Gauss-Jordan Elimination Method, Triangularization method, Cholesky Method, Partition method, error Analysis for direct methods, Iteration Methods.Eigen values and Eigen Vectors: Bounds on Eigen Values, Jacobi method for symmetric matrices, Givens method for symmetric matrices, Householder's method for symmetric matrices, Rutishauser method for arbitrary matrices, Power method, Inverse power method. **14 Hours**

Module 5: Linear Transformation: Introduction to Linear Transformation, The matrix of Linear Transformation, Linear Models in Science and Engineering Orthogonality and Least Squares: Inner product, length and orthogonality, orthogonal sets, Orthogonal projections, The Gram-schmidt process, Least Square problems, Inner product spaces**.**

12 Hours

Text Books:

1. S.S.Sastry, Introductory Methods of Numerical Analysis, PHI, 2005.
2. Steven C. Chapra, Raymond P.Canale, Numerical Methods for Engineers, Tata Mcgraw Hill, 4th Ed, 2002.
3. M K Jain, S.R.K Iyengar, R K. Jain, Numerical methods for Scientific and engg computation, New Age International, 2003.

Reference Books:

1. Pervez Moin, Fundamentals of Engineering Numerical Analysis, Cambridge, 2010.

2. David. C. Lay, Linear Algebra and its applications, 3rd edition, Pearson Education, 2002.

CourseOutcomes:

TheStudentwillbeableto

1. Modelsomesimplemathematicalmodelsofphysical Applications.
2. FindtherootsofpolynomialsinScienceandEngineeringproblems.
3. Differentiateandintegrateafunctionforagivensetoftabulateddata,for EngineeringApplications

ISEMESTERM.TECH. THERMAL ENGINEERING.
FINITE ELEMENT METHOD

<table>
<tr><th rowspan="2">Course</th><th rowspan="2">Code</th><th rowspan="2">Credits</th><th rowspan="2">L-T-P</th><th colspan="2">Assessment</th><th rowspan="2">Exam Duration</th></tr>
<tr><th>SEE</th><th>CIA</th></tr>
<tr><td>Finite Element Method</td><td>16MTP12</td><td>04</td><td>4-0-0</td><td>80</td><td>20</td><td>3Hrs</td></tr>
<tr><td colspan="7">Common to MTP,MTH</td></tr>
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Course Objectives

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

2. Apply the fundamental concepts of mathematical methods solve Heat Conduction, Transient and Phase Change ,Convective Heat Transfer problems.

Course Content:

1. Introduction: Importance of stress analysis, heat transfer and fluid flow, conservation laws for mass, momentum and energy; Fourierequation, N-S equations; energy principles in stress analysis; Basic equations in elasticity; Boundary conditions. Some Basic Discrete Systems: Discrete systems as basis for FEM analysis; Examples of discrete systems in stress analysis, heat transfer and fluid flow.

1-D Finite Elements: Introduction; Elements and shape functions - one dimensional linear element (bar element), one dimensional quadraticelement.

10 Hours

2. 2-D Finite Elements: two dimensional linear triangular elements, Local and Global coordinate systems, quadratic triangular elements, twodimensional quadrilateral elements, iso-parametric elements, three dimensional elements, beam, plate and shell elements, composite materials.

6 Hours

Formulation: Introduction; Variational approach; methods of weighted residuals for heat transfer problems, principle of virtual work forstress analysis problems; mixed formulation; penalty formulation for fluid flow problems. Primitive variables formulation for flow problems.

12 Hours

3. Heat conduction problems: FEM analysis of steady state heat conduction in one dimension using linear and quadratic elements; steadystate heat conduction in two dimensions using triangular and rectangular elements; three dimensions problems, Axi-symmetric problems.

6 Hours

4. Transient and Phase change problems: Transient heat conduction in one and multi dimensional problems; time stepping scheme usingfinite difference and finite element methods; phase change problems - solidification and melting; Inverse heat conduction problems.

6 Hours

5. Stress Analysis Problems: Introduction; stress analysis in one, two (plane stress and plane strain) and three dimensions; Axi-symmetricproblems; beam and plate bending problems; thermal stress development; shrinkage stress development; prediction of distortions in manufactured products; Introduction to simple dynamic problems.

10 Hours

6. Convective Heat Transfer Problems: Introduction; Galerkin method of Steady, convection-diffusion problems; upwind finite element inone dimension - Petro-Galerkin formulation, artificial diffusion; upwind method extended to multi-dimension; transient convection - diffusion problems - FEM solutions, extension to multi dimensions; primitive variables approach (u, v, w, p, t formulation); characteristic -based split scheme (CBS); artificial compressibility scheme; calculation of Nusselt number, drag and stream function; mesh convergence; Introduction to convection in Porous media; Laminar and turbulent flows.

8 Hours

Text Books:

1. **Fundamentals of the finite element method for heat and fluid flow -** R.W. Lewis, P. Nithiarasu and K. N. Seetharamu, , John Wileyand Sons, 2004.
2. **The finite element method in heat transfer analysis -** R.W. Lewis, K Morgan, H.R. Thomas, K.N. Seetharamu, John Wiley and Sons, 1996.

Reference Books:

1. **The finite element method in heat transfer and fluid dynamics -**J.N. Reddy and Gartling D.K., CRC publications, 2000.
2. **The finite element method volume 3: fluid dynamics -** O.C. Zienkiewicz and R.L. Taylor, John Wiley & Sons, 2001.
3. **The finite element and for solid and structural mechanics -** O.C. Zienkiewicz and R.L. Taylor, Elsevier Publishers , 2005.
4. **Introduction to Finite Elements in Engineering -** Tirupathi R. Chandrupatla, Ashok D. Belegundu, Prentice-Hall Ltd., 2002.
5. **Finite Element Analysis -** S.S. Bavikatti, New Age International, 2005.

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 Heat Transfer problems using the steps of FEM

ISEMESTERM.TECH. THERMAL ENGINEERING.
ADVANCED FLUID MECHANICS

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Advanced Fluid Mechanics	16MTP13	04	4-0-0	80	20	3Hrs
Common to MTP,MTH						

Course Objective:

To understand the kinematics of fluids, their governing equations, Mechanics of laminar and turbulent flow, NS Equations and Experimental Techniques.

Course Content:

1.Introduction and Kinematics of Fluids: Concepts of continuum rarefied gas dynamics, magneto fluid mechanics regimes in mechanics offluids; 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

2.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 equationmodel for fully turbulent flows; k-l, k- and other turbulence models; turbulent flow through pipes; losses in bends, valves etc; analysis of pipe network - Hard cross method.

3.Exact and Approximate solutions of N-S Equations: Introduction; Parallel flow past a sphere; Oseen's approximation; hydrodynamictheory of lubrication; Hele-Shaw Flow.

oundary 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**

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

5.Experimental Techniques: Introduction; improved modeling through experiments; design of fluid flow experiments; error sources duringmeasurement; 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 HourText Books:

1. **Foundations of fluid mechanics -** S.W. Yuan, Prentice Hall of India, 1976.
2. **Engineering Fluid Mechanics -** P.A. AswathaNarayana& K.N. Seetharamu, Narosa publications, 2005.

Reference Books:

3. **Fluid Mechanics -** F.M. White, McGraw-Hill publications.
4. **Advanced fluid mechanics -** K. Muralidhar and G. Biswas, Narosa publications, 1996.
5. **Introduction to fluid dynamics - Principles of analysis & design -** Stanley Middleman, Wiley, 1997.

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.

ISEMESTERM.TECH. THERMAL ENGINEERING.
THERMODYNAMICS &COMBUSTION ENGINEERING

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Thermodynamics &Combustion Engineering	16MTP14	04	4-0-0	80	20	3Hrs
Common to MTP,MTH						

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.

Course Content:

1.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.
12hours

2.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**

3.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

4.Combustion and flame velocities, laminar and turbulent flames, premixed and diffusion flames, their properties and structures.
8 Hours

5. 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.

Text Books:

1. **Engineering Thermodynamics -** P.K. Nag, Tata McGraw-Hill Publications.
2. **Fundamentals of Classical Thermodynamics -** G. Van Wylen and R.E. Sonntag, Wiley, 1986.

Reference Books:

1. **Energy. Combustion and Environment -** N.A. Chigier, McGraw-Hill, 1981.
2. **Introduction to combustion phenomena -** A. Murthy Kanury, Gordon and Breach, 1975.
3. **Fuels and combustion -** S.P. Sharma and Chandra Mohan, Tata McGraw-Hill, 1984.
4. **Engineering Thermodynamics -** Onkar Singh. New age International Publications.

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.

