ACADEMIC REGULATIONS
COURSE STRUCTURE AND
DETAILED SYLLABUS

MECHANICAL ENGINEERING

For

M. Tech. (Thermal Engineering)
(Two Years **Full Time** Programme)

JNTUH COLLEGE OF ENGINEERING HYDERABAD
(Autonomous)
Kukatpally, Hyderabad – 500 085, Telangana, India.

2018

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
DEPARTMENT OF MECHANICAL ENGINEERING
M. Tech. (Thermal Engineering)
2018-19 Admitted Batch

I – SEMESTER						
S. No	Course Type/ Code	Course Name	Teaching Scheme L	T	P	Credits
1.	Core –1	Advanced Heat and Mass Transfer	3	1	0	4
2.	Core- 2	Advanced IC Engines	3	1	0	4
3.	Core -3	Advanced Thermodynamics	3	0	0	3
4.	Programme Elective –I	Finite Element Analysis Renewable Energy Sources Computer Simulations of SI and CI Engines	2	0	0	2
5.	Programme Elective –II	Numerical Methods for Engineers Thermal and Nuclear Power Plant Nano Fluids	2	0	0	2
6.	Core Lab –I	Advanced Thermal Engineering lab	0	0	3	1.5
7.	Core Lab - II	Advanced Heat and Mass Transfer Lab	0	0	3	1.5
8.	Audit Course-I	English for Research Paper Writing	2	0	0	0
Total Credits						**18**

Semester – II						
S. No	Course Type/ Code	Course Name	Teaching Scheme			Credits
			L	T	P	
1.	Core –4	Advanced Refrigeration & Air Conditioning	3	0	0	3
2.	Core- 5	Advanced Fluid Mechanics	3	0	0	3
3.	Core -6	Fuels and Combustion	3	0	0	3
4.	Programme Elective –III	Energy Conservation and Management Jet Propulsion and Rocket Engineering Turbulence Modeling	2	0	0	2
5.	Programme Elective –IV	Optimization Techniques and Applications Alternate Fuels and Pollutions Computational Fluid Dynamics	2	0	0	2
6.	Core Lab –III	Computational Methods Lab	0	0	3	1.5
7.	Core Lab - IV	Advanced Refrigeration and Air Conditioning Lab	0	0	3	1.5
8.	Audit Course-II	Value Education	2	0	0	0
9.		Mini Project with Seminar	0	0	4	2
Total Credits						**18**

III – SEMESTER						
S. No	Course Type/ Code	Course Name	Teaching Scheme			Credits
			L	T	P	
1.	Programme Elective –V	Equipment Design for Thermal Systems Thermal Measurement and Process Control Advanced Materials for Thermal Systems.	2	0	0	2
2.	Open Elective	Microprocessors in Automation Composite Materials Waste to Energy	2	0	0	2
3.		Seminar	0	0	4	2
4.	Dissertation	Dissertation Phase - I	0	0	20	10
Total Credits						**16**

IV – SEMESTER						
S. No	Course Type/ Code	Course Name	Teaching Scheme			Credits
			L	T	P	
1.	Dissertation	Dissertation Phase - II	0	0	32	16
Total Credits						**16**

ADVANCED HEAT AND MASS TRANSFER
(CORE-1)

M.Tech. (TE) (FT) – I Sem

L	T	P	C
3	1	0	4

Pre-requisite: Thermodynamics

Course Objective: To apply the principles of heat transfer in the design of thermal systems

Course Outcomes: At the end of the course, the student should be able to
- Mathematically model heat and mass transfer and fluid flow problems and to be able to apply different boundary conditions
- Solve the simple heat and mass transfer and fluid flow problems using analytical methods and appreciate the need of numerical methods to solve complicated problems
- Apply semi empirical formulae to determine the heat transfer parameters and use different techniques, viz., experimental, analytical and semi empirical methods to design the thermal systems.

UNIT-I:
Introduction to Different Modes of Heat Transfer: Governing Laws and mathematical models -Initial and boundary conditions.
Heat Conduction – Development of Governing equation for 1D, 2D and 3D; steady and transient heat conduction – Solution of 1D steady state heat conduction – Composite Systems – Systems with heat generation – Variable thermal conductivity – Fins
2D Steady State Heat conduction – Use of conduction shape factors – Use of analytical method for temperature distribution in a slab for simple boundary conditions

UNIT-II:
Transient heat conduction: Lumped system analysis-Infinite Bodies - Heisler charts-semi infinite solid -2D transient heat conduction using product solutions.
Forced Convection: Equations of fluid flow-concepts of continuity, momentum equations-derivation of energy equation-methods to determine heat transfer coefficient: Analytical methods-dimensional analysis and concept of exact solution. Approximate method-integral analysis – Von Karman Integral Momentum and Energy Equations – Determination of laminar heat transfer coefficient for different velocity and temperature profiles for flow over a flat plate

UNIT-III:
External flows: Flow over a flat plate: Application of empirical relations to various geometries for laminar and turbulent flows.
Internal flows: Flow Classification based on hydrodynamic &thermal entry lengths- Fully developed flow: integral analysis for laminar heat transfer coefficient-constant wall temperature and constant heat flux boundary conditions-; use of empirical correlations for determination of heat transfer coefficient and friction factor for different types of internal flow applications.

