M. Tech. Thermal Engineering

Department of Mechanical Engineering

Scheme and Syllabus

First Semester:

Subject Code	Course Title	Course Category	Credits	L	T	P
MET602	Design of Thermal System	Core	3	3	0	0
MET603	CFD and Heat Transfer	Core	3	3	0	0
MET604	Energy Management	Core	3	3	0	0
MET614	Alternative Fuels in I.C. Engine	Core	3	3	0	0
HST609	Technical Writing and Presentation Skills	Core	3	3	0	0
MEP606	Thermal Lab	Core	2	0	0	3
Total Credits			**17**			

Second Semester:

Subject Code	Course Title	Course Category	Credits	L	T	P
XXX	Program /Open Elective 1	PE/OE	3	3	0	0
XXX	Program /Open Elective 2	PE/OE	3	3	0	0
XXX	Program /Open Elective 3	PE/OE	3	3	0	0
XXX	Program /Open Elective 4	PE/OE	3	3	0	0
XXX	Program /Open Elective 5	PE/OE	3	3	0	0
XXX	Program /Open Elective 6	PE/OE	3	3	0	0
Total Credits			**18**			

Third Semester:

Subject Code	Course Title	Course Category	Credits	L	T	P
MES641	Seminar	PC	4	0	0	4
MED642	Dissertation	PC	16	0	0	16
Total Credits			**20**			

Fourth Semester:

Subject Code	Course Title	Course Category	Credits	L	T	P
MED643	Dissertation	PC	16	0	0	16
Total Credits			**16**			

Program Electives

1. MET601 Simulation and Modeling 3 (3- 0- 0)
2. MET605 Advanced Fluid Mechanics 3 (3- 0- 0)
3. MET611 Refrigeration and Air-conditioning Systems 3 (3- 0- 0)
4. MET612 Advanced Refrigeration 3 (3- 0- 0)
5. MET613 Advanced Thermodynamics 3 (3- 0- 0)
6. MET616 Wind Energy Utilization 3 (3- 0- 0)
7. MET617 Pollution Control Technologies 3 (3- 0- 0)
8. MET618 Solar Thermal Engineering 3 (3- 0- 0)
9. MET619 Energy Conversion Technologies 3 (3- 0- 0)
10. MET620 Advance Heat Transfer 3 (3- 0- 0)
11. MET711 Computer Aided Fluid Dynamics 3 (3- 0- 0)

MET601 - Simulation and Modeling:

Definition of a system, System concepts, type of system, continuous & discrete systems, modeling process verification & validation.

Introduction of Probability Distributions and random processes, Central limit theorem. Estimation of mean and variance, Confidence interval, Hypothesis testing, Normal distribution, t-test, ANOVA- an Introduction

Markov chains: CTMC and DTMC

Queuing models: Basic queuing models. Little's Theorem and network of queues.

Introduction, classification of simulation models, advantages, and disadvantages of simulation. Concept of simulation time and real time. Discrete system simulation. Monte Carlo method, Random number generators.

Simulation of inventory systems.

Introduction to simulation environment and software tools.

Books:

1. Principles of Operations Research, Wagner, PHI.
2. Simulation modeling and analysis, Law and Kelton, McGraw Hill.
3. Probability and Statistics with Reliability, Queuing and Computer Science Application, Kishore S Trivedi, Wiley.
4. System simulation, Gorden G., Prentice Hall of India.

MET602 - Design of Thermal Systems

Mathematical Modeling of thermal Systems: Development of equations based on number-processing operation and physical laws for simulation and optimization of thermal systems. The art of equation fitting to performance data. Development of performance equations for heat exchangers, distillation separators and turbo machinery

Simulation of thermal Systems: Uses of system simulation, classes of simulation; Information-flow diagrams; sequential and simultaneous calculations; simulation of continuous, deterministic steady-state systems, e.g. gas turbine system; simulation of dynamic behavior of thermal systems.

Optimization of Thermal Systems: Optimization criteria; use of Lagrange Multipliers, search methods, dynamic programming and geometric programming for optimum design of thermal systems.