ISEMESTERM.TECH. THERMAL ENGINEERING.
NON CONVENTIONAL ENERGY SYSTEM
(Elective – I)

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Non Conventional Energy System	16MTP151	04	4-0-0	80	20	3Hrs
Common to MTP,MTH						

Course Objective:

- An understanding of renewable energy sources
- Have a knowledge of working principle of various energy systems
- A capability to carry out basic design of renewable energy systems

1. Global and National Energy Scenario: Over view of conventional & renewable energysources - Need & development of renewable energy sources - Types of renewableenergy systems - Future of Energy Use - Global and Indian Energy scenario -Renewable and Non-renewable Energy sources, Energy for sustainable development -Potential of renewable energy sources - Renewable electricity and key elements – Globalclimate change - CO2 reduction potential of renewable energy- Concept of Hybridsystems.

10 Hours

2. Solar Energy: Solar energy system - Solar Radiation – Availability - Measurement andEstimation - olar Thermal Conversion Devices and Storage - Applications SolarPhotovoltaic Conversion - solar thermal - Applications of solar energy systems.**10 Hours**

3. Wind Energy: Wind Energy Conversion – Potential - Wind energy potentialmeasurement - Site selection - Types of wind turbines - Wind farms - Wind Generationand Control - Nature of the wind - Power in the wind - Factors influencing wind – Winddata and energy estimation - Wind speed monitoring - Classification of wind –Characteristics - Applications of wind turbines - Offshore wind energy – Hybrid systems -Wind resource assessment - Betz limit - Site selection - Wind energy conversion devices- Wind mill component design - Economics and demand side management – Energywheeling - Energy banking concepts - Safety and environmental aspects - Wind energypotential and installation in India.**10 Hours**

4. Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technologyand status - Bio energy system - Design and constructional features – Biomassresources and their classification - Biomass conversion processes - Thermo chemicalconversion - Direct combustion - biomass gasification - pyrolysis and liquefaction -biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energyconversion - Biomass energy programme in India.**10 Hours**

5. Ocean Energy: Ocean wave energy conversion - Principle of Ocean Thermal EnergyConversion (OTEC) - Ocean thermal power plants - Tidal energy conversion - Tidal andwave energy its scope and development - Scheme of development of tidal energy.

Geothermal power plants - Various types - Hot springs and steam ejection.

Fuel cells: Introduction, applications, classification, different types of fuel cells such as phosphoric acid fuel cell, alkaline fuel cell, PEM fuel cell, MC fuel cell. Development and performance fuel cells.

10 Hours

COURSE OUTCOMES: At the end of the course the student will be able to

CO1	Identify the renewable energy sources and their utilization
CO2	Understand the basic concepts of the solar radiation and analyze the solar Thermal systems for their utilization
CO3	Understand the principle of working of solar cells and their modern manufacturing techniques
CO4	Understand the concepts of the ocean thermal energy conversion systems and their applications
CO5	Understand the energy conversion from wind energy, geothermal energy, biomass, biogas, fuel cells and hydrogen

READING:

1. B.H.Khan, Non conventional Energy Resources, Tata McGraw Hill, New Delhi, 2012
2. Non-Conventional Energy Sources G.D Rai,Khanna Publishers, 2004
3. S.Rao and B.B.Parulekar, Energy Technology: Non-Conventional, Renewable and Conventional, Khanna Publishers, 2010
4. S.P.Sukhatme and J.K.Nayak, Solar Energy-Principles of Thermal Collection and Storage, TMH, 2008
5. J.A.Duffie and W.A.Beckman, Solar Energy Thermal Processes, John Wiley, 2010

ISEMESTERM.TECH. THERMAL ENGINEERING.
NUCLEAR ENERGY CONVERSION
(Elective – I)

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Nuclear Energy Conversion	16MTP152	04	4-0-0	80	20	3Hrs
Common to MTP,MTH						

Course Objective:

- An understanding of Nuclear energy sources
- Have a knowledge of working principle of various Nuclear reactor
- Study Radioactive Waste Management and Biological and Environmental Effects

1.Nuclear Fuel and Reactor Theory: Nuclear fuels - Occurrence and extraction – Fissilecharacteristics – Enrichment - Fission process - Thermal and fast fission – Energyreleased from fission - Chain reaction - Reaction control.Neutron balance - Fast fission - Resonance capture – Thermalization - Geometric effects - Burn-up – Introduction to reactor kinetics.**10 Hours**

2. Nuclear Reactors: General components of nuclear reactor - Fuel cladding – fuelassembly – moderators – coolants - control rods -Different types of reactors -Pressurized Water Reactor - Boiling Water Reactor - Heavy Water cooled Reactor – Gascooled Reactor - Liquid metal cooled reactor - Organic moderated and cooled reactors -Fast Breeder Reactors - Reactor safety - Neutron Population growth - Assurance ofsafety - Emergency core cooling and containment.**10 Hours**

3. Radioactive Waste Management: The nuclear fuel cycle - Waste classification – Spentfuel storage – Transportation – Reprocessing - High-Level waste disposal - Low-levelwaste generation and treatment - Low-level waste disposal - Nuclear power plantdecommissioning.**10 Hours**

4. Biological and Environmental Effects: Biological effects of radiation - Radiation dose -Basic for limits and exposure - Sources of radiation dosage - Gas counters – Neutrondetectors - Scintillation counters - Solid state detectors - Statistics of counting – Pulseheight analysis - Protective measures - Calculation of dose - Effects of distance andshielding - Internal exposure - The Radon problem - Environmental radiological impact -Radiation standards.**10 Hours**

5. Nuclear Power for Propulsion and Energy Economics: Reactors for naval propulsion- Space reactors - Space isotopic power generator - Energy economics - Components ofelectrical power – cost forecast versus Reality - Challenges and opportunities – Technicaland institutional improvements – Developments in nuclear reactor.**10 Hours**

COURSE OUTCOMES: At the end of the course the student will be able to

CO1 Understand Nuclear Fuel and Reactor Theory.
CO2 Describe the working of nuclear reactor.
CO3 Explain Radioactive Waste Management, Biological and Environmental Effects
CO4 Study the economic feasibility and its implications on power generating units.

READING:

1. Nuclear Energy, Charles, D. Furguson, First Edition, Oxford University press,2011.
2. Nuclear Power Technology, W.Marshall, Vol. I &II, Clarendon press, Oxford, 1985.
3. Principle of Nuclear Reactor Engine, SamualGlasstone, Van Nostrand Reinhold Co. Inc., New York, 1963.
4. Nuclear Power Station, Margulova, Mir Publishers, Moscow, 1978.
5. Principle of Energy Conversion, Archie W.Culp, McGraw Hill Kogakusha Ltd., 1984.
6. A Course in Power Plant Technology, Domkundwar, Dhanpat Rai Sons

ISEMESTERM.TECH. THERMAL ENGINEERING.
ENERGY CONSERVATION AND MANAGEMENT
(Elective – I)

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Energy Conservation and Management	16MTP153	04	4-0-0	80	20	3Hrs
Common to MTP,MTH						

Course Objective:

- To get exposure to energy management of thermal and electrical systems and to Understand the various conservation techniques.

1. Energy Conservation: Introduction - Indian Energy Conservation Act - List of EnergyIntensive Industries - Rules for Efficient Energy Conservation - Identification of EnergyConservation opportunities - Technologies for Energy Conservation – EnergyConservation Schemes and Measures - Energy flow net works - Critical assessment ofenergy use - Optimizing Energy Inputs and Energy Balance - Pinch Technology.**10 Hours**

2. Energy Efficiency Improvement: Steam Generation - Distribution and Utilization –Furnaces - Fans and Blowers - Compressors Pumps - Pinch Technology - Fluidized bedCombustion - Heat Exchanger Net works - Case Studies - Analysis andrecommendation.**10 Hours**

3. Energy Audit: Definition and Concepts, Types of Energy Audits – Basic Energy Concepts –Energy audit questionnaire, Data Gathering – Analytical Techniques. Energy Consultant: Needof Energy Consultant – Consultant Selection Criteria, Economic Analysis: Scope, Characterization of an Investment Project – Types of Depreciation –Time Value of money – budget considerations, Risk Analysis.**10 Hours**

4. Energy Efficient Lighting: Terminology - Laws of illumination - Types of lamps -Characteristics - Design of illumination systems - Good lighting practice - Lighting control- Steps for lighting energy conservation.**08 Hours**

5. Economics of Generation and Distribution: Generation: Definitions - Connected load, Maximum demand - Demand factor –Diversity factor – Significance - Power Factor – Causes and disadvantages of low powerfactor – Economics of power factor improvement.Distribution: Electrical load analysis - Types of consumers & tariffs - Line losses -Corona losses - Types of distribution system - Kelvin’s law - Loss load factor – GreenLabeling – Star Rating.**12 Hours**

COURSE OUTCOMES: At the end of the course the student will be able to

CO1 Understand the various conservation techniques.
CO2 Explain various Energy Efficiency Improvementtechnique
CO3 Employ the principles of thermal engineering and energy management to improve the performance of thermal systems.