UNIT-IV:
FREE CONVECTION: Approximate analysis on laminar free convective heat transfer-Boussinesque approximation-different geometries-combined free and forced convection.
Boiling and condensation: Boiling curve-correlations-Nusselt's theory of film condensation on a vertical plate-assumptions & correlations of film condensation for different geometries.

UNIT-V:
RADIATION HEAT TRANSFER: Radiant heat exchange in grey, non-grey bodies, with transmitting. Reflecting and absorbing media, specular surfaces, gas radiation-radiation from flames.
Mass Transfer: Concepts of mass transfer-diffusion & convective mass transfer analogies-significance of non-dimensional numbers.
Recent Advances in Heat and Mass Transfer Applications.

Text Books:

1. Fundamentals of Heat Transfer by Incropera & Dewitt, John wiley
2. Heat Transfer by Necati Ozisik, TMH
3. Heat Transfer by P.S.Ghoshtastidar, Oxford Press

Reference Books:

1. Heat Transfer by Gregory Nellis & Sanford Klein, Cambridge University Press
2. Principals of Heat Transfer by Frank Kreith, Cengage Learning
3. Introduction to Heat Transfer by SK Som, PHI
4. Heat Transfer by Nellis & Klein, Cambridge University Press, 2012.
5. Engineering Heat & Mass Transfer by Sarit K. Das, Dhanpat Rai
6. Heat Transfer by P.K.Nag, TMH

ADVANCED I.C. ENGINES
(Core -2)

M.Tech. (TE) (FT) – I Sem

L	T	P	C
3	1	0	4

Prerequisites: Thermodynamics, Thermal Engineering I & II

Course objectives:
The course is intended to
- Analyze engine cycles and the factors responsible for making the cycle different from the Ideal cycle.
- Apply principles of thermodynamics, fluid mechanics, and heat transfer to influence the engine's performance
- Understand the delay period and fuel injection system
- Become aware of the relevance of environmental and social issues on the design process of internal combustion engines

Course Outcomes:
At the end of the course, the student will be able to:
- Apply thermodynamic analysis to IC engines and describe combustion phenomena in spark ignition and compression ignition engines.
- Describe the working of major systems used in conventional and modern engines.
- Summarize the methods used to improve engine performance and estimate performance parameters.
- Describe engine emission control techniques and implement viable alternate fuels.

UNIT-I:
Introduction – Historical Review – Engine Types – Design and operating Parameters.
Cycle Analysis: Thermo-chemistry of Fuel – Air mixtures, properties – Ideal Models of Engine cycles – Real Engine cycles - differences and Factors responsible for – Computer Modeling.

UNIT- II:
GAS EXCHANGE PROCESSES: Volumetric Efficiency – Flow through ports – Supercharging and Turbo charging.
Charge Motion: Mean velocity and Turbulent characteristics – Swirl, Squish – Pre-chamber Engine flows.

UNIT- III:
ENGINE COMBUSTION IN S.I ENGINES: Combustion and Speed – Cyclic Variations – Ignition – Abnormal combustion Fuel factors, MPFI, SI engine testing.
COMBUSTION IN CI ENGINES: Essential Features – Types off Cycle. Pr. Data – Fuel Spray Behavior – Ignition Delay – Mixing Formation and control, Common rail fuel injection system.

UNIT- IV:
POLLUTANT FORMATION AND CONTROL: Nature and extent of problems – Nitrogen Oxides, Carbon monoxide, unburnt Hydrocarbon and particulate – Emissions – Measurement – Exhaust Gas Treatment, Catalytic converter, SCR, Particulate Traps, Lean, NOx, Catalysts.

UNIT- V:
ENGINE HEAT TRANSFER: Importance of heat transfer, heat transfer and engine energy balance, Convective heat transfer, radiation heat transfer, Engine operating characteristics.
Fuel supply systems for S.I. and C.I engines to use gaseous fuels like LPG, CNG and Hydrogen.
Modern Trends in IC Engines: Lean Burning and Adiabatic concepts, Rotary Engines, Modification in I.C engines to suit Bio – fuels, HCCI and GDI concepts.

Text Books:
1. I.C. Engines by V.Ganesan, TMH
2. I.C. Engines Fundamentals by Heywood, TMH

Reference Books:
1. I.C. Engines by G.K. Pathak & DK Chevan, Standard Publications
2. Dual-Fuel Diesel Engines by Ghazi A. Karim, CRC Press
3. I.C. Engines by RK Rajput, Laxmi Publications
4. Internal Combustion Engines by S.S. Thipse, Jaico
5. Computer Simulation of C.I. Engine Process by V. Ganesan, University Press
6. Fundamentals of IC Engines by HN Gupta, PHI, 2nd edition
7. I.C. Engines by Fergnson, Wiley.
8. The I.C. Engine in theory and Practice Vol. I /Teylor /IT Prof. And Vol. II
9. Computer Simulation of Spark-Ignition Engine Processes by V. Ganesan, Universities Press.