Books:

1. W.F. Stocker; "Design of thermal Systems", McGraw Hill International, 1989.
2. B.K. Hodge, "Analysis and Design of Energy Systems", Prentice-Hall Inc., 1990.

MET603 - Computational Fluid Dynamics and Heat Transfer

Finite Difference Method: Forward, backward, and central difference scheme- explicit and implicit methods. Errors, consistency, stability analysis, upwind schemes.

Incompressible Flow: Finite differences, MAC and SIMPLE algorithms, stream function, velocity potential function and vorticity formulation. **Inviscid Flow:** Basic governing equation and different solution algorithms for compressible flow with calculations of lift and drag.

Conduction Heat Transfer: Steady and unsteady state, boundary condition, Rang-Kutta method, finite difference method, iterative and direct methods.

Convective Heat Transfer: Governing equations, solutions for natural and forced convection, modeling of convection problems.

Radiative Heat Transfer: Basic concepts, radiosity method, Monte – Carlo method, phase change problems.

Books:

1. Yogesh Jaluria and Kenneth E. Torrance, Computational Heat Transfer, Hemisphere Publishing Corporation, 1986.
2. K. Muralidhar & T. Sundararajan, Computational Fluid Flow and Heat Transfer, Narosa Publication, 1995.
3. S.V. Patankar, Numerical Heat Transfer and Fluid Flow, Hemishere Publication Company New York 1980.

MET604 - Energy Management

Introduction to Energy Management: Aims and approaches of auditing, types of energy audit, energy indices in residential, commercial, and industrial sector, data collection.

Energy in Manufacturing: Energy and environmental analysis of products, energy consumption in manufacturing, laws of energy and materials flow.

Energy in Residential Sector: Supply of energy for rural and urban housing, fuel substitution, efficiency improvement of domestic appliances.

Instrumentation for Energy Management:

Measurement of heat flux, radiation, psychometric variables, fluid flow & velocities, data analysis.

Life Cycle Analysis: LCA of energy systems, concept of life cycle costing and its use.

Demand Side Management: Principles of DSM, rules and tools of DSM, fundamentals of demand response, DSM tools and practices.

Books:

1. C.B. Smith, Energy Management Principles, Pergamon Press, New York, 1981.
2. Hamies, Energy Auditing and Conservation: Methods, Measurements, Management & case study, hemishpere, Washington, 1980.
3. Diamant R.M.,Total Energy, Pergamon Press, Oxford, 1970**.**

MET605 - Advanced Fluid Mechanics

Basic Equations: Deformation and the rate of strain, the deformation tensor, skew-symmetry of the deformation tensor, symmetry of the stress tensor, polar and non-polar fluids, stokesian and Newtonian fluids.

Derivation of the general differential equations of continuity, momentum, and energy in vector form. Euler's and Navier-Stokes equations, Integration of the momentum equation and the generalized Bernoulli's equation.

Two Dimensional Irrotational Flow: Two-dimensional flow in rectangular and polar coordinates; continuity equation and the stream function, irrotationality and the velocity potential function, vorticity and circulation, plane potential flow and the complex potential function. Sources, sinks,

doublets and vortices. Superposition of uniform stream with above; flow around corners; Rankine ovals, flow around circular cylinders with the without circulation, pressure distribution on the surface of these bodies.

Elements of two dimensional aerofoils theory, symmetrical aerofoil theory, lift and moment.

Vortex Motion: Definitions, vortex lines, surfaces and tubes, vorticity, circulation; Kelvin's circulation theorem, Helmholtz's vorticity theorems; the convection and diffusion of vorticity.

Viscous Flow: Exact solution, plane Poiseuille and Couette flows; Hagen Poiseuille flow through pipes.

Flows with very small Reynolds number. Flows with very large Reynolds number, elements of two dimensional boundary layer theory; displacement thickness and momentum thickness, skin friction, Blasius solution for boundary layer on a flat plate without pressure gradient; the Karman-Polhausen integral method for obtaining approximate solutions. Drag on bodies; form drag and skin friction drag profile drag and its measurement.