CO4 Assess energy projects on the basis of economic and financial criteria.

CO5 Describe methods of energy production for improved utilization

READING:

1. Turner, W. C., Doty, S. and Truner, W. C., Energy Management Hand book, 7th edition, Fairmont Press, 2009.
2. De, B. K., Energy Management audit & Conservation, 2nd Edition, Vrinda Publication, 2010.
3. Murphy, W. R., Energy Management, Elsevier, 2007.
4. Smith, C. B., Energy Management Principles, Pergamon Press, 2007.

ISEMESTERM.TECH. THERMAL ENGINEERING.
REFRIGERATION AND AIR CONDITIONING
(Elective – I)

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Refrigeration and Air Conditioning	16MTP154	04	4-0-0	80	20	3Hrs
Common to MTP,MTH						

Course Objective:

- Study the basic definition, ASHRAE Nomenclature for refrigerating systems
- Understand the working principles and applications of different types of refrigeration systems
- Study the working of air conditioning systems and their applications
- Identify the performance parameters and their relations of an air conditioning system

1. **Refrigeration cycles** – analysis: Development of Vapor Compression Refrigeration Cycle from Reverse Carnot Cycle- conditions for high COP-deviations from ideal vapor compression cycle ,Multipressure Systems , Cascade Systems-Analysis.
   Main system components: Compressor- Types , performance , Characteristics of Reciprocating Compressors , Capacity Control , Types of Evaporators & Condensers and their functional aspects , Expansion Devices and their Behaviour with fluctuating load. **10 Hours**

2. **Refrigerants:**Classification of Refrigerants, Refrigerant properties, Oil Compatibility, Environmental Impact-Montreal/ Kyoto protocols-Eco Friendly Refrigerants. Different Types of Refrigeration Tools, Evacuation and Charging Unit, Recovery and Recycling Unit, Vacuum Pumps.
   Other refrigeration cycles: Vapor Absorption Systems-Aqua Ammonia &LiBr Systems, Steam Jet Refrigeration Thermo Electric Refrigeration, Air Refrigeration cycles. **10 Hours**

3. **Psychrometry:**Moist Air properties , use of Psychrometric Chart , Various Psychrometric processes , Air Washer , Adiabatic Saturation. Summer and winter air conditioning:
   Air conditioning processes-RSHF, summer Air conditioning, Winter Air conditioning, Bypass Factor. Applications with specified ventilation air quantity- Use of ERSHF, Application with low latent heat loads and high latent heat loads.**12 Hours**

4. **Load estimation & air conditioning control:** Solar Radiation-Heat Gain through Glasses, Heat transfer through roofs and walls, Total Cooling Load Estimation. Controls of Temperature, Humidity and Air flow. **08 Hours**

5. **Air distribution:** Flow through Ducts , Static & Dynamic Losses , Air outlets , Duct Design–Equal, Friction Method , Duct Balancing , Indoor Air Quality , Thermal Insulation , Fans & Duct System

Characteristics , Fan Arrangement Variable Air Volume systems , Air Handling Units and Fan Coil units.**10 Hours**

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

CO1	Understand physical and mathematical aspects of refrigeration and air- conditioning systems.
CO2	Employ the theoretical and mathematical principles to simple, complex vapour compression and vapour absorption refrigeration systems.
CO3	Understand conventional and alternate refrigerants and their impact on environment.
CO4	Design air-conditioning systems.

READING:

1. Roy J. Dossat, Principles of Refrigeration, Wiley Limited 2002
2. Arora C.P., Refrigeration and Air-conditioning, 3rd edition,Tata McGraw –Hill, New Delhi 2008
3. Stoecker W.F., and Jones J.W., Refrigeration and Air-conditioning, 2nd edition McGraw - Hill, New Delhi
4. Data Books: Refrigerant and Psychrometric Properties (Tables & Charts) SI Units, Mathur M.L. & Mehta F.S., Jain Brothers. 2010.
5. Principles and Refrigeration- Goshnay W.B., Cambridge, University Press, 1985.
6. Solid state electronic controls for HVACR' -Langley, Billy C., 'Prentice-Hall 1986
7. Refrigeration and Air Conditioning- Arora C.P., Tata McGraw Hill Pub. Company
8. Handbook of Air Conditioning Systems design- Carrier Air Conditioning Co., McGraw Hill,
9. Refrigeration and Air Conditioning (3/e) - Langley Billy C., Engie wood Cliffs (N.J) PHI.
10. Fundamentals and equipment- 4 volumes-ASHRAE Inc. 2005.
11. Air Conditioning Engineering-Jones, Edward Amold pub. 2001.

ISEMESTERM.TECH. THERMAL ENGINEERING.

THERMAL ENGINEERING MEASUREMENT - LAB 1

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Thermal Engineering measurement - Lab 1	16MTP16	02	0-0-3	80	20	3Hrs
Common to MTP,MTH						

Course Objective

- This course will provide a basic understanding of flow measurements using various types of flow measuring devices, calibration and losses associated with these devices.
- Energy conversion principles, analysis and understanding of hydraulic turbines, Pumps and I C Engines will be discussed. Application of these concepts for these machines will be demonstrated. Performance analysis will be carried out using characteristic curves.
- Exhaust emissions of I C Engines will be measured and compared with the standards

Course Content:

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 upto 2 litres per second at atmospheric temperature of 30 degree 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 flowrate 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 test 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 test 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 OUTCOMES: At the end of the course, the student will be able to:

- Perform experiments to determine the coefficient of discharge of flow measuring devices.
- Conduct experiments on hydraulic turbines and pumps to draw characteristics.
- Test basic performance parameters of hydraulic turbines and pumps and execute the knowledge in real life situations.
- Identify exhaust emission, factors affecting them and report the remedies.
- Determine the energy flow pattern through the hydraulic machines and I C Engine
- Exhibit his competency towards preventive maintenance of IC engines.

Reading:

1. K.L.Kumar.“Engineering Fluid Mechanics” Experiments, Eurasia Publishing House, 1997
2. Jagdish Lal, Hydraulic Machines, Metropolitan Book Co, Delhi, 1995
3. George E. Totten , Victor J. De Negri “Handbook of Hydraulic Fluid Technology, Second Edition, 2011.
4. E.F.Obert, Internal combustion engines and air pollution intext educational publishers (1973). 2. John Heywood, Internal combustion engine fundamentals, McGraw- Hill (1988) - USA.
5. Colin R Ferguson and Allan T. Kirkpatrick Internal combustion engines Applied Thermodynamics, John Wiley & sons – 2001.
6. Richard stone,Introduction to internal combustion engines, MacMillan (1992) – USA
7. M. L. Mathur And R.P. Sharma A course in internal combustion engines, Dhanpat Rai& sons- India.
8. C. F. Taylor The internal combustion engines in theory and practice, 2 vols. by:, pub.: Wily.
9. C. F. Taylor The internal combustion engines in theory and practice, 2 vols. by:, pub.: Wily.
10. Ganesan, V., Fundamentals of IC Engines, Tata McGraw Hill, 2003
11. Bosch, Automotive hand book, 9th edition.

IISEMESTERM.TECH.THERMAL ENGINEERING.

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Advanced Heat Transfer	16MTP21	04	4-0-0	80	20	3Hrs
Common to MTP,MTH						

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 have an understanding of the numerical technique to handle heat transfer problems

Course Content:

1.Introduction and one-dimensional heat transfer: The differential equation of heat conduction, heat generation, two dimensional steady state heat conduction, unsteady state processes, extended surfaces- fins of uniform cross section and non uniform cross sections, Thermal resistance networks and applications.

Numerical heat Transfer:Numerical techniques for solving heat conduction problems, the finite difference method for steady state situations, the finite difference method for unsteady state situations, Controlling Numerical Errors, problems.**12 Hours**

2.Thermal radiation: basic concepts and laws of thermal radiation, the shape factor, Eradiant heat exchange in enclosures ,black and Grey surfaces ,radiation shields and Radiation Effect on temperature measurements.Radiation properties of participating Medium,Emmissivity and absorbivity of Gases and Gas Mixtures ,Heat transfer from the Human Body problems.

8Hours

3. Analysis of Convection Heat Transfer: Boundary layer fundamentals evaluation of convection heat transfer coefficient, Analytical solution for laminar boundary layer flow over a flat plate ,Approximate integral boundary layer analysis, Analogy between momentum and heat transfer in turbulent flow over a flat surface, Reynolds Analogy for Turbulent Flow Over Plane Surfaces, Mixed Boundary Layer, Special Boundary Conditions and High-Speed Flow.**10Hours**

4.Natural convection: Introduction, Similarity Parameters for Natural Convection, Empirical Correlation for Various Shapes, Rotating Cylinders, Disks, and Spheres, Finned Surfaces

Heat transfer by forced convection: Introduction, Analysis of Laminar Forced Convection in a Long Tube, Correlations for Laminar Forced Convection, Analogy Between Heat and Momentum Transfer in Turbulent Flow, Empirical Correlations for Turbulent Forced Convection, Heat Transfer Enhancement and Electronic-Device Cooling, Flow Over Bluff Bodies , Packed Beds, Free Jets**12 Hours**

5.Heat exchangers: Basic concepts**,**types of heat exchangers, Analysis of heat exchangers, Counter-Flow Heat Exchangers, Multipass and Cross-Flow Heat Exchangers, Use of a Correction Factor , Selection of Heat Exchangers such as Heat Transfer Rate ,Cost ,Pumping Power, Size and Weight ,Type, Materials,Other Considerations,Compact Heat Exchangers. Heat Exchangers for multi phaseflow**10 Hours**

Reference Books:

1. **Heat Transfer – A Basic Approach -** Ozisik M.N., McGraw-Hill Publications, 1st edition.
2. **Heat Transfer -** Holmon J.P., McGraw-Hill Publications, 6th Edition.
3. **Principles of Heat Transfer -** Frank Kreith,Thomson Publications, 7th Edition.
4. **Heat Transfer-** A practical Aproach ,Yunus A CengelMcGraw-Hill Publications 2nd edition

Course Outcome:after undergoing this course students are able to

- **Summarize both the physics and the mathematical treatment of the advanced topics pertaining to the modes of heat transfer.**
- **Use principles of heat transfer to develop mathematical models for uniform and non-uniform fins.**
- **Employ mathematical functions and heat conduction charts in tackling two- dimensional and three-dimensional heat conduction problems.**
- **Identify free and forced convection problems involving complex geometries with proper boundary conditions.**
- **Use the concepts of radiation heat transfer for enclosure analysis.**

IISEMESTERM.TECH. THERMAL ENGINEERING.

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Steam and Gas Turbines	16MTP22	04	4-0-0	80	20	3Hrs
Common to MTP,MTH						

Course Objective:

- To understand the working principle, operations and analysis of nozzles, diffusers, steam and gas turbines.

Course Content:

1.Nozzles and diffusers: Introduction types of nozzles, types of Diffusers, Equation of Continuity Sonic Velocity and Mach Numbers, TheSteady Flow Energy Equation in Nozzles, Gas Nozzles The Momentum Equation for the flow Through Steam Nozzles, Entropy Changes with friction, Nozzle Efficiency, The Effect of Friction on the Velocity of steam Leaving the Nozzles, Diffusion Efficiency, shape of Nozzle for Uniform Pressure Drop, Mass of Discharge of Critical Pressure in Nozzle Flow or Chocked Flow, Physical Explanation of Critical Pressure, Maximum Discharge of Saturated Steam, Maximum Discharge of Steam initially Superheated, Critical Pressure Ratio for Adiabatic and Frictionless Expansion of Steam from Ratio for Adiabatic and Frictionless Expansion of Steam from a given initial Velocity, Idea of Total or Stagnation Enthalpy and Pressure, General Relationship Between or Area Velocity and pressure in Nozzle Flow ,Effect of Friction on Critical Pressure Ratio Critical Pressure Ratio in a Frictionally Resisted Expansion from a Given Initial Velocity, Supersaturated Flow in Nozzles, Effect of Variation of Back Pressure, Parameters Affecting the Performance of Nozzles, Experimental Methods to Determine Velocity Coefficient, Experimental Results. **10 Hours**

2.Steam Turbines Types and Flow of Steam through Impulse Blades: Basic concepts,Principal of operation of turbine, Comparison of Steam Engines and Turbines, Classifications of Steam Turbine, 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. **10 Hours**

3.Flow of Steam Through Impulse-Reaction Turbine Blades: Velocity diagram, degree of reaction, impulse- reaction turbine with similarblade 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 blaring 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 impulseturbine, 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**

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

Shaft power Cycles and Gas turbine cycles for Air-craft propulsion: Ideal cycles, methods of accounting for component cycles, design pointperformance calculations, comparative performance of practical cycles, COGAS cycles and cogeneration schemes, closed cycle gas turbines, simple turbojet cycle, turbo fan engine, turbo prop engine, thrust augmentation.
10 Hours

5.Axial and Radial Flow Gas Turbines and Prediction of performance: Elementary theory of axial flow turbine, vortex theory, choice ofblade 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.

Energy losses in turbines: Valve, nozzle, blade, Trailing edge wake, impingement, leakage losses. Blade friction, turning of steam jet, blade windage losses, losses due to shrouding, Discfriction ,radiation and conduction,mechanical losses ,leakage through the end seals.
10 Hours
Reference Books:

1. **Steam and Gas Turbines -** R. Yadav, Central Publishing House, Allahabad.7th edition 2
2. **Gas Turbine Theory -** H.I.H. Saravanamuttoo, G.F.C. Rogers & H Cohen, Pearson Education.8th edition
3. **Gas Turbines -** V. Ganesan, Tata McGraw-Hill Publications.3rd edition
4. **Elements of Gas Turbine Propulsion-** Jack D Mattingley ,McGraw-Hill Publications 1st edition

Course Outcome:after undergoing this course students are able to

- **Summarize the working principles of Gas and steam turbines nozzle and diffusers.**
- **Use the principles of thermodynamics to determine the performance of steam and gas turbines.**
- **Distinguish and demonstrate the working principle and performance of impulse and reaction turbines**
- **Explain the concepts of axial flow and centrifugal compressors**
- **Differentiate axial flow and radial flow gas turbines for their analysis.**
- **Identify the various losses associated with the turbines.**

IISEMESTERM.TECH. THERMAL ENGINEERING.

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Advanced Power plant Cycles	16MTP23	04	4-0-0	80	20	3Hrs
Common to MTP,MTH						

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.

Course Content:

1.Analysis of Steam cycles: Rankine cycle, Carnot cycle, mean temperature of heat addition, effect of variation of steam condition on thermalefficiency 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 powercycle, Binary vapor cycles, coupled cycles , combined cycle plants, gas turbine- steam turbine power plant, MHD-steam power plant, Thermionic- Steam power plant. **10 Hours**

2.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.

Combustion Mechanisms : Kinetics of combustion, mechanisms of solid fuel combustion, kinetic and diffusion control, pulverized coal firingsystem, fuel-bed combustion, fluidized bed combustion, coal gasifiers, combustion of fuel oil, combustion of gas, combined gas fuel oil burners, Requirements for efficient combustion ,Recent trends in furnce /combustion chamber.

10Hours

3.Steam Generators: Basic type of steam generators, fire tube boilers, water tube boilers. Economizers, superheaters, reheaters, steam generatorcontrol, 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 watersystem, cooling towers, calculations, Numerical Problems. **10 Hours**

4.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 and Fusion Power reactors. **10 Hours**

5.Hydro Electric Power Plant: Introduction, advantages and disadvantages of water power, optimization of hydro – thermal mix, hydrologicalcycles, storage and pondage

Power plant Economics: Definitions, Principles, Location of power plant, cost analysis selection of type of generation, selection of power plant equipments **10 Hours**

Reference Books:

1. **Power Plant Engineering -** P.K. Nag, Tata McGraw-Hill Publications. 2nd edition
2. **Power Plant Engineering -** M.M. EI-Wakil, McGraw- Hill Publications. 1st edition
3. **Power plant engineering –**R.K.Rajput ,Laxmi Publications 3rd edition

Course Outcome:after undergoing this course students are able to

- **Distinguish the various power plant cycle and their working principles.**
- **Explain combustion phenomenon of different type of fuels and energy associated.**
- **Demonstrate the working principles of different components of power plant.**
- **Explain the concepts of power generation by nuclear power plant.**
- **Differentiate axial flow and radial flow gas turbines for their analysis.**
- **Identify the design parameters and economics of power plant.**

IISEMESTERM.TECH. THERMAL ENGINEERING.

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Theory of I C Engines	16MTP24	04	4-0-0	80	20	3Hrs
Common to MTP,MTH						

Course Objective:

- To understand the working cycle, Engine design and operating conditions, combustion phenomena, Engine emission and control,
- use of alternate fuels in IC engines.