MET611 - Refrigeration and Air Conditioning System

Load Calculations: Solar heat gains through structures; review of refrigeration and air-conditioning load calculations.

Performance characteristics and capacity control of reciprocating; rotary and centrifugal compressors; screw compressors; hermetically sealed units; analysis of centrifugal compressors.

Water-cooled and air-cooled condensers: overall heat transfer coefficients; fouling factor; performance characteristics and design; performance and heat transfer processes in evaporative condenser.

Flooded and dry expansion type evaporators; liquid chiller; overall performance of evaporators.

Capillary tubes: system design factors; pressure and temperature distribution; ASHRAE simplified calculation procedure.

Expansion valves: operation and performance calculation of thermostatic expansion valve; application of constant pressure expansion valve.

Condensing Unit-Evaporators: Elements of steam; water and warm-air heating; radiators and convectors.

Piping and Ducts: Pressure drops in piping and fittings; design of water and refrigerant piping; review of duct design methods; static regain method.

Applications and System Design: Ice manufacture; food preservation and transportation; freeze drying; air-conditioning of auditoriums and restaurants; central air-conditioning systems.

Complete design of a refrigeration of an air-conditioning system.

Books:

1. Refrigeration and Air-conditioning Stoecker McGraw Hill
2. Air-conditioning Design Handbook Carrier Corpn. (Ed.) McGraw Hill
3. ASHRAE Handbooks ----ASHRAE
4. Environmental Engg. Analysis & Practice Jennings International
5. Climatological and Solar Data for India CBRI Sarita Prakashan

MET613 - Advanced Thermodynamics

Review of basic thermodynamic principles; entropy; availability; irreversibility; first and second law analysis of steady and unsteady systems.

General thermodynamics relations; Fundamentals of partial derivatives; relations for specific heats; internal energy enthalpy and entropy; Joule - Thompson coefficient; Clapeyron equation. Multi component systems; Review of equation of state for ideal and real gases; thermodynamic surfaces; gaseous mixtures; fugacity; ideal solutions; dilute solutions; activity; non ideal liquid solutions.

Multi component phase equilibrium; Criteria of equilibrium; stability; heterogeneous equilibrium;

binary vapour liquid systems; the nucleus of condensation and the behaviour of stream with formation of large and small drops; Gibbs Phase rule; higher order phase transitions. Thermodynamics of chemical reaction (combustion); internal energy and enthalpy - first law analysis and second law analysis; basic relations involving partial pressures; third law of thermodynamics; chemical equilibrium and chemical potential equilibrium constants; thermodynamics of low temperature.

Statistical mechanics - Maxwell - Boltzmann statistics; microstate and macrostates; thermodynamic probability; entropy and probability Bose Einstein statistics; Fermi Dirac statistics. Elementary concepts of irreversible thermodynamics.

MET614 - Alternative Fuels in I.C. Engines

Introduction: Need of alternative gaseous fuels, future automotive gaseous fuels, hydrogen, CNG, LNG, and Producer gas, biogas, LPG. Stochiometric air-fuel ratio, Physical properties of different gaseous fuels, mode of engine operations, spark ignition and dual fuel mode, multi fuel mode, combustion and performance of engines, specific problems, safety and environmental aspects, economic aspects, production.

Use of alcohol in four stroke spark ignition engines and diesel engines, use of alcohol in two stroke engines, use of bio diesels, combustion and performance of engines, stochiometric air fuel ratio, specific problems, safety and environmental aspects, economic aspects, production.

Impacts: Impact of alternative fuels on engine test and test procedures, guidelines for emission measurements, emission norms for engines using alternative fuels.

Legal Aspects: Legal aspects of blending alternative fuels into conventional liquid fuels, properties of blends, comparison of neat versus blended fuels, fuel testing.

Computer simulation: Computer simulation of engines using alternative fuels.