Course Content:

1.Introduction to IC Engines: Basic engine components and nomenclature ,Applications of IC Engines **,** Engine characteristics, geometrical properties of reciprocating engines, specific emissions and emission index, relationships between performance parameters, Engine design and performance data.Energy flow through IC engines ,Various Auxiliary systems.Envirnoment friendly engines.

Fuel –Air and Actual Engines: Modeling of Fuel-Air cycle Effect of operating variables on the performance of Fuel –air Cycles, Detailed analysis of difference between Fuel-Air and Real Cycle, Combustion charts and Gas Tables. **10 Hours**

2.Carburetion : Introduction, Factors affecting carburetion ,mixture requirements at different load and speed ,principles of carburetion ,essential parts and functions of a carburetor ,compensating devices ,Modern Carburetors, Altitude compensation devices,Injection in SI engine

Injection Systems: Introduction to Mechanical Injection System,Functional Requirements and classification, Fuel feed pump and Fuel Injector ,

Electronic injection systems: Types , Merits and Demerits ,Multi point fuel injection system (MPFI) , Electronic control system ,Injection timings,Common –Rail Fuel Injection System .**10 Hours**

3.Modelling of IC Engines : Governing Equation for open thermodynamic systems ,intake and exhaust flow models , Thermodynamic based in cylinder models,Direct-injection CI engine models, Combustion models ,Fluid Mechanics based multi dimensional models**10 Hours**

4.Engine emissions and their control: Air pollution due to IC engines, emission characteristics ,Euro norms, engine emissions, Hydro carbon emissions,COemission,NOx- Photo chemical smog ,Particulates,otheremissions,Smoke,emission control methods – therm alconverters, catalytic converters, particulate traps, Ammonia injection systems, exhaust gas recirculation,ELCD,Crank case blow by control. IC engine Noise characteristics, types, standards and control methods,Air quality emission standards
Measurement: Noise, Emission, Pressure, crank angle torque, valve timings, Temperature and flow measurements **10 Hours**

5.Alternate fuels for I.C engines: Vegetable oils, alcohol's, L.P.G, C.N.G, Hydrogen fuels,Bio gas ,Dual fuels,other possible fuels

Case studies : The rover K series engine,Chrysler 2.3 litre SI engine, Ford 2,5 Litre DI Diesel Engine**10 Hours**

Reference Books:

1. V. Ganesan, “Internal Combustion Engines”, Tata McG raw-Hill Publications,4th Edition
2. John B. Heywood, “IC Engines fundamentals”, McGraw- Hill Publications,2011
3. C.R. Fergusan, “Internal Combustion Engines: Applie d Thermo sciences”, John Wiley & Sons.
4. Richard stone ‘’Introduction to IC Engines’’ Palgrave Publication 3rd edition
5. Charles Fayette Taylor ‘’ The Internal-Combustion Enginein Theory and Practice’’ MIT Press 2nd edition.

Course Outcome:after undergoing this course students are able to

- Distinguish different Fuel-air and actual cycles.
- Demonstrate the different types of injection and carburetor systems
- Formulate the flow and combustion phenomenon for modeling
- Identify the various types of emissions ,noise and their control systems
- Recommend the suitable alternative fuel for IC Engine.

IISEMESTERM.TECH. THERMAL ENGINEERING.

Elective-II

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Thermal Power Station-I	16MTP251	04	4-0-0	80	20	3Hrs
Common to MTP,MTH						

Course Objective:

- To study the working ,operation and maintenance of a various steam generator components .
- To understand the arrangements of different flow systems their operation and maintenance and their effects on environment.
- To have the knowledge of working expenses ,current scenario and trends in power generation .

Course Content:

1.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.

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**12 Hours**

2.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**

3.Feed Water system: Impurities in water and its effects, feed and boiler water corrosion, quality of feed water, boiler drum water treatment andsteam 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**

4. 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**

5. Miscellaneous of steam power plant: Methods of loading, plant selection, arrangements, useful life of plant components, pumps, cost estimation steam power plant,comparison of different power plants, current scenario of thermal power generation in India,Indian boiler act and amendments, case studies**10 Hours**

Reference Books:

1. **Power Plant Engineering -** P.K. Nag, Tata McGraw-Hill Publications. 2nd edition
2. **Power Plant Engineering -** M.M. EI-Wakil, McGraw- Hill Publications. 1st edition
3. **Power plant engineering –**R.K.Rajput ,Laxmi Publications 3rd edition

Course Outcome:after undergoing this course students are able to

- Describe the working, operation and maintenance of a various steam generator components.
- Identify the arrangements of different flow systems their operation and maintenance and their effects on environment.
- Estimate the working expenses, current scenario and trends in power generation.
- Asses the performance and suitability .

IISEMESTERM.TECH. THERMAL ENGINEERING.

Elective-II

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Alternate Fuels for IC Engines	16MTP252	04	4-0-0	80	20	3Hrs
Common to MTP,MTH						

Course Objective:

- To have a knowledge about conventional fuels, their current usage and limitations.
- To understand and identify the suitable alternative fuels and their relevance ,importance and limitation

Course Content:

1.Conventional Fuels: Introduction, Current fuel scenario and consumption, per capita consumption Indian scenario, Structure of petroleum, Refining process, Products of refining process, Fuels for spark ignition, Knock rating of SI enginefuels, Octane number requirement, Diesel fuels.

Properties of petroleum products: Specific gravity, Density, Molecular weight, Vapour pressure, Viscosity, Flash point, Fire point, Cloudpoint, 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.**10Hours**

2.Alternative fuels for I.C. engines: Need for alternative fuels such as Ethanol, Methanol, LPG, CNG, Hydrogen, Biogas and Producer gas andtheir methods of manufacturing.

Single Fuel Engines: Properties of alternative fuels, Use of alternative fuels in SI engines, Engine modifications required, Performance andemission characteristics of alternative fuels in SI mode of operation v/s gasoline operation. **10Hours**

3.Dual fuel Engine: Need and advantages, The working principle, Combustion in dual fuel engines, Factors affecting combustion in dual fuelengine, Use of alcohols, LPG, CNG, Hydrogen, Biogas and Producer gas in CI engines in dual fuel mode. Engine modifications required. Performance and emission characteristics of alternative fuels (mentioned above) in Dual Fuel mode of operation v/s Diesel operation.**10 Hours**

4. Bio-diesels: What are bio-diesels Need of bio-diesels, Properties of bio-diesels v/s petro-diesel, Performance and emission characteristics ofbio-diesels v/s Petro diesel operation.

Availability: Suitability & Future prospects of these gaseous fuels in Indian context.**10 Hours** **10Hou**

5.Environmental pollution: with conventional and alternate fuels, Pollution control methods and packages.Euro norms , Engineemissions, Emission control methods, EPA. Air quality emission standards 10**Hours**

Reference Books:

1. **A Course in Internal Combustion Engines -** R.P Sharma & M.L. Mathur, DanpatRai& Sons.
2. **Elements of Fuels, Furnaces & Refractories -** O.P. Gupta, Khanna Publishers.

3. **Internal Combustion Engines -**Domkundwar V.M., I Edition, DhanpatRai& Sons.
4. **Internal Combustion Engines Fundamentals -** John B. Heywood, McGraw Hill International Edition.
5. **Present and Future Automotive Fuels -** Osamu Hirao& Richard Pefley, Wiley Interscience Publications.
6. **Internal Combustion Engines -** V. Ganesan, Tata McGraw-Hill Publications.

Course Outcome:after undergoing this course students are able to

- Explain about the availability and usage of conventional fuels for IC engines.
- Identify possible alternative fuels for IC engines.
- Demonstrate the use of alternative fuels for different types of engines
- Assess the environmental impact standards and procedures of using alternate fuels.

IISEMESTERM.TECH. THERMAL ENGINEERING.

Elective-II

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Modeling and Simulation of Thermal Systems	16MTP253	04	4-0-0	80	20	3Hrs
Common to MTP,MTH						

Course Objective:

- To have the knowledge about basic principles of thermodynamics, heat transfer and fluid mechanics for modeling and simulation techniques
- To have the understanding of modeling and simulation.
- To study the design and performance of thermal system using modeling and simulation

Course Content:

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

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

2.Random Number Generation: technique for generating random numbers —mid squar e method- The mid product method- constantmultiplier technique-additive congruential method — linear congruential method —tests for random number s —the kolmogorov-simrnov test-the Chi-square test.

Random Variable Generation: inversion transform technique- exponential distribution- uniform distribution-weibul distribution empiricalcontinuous distribution- generating approximate normal variates —Erlang distribution. **12Hours**

3.Empirical Discrete Distribution: Discrete uniform distribution—poissondistribution- geometricdistribution- acceptance-rejectiontechnique for poission distribution-gamma distribution.

Design And Evaluation Of Simulation Experiments: variance reduction techniques-antithetic variables-variables-verification and validationof simulation models.**10Hours**

4.Discrete Event Simulation: concepts in discrete-event simulation, manual simulation using event scheduling, single channel queue, twoserver queue simulation of inventory problem.
9 Hours
5. Introduction to GPSS: Programming for discrete event systems in GPSS, case studies.
9Hours

Reference Books:

1. **Discrete event system simulation -** Jerry Banks & John S Carson II, prentice hall Inc, 1984.
2. **Systems simulation** - Gordon g, prentice Hall of India Ltd,1991.
3. **System simulation with digital Computer -** NarsinghDeo, Prentice Hall of India, 1979.
4. **Thermal Power Plant Simulation & Control -** D. Flynn (Ed), IET,2003.

Course Outcome:after undergoing this course students are able to

- Explain the basic principles and concepts underlying in modeling and simulation techniques
- Optimize the design of thermal systems .
- Develop representational modes of real processes and systems.
- Generate suitable modeling techniques to compute the performance.

IISEMESTERM.TECH. THERMAL ENGINEERING.

Elective-II

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
COMPUTATIONAL METHODS IN HEAT TRANSFER & FLUID FLOW	16MTP254	04	4-0-0	80	20	3Hrs
Common to MTP,MTH						

Course Objective:

- To understand the numerical techniques to solve ODE and PDE relevant to heat and fluid flow systems.
- To learn the possible numerical tools to formulate flow situations.
- To identify the temperature and energy distribution over the computational domain.

Course Content:

1.Introduction: History and Philosophy of computational fluid dynamics, CFD as a design and research tool, Applications of CFD in engineering, Programming fundamentals, MATLAB programming, Numerical Methods

Governing equations of fluid dynamics: Models of the flow, The substantial derivative, Physical meaning of the divergence of velocity, The continuity equation, The momentum equation, The energy equation, Navier-Stokes equations for viscous flow, Euler equations for inviscid flow, Physical boundary conditions, Forms of the governing equations suited for CFD, Conservation form of the equations, shock fitting and shock capturing, Time marching and space marching.

2. Mathematical behavior of partial differential equations: Classification of quasi-linear partial differential equations, Methods of determining the classification, General behavior of Hyperbolic, Parabolic and Elliptic equations.

Basic aspects of discretization: Introduction to finite differences, Finite difference equations using Taylor series expansion and polynomials, Explicit and implicit approaches, Uniform and unequally spaced grid points.

Grids with appropriate transformation: General transformation of the equations, Metrics and Jacobians, The transformed governing equations of the CFD, Boundary fitted coordinate systems, Algebraic and elliptic grid generation techniques, Adaptive grids.

3.Parabolic partial differential equations: Finite difference formulations, Explicit methods – FTCS, Richardson and DuFort-Frankel methods, Implicit methods – Laasonen, Crank-Nicolson and Beta formulation methods, Approximate factorization, Fractional step methods, Consistency analysis, Linearization.

Stability analysis: Discrete Perturbation Stability analysis, von Neumann Stability analysis, Error analysis, Modified equations, artificial dissipation and dispersion.

4.Elliptic equations: Finite difference formulation, solution algorithms: Jacobi-iteration method, a Gauss-Siedel iteration method, point- and line-successive over-relaxation methods, and alternative direction implicit methods.

Hyperbolic equations: Explicit and implicit finite difference formulations, splitting methods, multi-step methods, applications to linear and nonlinear problems, linear damping, flux corrected transport, monotone and total variation diminishing schemes, tvd formulations, entropy condition, first-order and second-order tvd schemes.

5.Scalar representation of navier-stokes equations: Equations of fluid motion, numerical algorithms: FTCS explicit, FTBCS explicit, Dufort-Frankel explicit, Maccormack explicit and implicit, BTCS and BTBCs implicit algorithms, applications.
Grid generation: Algebraic Grid Generation, Elliptic Grid Generation, Hyperbolic Grid Generation, Parabolic Grid Generation.
Finite volume method for unstructured grids: Advantages, Cell Centered and Nodal point Approaches, Solution of Generic Equation with tetra hedral Elements, 2-D Heat conduction with Triangular Elements
Numerical solution of quasi one-dimensional nozzle flow: Subsonic-Supersonic isentropic flow, Governing equations for Quasi 1-D flow, Non-dimensionalizing the equations, MacCormack technique of discretization, Stability condition, Boundary conditions, Solution for shock flows.
8Hours

Reference Books:

1. Numerical Heat Transfer and Fluid Flow - S.V. Patankar, Hemisphere Publishing Company.
2. Computational Fluid Dynamics - T.J. Chung, Cambridge University Press 2003
3. Computational fluid flow and heat transfer - K. Murlidhar and T. Sounderrajan, Narosa Publishing Co.
4. **Computational fluid mechanics and heat transfer -** D. A. Anderson, J. C. Tannehill, R.H. Pletcher, Tata McGraw-Hill Publications 2002
5. **Computational fluid dynamics** - J.A. Anderson, McGraw-Hill Publications 1995
6. **An Introduction to Computational Fluid Dynamics**Versteeg, H.K. and Malalasekara, W., , Pearson Education, 2010.

Course Outcome:

- To derive the stepwise procedure to completely solve a fluid dynamics problem using computational methods.
- To explain the governing equations and understand the behavior of the equations.
- To determine the consistency, stability and convergence of various discretisation schemes for parabolic, elliptic and hyperbolic partial differential equations.
- To verify variations of SIMPLE schemes for incompressible flows and Variations of Flux Splitting algorithms for compressible flows.
- To identify various methods of grid generation techniques and application of finite difference and finite volume methods to various thermal problems.

IISEMESTERM.TECH. THERMAL ENGINEERING.

Elective-II

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Simulation Laboratory Projects on Thermal Engineering - Lab 2	16MTP26	02	0-0-2	80	20	3Hrs
Common to MTP,MTH,MCS						

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 aPresentation on the same for Internal Evaluation
- Any one of the exercises done from the following list has to be asked in the Examination for evaluation.
- Computer programme can be developed in ‘C’ or MATLAB.
- MATLAB Simulink can be used wherever applicable.

Course Content:

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 $\frac{\partial u}{\partial t} = \propto \frac{\partial^2 u}{\partial x^2}$ 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 $\frac{\partial u}{\partial t} = \propto \frac{\partial^2 u}{\partial x^2}$ and draw the characteristic curves for various boundary conditions. Use Dufort-Frankel Model.

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

8. Develop programmes in C or MATLAB to solve $\frac{\partial u}{\partial t} = \propto \frac{\partial^2 u}{\partial x^2}$ and draw the characteristic curves for various boundary conditions. Use Crank Nicholsen Model.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI CHOICE BASED CREDIT SYSTEM (CBCS) SCHEME OF TEACHING AND EXAMINATION 2016-2017

M. Tech in Thermal Engineering/Thermal Power Engineering

III SEMESTER: Internship **CREDIT BASED**

Sl. No	Subject Code	Title	Teaching Hours /Week		Examination				Credits
			Lecture Hours	Practical/ Field Work/ Assignment	Duration	I.A. Marks	Theory/ Practical Marks	Total Marks	
1	16MTP/ MTH31	Seminar / Presentation on Internship (After 8 weeks from the date of commencement)	-	-	-	25	-	25	20
2	16MTP/ MTH32	Report on Internship	-	-	-	25	-	25	
3	16MTP/ MTH33	Evaluation and Viva-Voce of Internship	-	-	-	-	50	50	
4	16MTP/ MTH34	Evaluation of Project phase -1	-	-	-	50	-	50	1
TOTAL			**-**	**-**	**-**	**100**	**50**	**150**	**21**

IVSEMESTERM.TECH. THERMAL ENGINEERING.