References:

1. Future automotive fuels, Edited by Joseph M. Colucci and Nicoles C. Gallopoulos, Plenum press, New York
2. Dual fuel engines, edited by R.L. Evans, Plenum Press, 1987
3. SAE hand book, volume III, Engines, fuels, lubricants, emissions and noise
4. Automotive fuels and fuel systems, volume II, T.K. Garrett, Pantech Press, London
5. Gaseous fuels for transportation I, proceedings of the conference held at Vancouver, British Columbia, Canada, 1987,
6. Pandel U, Poonia M.P.; Energy Technologies for Sustainable Development, Prime Publishing House Gajiabad, 2003.

MET617 - Pollution Control Technologies

Introduction: Introduction to air pollution, classification of pollutants, their effects, impact of environment on human.

Air Pollution Sources: Mobile and stationary sources, types of plume dispersion mechanisms, air quality measurement concepts.

Control devices for particulate contaminants: gravitational settlement, centrifugal and wet collectors, fabric filters, cyclone separators, electrostatic precipitators

Control devices for gaseous contaminants from stationary sources: adsorption, adsorption, condensation, combustion based pollution control systems.

Automotive Emission control: Types and construction of catalytic converters, emission control through operating parameters and engine design, alternative fuels for emission reduction.

Laws and regulations: National and international standards for mobile and stationary sources of air pollution.

Books:

1. Howard S. Peavy, Donald Rowe; Environmental Engineering; Tata Mc-Graw Hill, 1989.

MET618 - Solar Thermal Engineering

SOLAR RADIATION: Solar Radiation, instruments for measuring solar radiation, solar radiation geometry, empirical equations, solar radiation on tilted surfaces.

LIQUID FLAT PLATE COLLECTORS: Basic elements, performance analysis, transmissivity - absorptivity, heat transfer coefficients and correlations, collector efficiency and heat removal factors, effects of various parameters, types of other liquid flat-plate collectors, transient analysis.

SOLAR AIR HEATERS: Type of air heaters, performance analysis of a conventional air heater, other types of air heater, Testing procedures.

CONCENTRATING COLLECTORS: Type of concentrating collectors and their general characteristics, geometry, heat transfer correlations, tracking requirements performance analysis

THERMAL ENERGY STORAGE: Basic methods, Sensible heat storage –liquids- solids-analysis, latent heat storage, thermo chemical storage.

SOLAR POND: Basic concept and working, description, performance analysis, transmissivity, temperature distribution and collection efficiency, experimental studies and other aspects.

SOLAR REFRIGERATION: Adsorption and absorption based solar refrigeration technologies

References:

1. Krith F. and Krelder J.F., Principles of Solar Engineering, McGraw hill Book Company, 1978.
2. John A, Duffie, William A. Beckman; Solar Engineering of thermal processes,John Wiley and Sons, 1991.
3. Garg H.P. and Prakash J., Solar energy fundamentals and application, TATA Mc Graw Hill Publishing company limited, New Delhi, 2000.
4. Sukhatme S.P., Solar Energy Principle of thermal collection and storage, TATA McGraw Hill Publishing company limited, New Delhi, 1996.

MET619 - Energy Conservation Technologies

Radiant Heating Equipment: Panel of heaters - steam - water, electrical radiant heaters, tubular radiant heaters, reflectors, heat transfer, comfort conditions, reduction of heat loss, installation.

Prime Movers and Generators: Energy conversion and efficiency, steam turbines, gas turbines, diesel and gas engines, electrical motors and DG-sets. Selection, factors affecting performance, load matching, PF improvement, maintenance practice.

Heat Pumps: General principles, appropriate conditions for using heat pumps, theoretical and practical COP, refrigerants, absorption heat pump, applications of heat pumps; gas driven heat pumps.

Heat Recuperators: Basic concepts, liquid/liquid heat exchangers, liquid/gas and gas/liquid heat exchangers, gas/gas exchangers, heat transfer calculations and area determination.

Heat Regenerators: Thermal wheel - basic principle- construction - flue gas as energy source - preheating combustion air - installation, regenerative heat recovery, double-effect operation and coupling of columns.

Heat Pipes: Basic concepts, design of heat pipes - heat transfer rate - thermodynamic efficiency - influencing factors- wick design - heat recovery from exhaust air, classification of heat pipes, practical applications.