DESIGN OF HEAT TRANSFER EQUIPMENTS FOR THERMAL POWER PLANT

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Design of heat TransferEquipments for thermal power plant	16MTP41	04	4-0-0	80	20	3Hrs
Common to MTP,MTH						

Course Objective:

- Study the modes of heat transfer involved in heat exchanger design .
- Study the basic principles of heat exchanger analysis and thermal design.
- Understand the principles of direct contact heat exchanger

1. **CLASSIFICATION OF HEAT EXCHANGERS**: Introduction, Recuperation & regeneration, Tabular heat exchangers, Double pipe, shell & tube heat exchanger, Plate heat Exchangers, Gasketed plate heat exchanger. Spiral plate heat exchanger, Lamella heat exchanger, Extended surface heat exchanger, Plate fin and Tabular fin. Basic Design Methods of Heat Exchanger: Introduction, Basic equations in design, Overall heat transfer coefficient, LMTD method for heat exchanger analysis, Parallel flow, Counter flow. Multipass, cross flow heat exchanger design calculations:**08Hours**

2. **DOUBLE PIPE HEAT EXCHANGER**: Film coefficient for fluids in annulus, fouling factors, Calorific temperature, Average fluid temperature, The calculation of double pipe exchanger, Double pipe exchangers in series parallel arrangements. Shell & Tube Heat Exchangers: Tube layouts for exchangers, Baffle heat exchangers, Calculation of shell and tube heat exchangers, Shell side film coefficients, Shell side equivalent diameter, The true temperature difference in a 1-2 heat exchanger. Influence of approach temperature on correction factor. Shell side pressure drop, Tube side pressure drop, Analysis of performance of 1-2 heat exchanger and design of shell & tube heat exchangers, Flow arrangements for increased heat recovery, the calculation of 2-4 exchangers. **12Hours**
3. **CONDENSATION OF SINGLE VAPOURS**: Calculation of horizontal condenser, Vertical condenser, De-Super heater condenser, Vertical condenser-sub-Cooler, Horizontal Condenser-Sub cooler, Vertical reflux type condenser. Condensation of steam.**10Hours**

4. **VAPORIZERS, EVAPORATORS AND REBOILERS**: Vaporizing processes, Forced circulation vaporizing exchanger, Natural circulation vaporizing exchangers, Calculations of a reboiler. Extended Surfaces: Longitudinal fins. Weighted fin efficiency curve, Calculation of a Double pipe fin efficiency curve. Calculation of a double pipe finned exchanger, Calculation of a longitudinal fin shell and tube exchanger.**10Hours**

5. **DIRECT CONTACT HEAT EXCHANGER:** Cooling towers, relation between wet bulb & dew point temperatures, The Lewis number and Classification of cooling towers, Cooling tower internals and the roll of fill, Heat Balance. Heat Transfer by simultaneous diffusion and convection, Analysis of cooling tower requirements, Deign of cooling towers, Determination of the number of diffusion units, Calculation of cooling tower performance.**10Hours**

Course Outcome

CO1 Understand the physics and the mathematical treatment of typical heat exchangers.

CO2 Employ LMTD and Effectiveness methods in the design of heat exchangers and analyze the importance of LMTD approach over AMTD approach.

CO3 Examine the performance of double-pipe counter flow (hair-pin) heat exchangers.

CO4 Design and analyze the shell and tube heat exchanger.

CO5 Understand the fundamental, physical and mathematical aspects of boiling and condensation.

CO6 Classify cooling towers and explain their technical features.

READING

1. James R. Couper; W. Roy Penney, James R. Fair, Stanley M. Walas, Chemical Process Equipment: selection and design, Elsevier Inc., 2nd ed. 2005
2. 1.Process heat transfer- Donald Q.Kern, Tata McGraw Hill Publishing Company Ltd.
3. Heat Exchangers Selection, Rating and Thermal Design- SadikKakac and Hongtan Liu, CRC Press.
4. Process Heat Transfer- Sarit K.Das, Narosa Publishing House Pvt. Ltd.
5. Standards of the Tubular Exchange Manufacturers Association, TMEA, New York.
6. Heat exchanger design- Press and N. Ozisik.
7. Heat Exchangers- Kakac, S., A.E. Bergles and F. Mayinger (Eds.) Hemisphere, 1981.
8. Compact Heat exchangers- Kays, W.M., and A.L. London, McGraw Hill.

IVSEMESTERM.TECH. THERMAL ENGINEERING.

CONVECTIVE HEAT AND MASS TRANSFER
(Elective-III)

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Convective Heat and Mass Transfer	16MTP421	04	4-0-0	80	20	3Hrs
Common to MTP,MTH						

Course Objective

- Use empirical correlations for fully-developed laminar, turbulent internal flows and external boundary layer convective flow problems.
- Study the basic principles of mixed convective flow and their heat transfer analysis .
- Understand the principles of convective heat transfer through porous media related engineering problems.

1. **INTRODUCTION TO FORCED, FREE & COMBINED CONVECTION** – convective heat transfer coefficient – Applicationof dimensional analysis to convection – Physical interpretation of dimensionless numbers.Equations of Convective Heat Transfer: Continuity, Navier-Strokes equation & energy equation forsteady state flows – similarity – Equations for turbulent convective heat transfer – Boundary layerequations for laminar, turbulent flows – Boundary layer integral equations.**10Hours**

2. **EXTERNAL LAMINAR FORCED CONVECTION**: Similarity solution for flow over an isothermal plate– integral equation solutions – Numerical solutions – Viscous dissipation effects on flow over a flatplate.External Turbulent Flows: Analogy solutions for boundary layer flows – Integral equation solutions Effects of dissipation on flow over a flat plate.Internal Laminar Flows: Fully developed laminar flow in pipe, plane duct & ducts with other crosssectionalshapes – Pipe flow & plane duct flow with developing temperature field – Pipe flows & planeduct flow with developing velocity & temperature fields.Internal Turbulent Flows: Analogy solutions for fully developed pipe flow –Thermally developingpipe & plane duct flow.**12Hours**

3. **NATURAL CONVECTION**: Boussineq approximation – Governing equations – Similarity – Boundarylayer equations for free convective laminar flows – Numerical solution of boundary layer equations.Free Convective flows through a vertical channel across a rectangular enclosure – Horizontalenclosure – Turbulent natural convection.**08Hours**

4. **COMBINED CONVECTION**: Governing parameters & equations – laminar boundary layer flow overan isothermal vertical plate – combined convection over a horizontal plate – correlations for mixedconvection – effect of boundary forces on turbulent flows – internal flows - internal mixed convectiveflows – Fully developed mixed convective flow in a vertical plane channel & in a horizontal duct.**10Hours**

5. **CONVECTIVE HEAT TRANSFER THROUGH POROUS MEDIA**: Area weighted velocity – Darcy flowmodel – energy equation – boundary layer solutions for 2-D forced convection – Fully developed ductflow – Natural convection in porous media – filled enclosures – stability of horizontal porous layers.
   CONVECTIVE MASS TRANSFER: Basic Definitions and Formulation of a Simplified Theory, Evaluation of The Mass-Transfer Conductance, Examples for application of the Simplified Method.

10Hours

Course Outcome

CO1 Understand the fundamental and advanced principles of forced and natural convection heat transfer processes.
CO2 Formulate and solve convective heat transfer problems
CO3 Relate the principles of convective heat transfer to estimate the heat dissipation from devices.
CO4 Estimate the energy requirements for operating a flow system with heat transfer.
CO5 Relate to the current challenges in the field of convective heat transfer.

READING:

1. Bejan, A., Convection Heat Transfer, John Willey and Sons, New York, 2001.
2. Louis, C. Burmeister, Convective Heat Transfer, John Willey and Sons, New York, 2003.
3. Kays, W.M. and Crawford, M. E., Convective Heat and Mass Transfer, McGraw Hill, New York, 2001.

IVSEMESTERM.TECH. THERMAL ENGINEERING.

ENGINE FLOW AND COMBUSTION

(Elective-III)

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Engine Flow and Combustion	16MTP422	04	4-0-0	80	20	3Hrs
Common to MTP,MTH						

Course Objective

- Study the Inlet& exhaust processes of I C Engine.
- Understand the combustion phenomenon of I C Engines pollutant formation
- Study the combustion models nd emission norms.

1.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.Intake jet flow, mean velocity turbulence characteristics, swirl, squish, pre chamber engine flows, creviceflow and blow by, flows generated by piston cylinder wall interaction.**10Hours**

2.Combustion in IC Engines: Combustion in SI engines: Ignition, flame velocity, Normal andabnormal combustion, knocking, pre-ignition, effect of engine variables on knocking, featuresand design consideration of combustion chambers, concept of lean burn engines, Combustion inCI engines: Air motion: Swirl and squish, spray formation and vaporization, Stages ofcombustion, physical and chemical delay, diesel knock, effect of engine variables on dieselknock, combustion chambers: design features, Combustion characteristics of Biodiesel andBiodiesel blends, Low NOx diesel combustion: homogeneous charge compression ignitionengine (HCCI- combustion), pHCCI, and EGR techniques**10Hours**

3.Combustion Models: Fuel spray: Factors influencing fuel spray atomization, Spray equationmodels, penetration and dispersion of fuel, fuel line hydraulics, fuel pumps and injectors, Zerodimensional modeling, quasi dimensional modeling, combustion systems: efficiency and itsapplications, Single zone models, multi zone models, Premixed and diffusive models, Heattransfer coefficients, and specific heat relations, Weibes function analysis, two zone models, heattransfer in IC engines, heat transfer correlations, data logging and acquisition, cylinder-pressuremeasurement and Gross and net release rate calculations.
10Hours

4.Engine Emissions and Air-Pollution: Emissions and its Formation: Gaseous emissions: CO,CO_2, HC, NOx (NO & NO_2), SOx (SO_2 & SO_3); particulate matter (PM), Sources of emissionformation; Emissions formation mechanisms of PM and NOx; volatile organic compounds(VOCs), poly aromatic hydrocarbons (PAH), soluble organic fraction (SOF); Mechanism of airpollution: Ozone depletion, Greenhouse effect, Photochemical smog, acid rain, Effect of airpollutionon health and environment, Emission norms (passenger and commercial vehicles):National and International emission standards: BS-III and BS-IV & Euro III, IV, and V**10Hours**

5.Emission Control Technologies and Emission Measurements: PM reduction technologies:Diesel oxidation catalysts (DOCs), Diesel particulate filters (DPFs), closed crankcase ventilation(CCV); NOx reduction technologies: Exhaust gas recirculation (EGR), Selective catalyticreduction (SCR), Lean NOx catalysts (LNCs), Lean NOx traps (LNTs), NOx adsorber catalysts,Exhaust gas recirculation (EGR), Diesel exhaust after treatment: diesel oxidation catalyst (DOC), diesel particulate filter (DPF), Soot suppression by fuel additives, relationship: soot, combustionchamber and swirl ratio, catalytic convertors: constructional features and types: 2-way and 3-way catalytic convertors. Measurement of gaseous emissions using thermal, chemical, magneticand optical gas analyzers: infrared gas analyzer, chemiluminescent analyzer, gaschromatography, smoke (soot) measurement, application of microprocessor in emission control.Trends of emission reduction**10Hours**

Course Outcome

- Understand the Engine inlet and exhaust flow systems
- Explain the phynomenon of I C Engine combustion and their pollutant formation
- Distinguish different combustion models of I C Engines.
- Explain the emission norms and their controlling measures.

READING

1. Combustion Modeling in Reciprocating Engines, by James N Mattavi and Charles A Amann, Plenum press, 1980
2. Thermodynamic Analysis of Combustion Engines, by Ashley S Campbell, John Wiley and Sons, 1980
3. Internal Combustion Engines and Air Pollution, by Edward .F Obert, Intext Education Publishers, 1980
4. Automotive Emission Control , Crouse William, Gregg division, McGraw-Hill,
5. Internal Combustion Engine Fundamentals, John B. Heywood, Tata McGraw-Hill,1998
6. Internal combustion engine modeling, by J I Ramos, Hemisphere Publishing Corporation, 1989
7. Experimental Methods for Engineers by Holman J. P, McGraw-Hill,1988
8. Computer Simulation of Spark Ignition Engine Processes, by Ganesan V., University press, 1995

IVSEMESTERM.TECH. THERMAL ENGINEERING.

DESIGN & ANALYSIS OF THERMAL SYSTEMS

(Elective-III)

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Design & Analysis of Thermal Systems	16MTP423	04	4-0-0	80	20	3Hrs
Common to MTP,MTH						

Course Objective

- Have an exposure to different Design Methodologies and simulation processes.

1. Thermal Systems: Characteristics- formulation of design problem - Steps in the designprocess - Modeling of thermal systems – importance - Types of models – MathematicalModeling, Exponential forms- Method of least squares - Counter flow heat exchanger, Evaporators and Condensers, Effectiveness, NTU, Pressure drop and pumping power**10Hours**

2.Design of piping and pump systems:- Head loss representation ;Piping networks ; Hardy – Cross method Generalized Hardy – Crossanalysis ; Pump testing methods ; Cavitation considerations ; Dimensional analysis of pumps ; piping system design practice.**10Hours**

3.Unconstrained Optimization Techniques: Univariate, Conjugate Gradient Method and Variable Metric Method. **Constrained Optimization Techniques:** Characteristics of a constrained problem; Direct Method of feasible directions; Indirect Method of interior and exterior penalty functions.**10Hours**

4.Thermo-economic analysis and evaluation:- Fundamentals of thermo-economics, Thermo-economic variables for component evaluation ;thermo-economic evaluation ; additional costing considerations.
10Hours

5.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.**10Hours**

Course outcome

CO1 Formulation of design problems related to thermal Systems

CO2 Develop a mathematical model for a given problem.

CO3 Solve practical problems using suitable optimization technique.

CO4 Design of piping and pump systems

CO5 Developthermo-economic analysis and evaluation,optimization for variety of industrial problems.

READING

1. **Thermal Design & Optimization -** Bejan, A., et al., John Wiley, 1996
2. **Analysis & Design of Thermal Systems -** Hodge, B.K., 2ndedition, Prentice Hall, 1990.
3. **Design of Thermal Systems -** Boehm, R.F., John Wiley, 1987
4. **Design of Thermal Systems -** Stoecker, W.F., McGraw-Hill

IVSEMESTERM.TECH. THERMAL ENGINEERING.

EXPERIMENTAL METHODS IN THERMAL POWER ENGINEERING

(Elective-III)

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Experimental Methods in Thermal Power Engineering	16MTP424	04	4-0-0	80	20	3Hrs
Common to MTP,MTH						

Course Objective

1. **Basics of Measurements:** Introduction, General measurement system, Signal flow diagram of measurement system, Inputs and their methods of correction
   Pressure measurement: Different pressure measurement instruments and their comparison, Transient response of pressure transducers, dead-weight tester, low-pressure measurement.

2. **Thermometry:** Overview of thermometry, temperature measurement by mechanical, electrical and radiation effects. Pyrometer, Thermocouple compensation, effect of heat transfer.
   Thermal and transport property measurement: Measurement of thermal conductivity, diffusivity, viscosity, humidity, gas composition, pH, heat flux, calorimetry, etc.

3. **Flow Measurement:** Flow obstruction methods, Magnetic flow meters, Interferometer, LDA, flow measurement by drag effects, pressure probes, other methods.
   Nuclear, thermal radiation measurement: Measurement of reflectivity, transmissivity, emissivity, nuclear radiation, neutron detection, etc.Other measurements: Basics in measurement of torque, strain.

4. **Analysis of experimental data:** Causes and types of errors in measurement, Propagation of errors, Uncertainty analysis, Regression analysis, Statistical analysis of Experimental data.
   Sensing Devices : Transducers-LVDT, Capacitive, piezoelectric, photoelectric, photovoltaic, Ionization, Photoconductive, Hall-effect transducers, etc.

5. **Air-Pollution:** Air-Pollution standards, general air-sampling techniques, opacity measurement, sulphur dioxide measurement, particulate sampling technique, combustion products measurement.
   Advanced topics: Issues in measuring thermo physical properties of micro and Nano fluids.
   Design of Experiments: Basic ideas of designing experiments, Experimental design protocols with some examples and DAS

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

CO1 Understand the concepts of errors in measurements, statistical analysis of data, regression analysis, correlation and estimation of uncertainty.

CO2 Describe the working principles in the measurement of field and derived quantities.

CO3 Examine sensing requirements for measurement of thermo-physical properties, radiation properties of surfaces, and vibration.

CO4 Understand conceptual development of zero, first and second order systems.

CO5 Interpret International Standards of measurements (ITS-90) and identify internationally accepted measuring standards for measurands.

READING

1. Modern Electronic Instrumentation and Measurement Techniques; Albert D Helfrick and William D Cooper, 2004, PHI.
2. b. Process Control: Principles and Applications; Surekha Bhanot, Oxford University press, Fourth Impression, 2010.
3. Instrumentation, Measurement and Analysis; BC Nakra, and KK Chaudhry; 2 ed, 2004, Tata McGraw-Hill
4. Transducers and Instrumentation; DVS Murthy, 2003, PHI
5. Instrumentation Devices and Systems; CS Rangan, GR Sarma, and VSV Mani; 2 ed, Tata McGraw-Hill
6. Measurement Systems Application and Design; Doeblin and Ernest; 5 ed, 2004, Tata McGraw-Hill.
7. Measurement Systems – Applications & design; Doeblin E.O. 4th ed. Mc. Graw Hill
8. Principles of Industrial Instrumentation, Patranabis D. TMH – 1997
9. Mechanical & Industrial Measurements, Jain R.K, Khanna Publishers – 1986
10. Process Instruments and control Hand book, Considine D.M, 4th ed, Mc.Graw Hill
11. Instrument Technology – Vol.1m, Jones E.B., Butterworths – 1981
12. Control Systems Engineering, Nagrath&M.Gopal, Wiley Eastern
13. Automatic Control Systems, B.C.Kuo, John Wiley, 2009
14. Modern Control Engineering, Katsuhiko Ogata, Prentice Hall