Heating Ventilation and Air Conditioning: Comfortable environment, effective temperature, heating and cooling systems, reheat systems, variable air volume, dual duct system, air water system, design considerations.

Cogeneration: Application for cogeneration, types of cogeneration processes stopping cycle plant-bottoming cycle plant. Choice of configuration, effect of legislation-case studies.

Books:

1. R.M.E. Diamant, Energy Conservation Equipment, The Architectural Press, 1984.

References:

1. S. David Hu, Handbook of Industrial Energy Conservation; Van Nostrand, Reinhold Pub., 1983.
2. S.C. Tripathy, Electrical Energy Utilization and Conservation, Tata McGraw Hill, 1986

MET620 - Advanced Heat Transfer

Review: Review of the basic laws of conduction, radiation, and convection.

Conduction: One dimensional steady state conduction with variables thermal conductivity and with internal distributed heat sources; local heat source in non-adiabatic plate; thermo-couple condition error.

Extended surfaces-review; optimum fin of rectangular profile; straight fins of triangular and fin of rectangular profile; spines; design considerations. Two-dimensional steady state conduction; semi-infinite and finite flat plates; temperature field in finite cylinders and infinite semi-cylinders; spherical shells; graphical method; relaxation technique. Unsteady state conduction; sudden changes in the surface temperatures of infinite plates, cylinders and spheres; solutions using Groeber's and Heisler's charts for plates, cylinders and spheres suddenly immersed in fluids.

Radiation: Review of radiation principles; diffuse surfaces and the Lambert's cosine law. Radiation through non-absorbing media; Hottel's method of successive reflections; Gebhart's unified method; Poljak's method. Radiation through absorbing media; logarithmic decrement of radiation; apparent

absorptivity of simple shaped gas bodies; net heat exchange between surface separated by absorbing medium; radiator of luminous gas flames.

Convection: Heat transfer in laminar flow; free convection between parallel plates; forced internal flow through circular tubes; fully developed flow; velocity and thermal entry lengths; solutions with constant wall temperature and with constant heat flux; forced external flow a flat plate; the two dimensional velocity and temperature boundary layer equations; Karman Pohhousen approximate integral method. Heat transfer in turbulent flow; eddy heat diffusivity; Reynolds' analogy between skin friction and heat transfer; Prandtl- Taylor, von Karman and Martineli's analogies; turbulent flow through circular tubes.

Books:

1. Analysis of Heat and Mass Transfer Eckert and Drakes McGraw Hill
2. Fundamental of Heat Transfer Grober, Erk and Grigull McGraw Hill
3. Conduction Heat Transfer Schneider Addison Wesley
4. Thermal Radiation Siegel and Howell McGraw Hill
5. Heat, Mass and Momentum Transfer Rohsenow and Choi Prentice Hall

HST 609- Technical Writing and Presentation Skills

WRITING SKILLS

Technical Writing-Basic Principles: Words-Phrases-Sentences, Construction of Cohesive Paragraphs, Elements of Style

Principles of Summarizing: Abstract, Summary, Synopsis

Technical Reports: Salient Features, Types of Reports, Structure of Reports, Data Collection, Use of Graphic Aids, Drafting and Writing

PRESENTATION SKILLS

Speaking Skills: Accuracy vs. Fluency, The Audience, Pronunciation Guidelines, Voice Control.

Professional Presentations: Planning, Preparing, Presentation Strategies, Overcoming, Communication Barriers, Using Technology, Effective Presentations.

References:

1. Kumar, Sanjay & Pushp Lata, "Communication Skills", Oxford University Press,2011
2. Quirk & Randolph, "A University Grammar of English", Pearson,2006
3. Rutherford, Andrea J., "Basic Communication Skills for Technology", Pearson 2007
4. Rizvi, M Ashraf, "Effective Technical Communication", McGraw Hill,2009
5. Leigh, Andrew & Maynard, Michael, "The Perfect Presentation", Random House
6. Barker, Larry L., "Communication", Prentice-Hall
7. Lesikar & Flatley, "Basic Business Communication-Skills for Empowering the Internet Generation", Tata McGraw-Hill.