ADVANCED THERMODYNAMICS
(Core-3)

M.Tech. (TE) (FT)–I Sem

L	T	P	C
3	0	0	3

Prerequisites: Thermodynamics

Course Objectives:
The course is intended to
- Provide analytical methods for the determination of the direction of processes from the first and second laws of thermodynamics and to Introduce methods in using equations of potentials, availability, and excergy for thermodynamic analysis
- Gain the knowledge on non-reactive mixture properties , Psychometric Mixture properties and psychometric chart and Air conditioning processes
- Develop the ability of analyzing vapor and Gas power cycles
- Provide in depth knowledge of Direct Energy Conversion of Fuel Cells , Thermo electric energy ,Thermionic power generation ,Thermodynamic devices Magneto Hydrodynamic Generations and Photo voltaic cells
- Develop communication and teamwork skills in the collaborative course project

Course Outcomes:
At the end of the course, the student will be able to:
- Explain basic thermodynamic concepts and laws
- Describe the concepts entropy and excergy and their use in analyses of thermal energy systems
- Analyze power plants, refrigeration plants and thermal/chemical installations
- Evaluate means for minimizing excergy losses in selected processes
- Use advanced thermodynamics on a research case

UNIT -I:
REVIEW OF THERMODYNAMIC LAWS AND COROLLARIES: Transient flow analysis, Second law thermodynamics, Entropy, Availability and unavailability, Thermodynamic potential. Maxwell relations, Specific heat relations, Mayer's relation. Evaluation of thermodynamic properties of working substance

UNIT-II:
P.V.T SURFACE: Equation of state. Real gas behavior, Vander Waal's equation, Generalization compressibility factor. Energy properties of real gases. Vapour pressure, Clausius, Clapeyro equation. Throttling, Joule. Thompson coefficient. Non reactive mixtures of perfect gases. Governing laws, Evaluation of properties, Psychometric mixture properties and psychometric chart, Air conditioning processes, cooling towers. Real gas mixture.

UNIT-III:
COMBUSTION: Combustion Reactions, Enthalpy of formation. Entropy of formation, Reference levels of tables. Energy of formation, Heat reaction, Adiabatic flame temperature generated product, Enthalpies, Equilibrium. Chemical equilibrium of ideal gases, Effect of non reacting gases equilibrium in multiple reactions, The Vent Hoff's equation. The chemical potential and phase equilibrium. The Gibbs phase rule.

UNIT-IV:
POWER CYCLES: Review binary vapour cycle, co generation and combined cycles, Second law analysts of cycles. Refrigeration cycles. Thermodynamics off irreversible processes. Introduction, Phenomenological laws, Onsager Reciprocity relation, Applicability of the Phenomenological relations, Heat flux and entropy production, Thermodynamic phenomena, Thermo electric circuits.

UNIT-V:

DIRECT ENERGY CONVERSION INTRODUCTION: Fuel cells, Thermo electric energy, Thermo ionic power generation, Thermodynamic devices magneto hydrodynamic generations, Photovoltaic cells.

Text Books:

1. Basic and Applied Thermodynamics by P.K. Nag, TMH
2. Engineering Thermodynamics by Rogers & Mayhew, Pearson
3. Thermodynamics by Holman, Mc Graw Hill.

Reference Books:

1. Thermal Engineering by Rathore, TMH
2. Applied Thermodynamics by R.K. Rajput, Laxmi Publications
3. Thermal Engineering by Soman, PHI
4. Engineering Thermodynamics by P.L.Dhar, Elsevier
5. Thermodynamics by Sonnatag & Van Wylen, John Wiley & Sons
6. Thermodynamics for Engineers by Doolittle-Messe, John Wiley & Sons
7. Irreversible Thermodynamics by HR De Groff.
8. Thermodynamics & Heat Power by Granet & Bluestein, CRC Press
9. Engineering Thermodynamics by Chatopadyaya

FINITE ELEMENT ANALYSIS
(Programme Elective -I)

M.Tech. (TE) (FT) – I Sem

L	T	P	C
2	0	0	2

Prerequisites: Finite Element Methods, Heat Transfer, Mechanical Vibrations

Course Objectives:
The course is intended to
- Gain a fundamental understanding of the finite element method for solving 1-D structural problem.
- Formulate the finite element equations for truss and beam elements.
- Study two-dimensional problems such as plain stress and plain strain elasticity problems.
- Learn finite element analysis of 1-D and 2-D heat conduction and torsion problem Analysis the structures by considering the mechanical vibrations.

Course Outcomes:
At the end of the course, the student will be able to:
- Establish the mathematical models for the complex analysis problems and predict the nature of solution
- Formulate element characteristic matrices and vectors.
- Identify the boundary conditions and their incorporation in to the FE equations
- Solve the problems with simple geometries, with hand calculations involving the fundamental concepts
- Interpret the analysis results for the improvement or modification of the system.

UNIT-I:
Introduction to FEM, basic concepts, applications of FEM, general procedure, comparison of FEM with other methods, variational approach, Co-ordinates, basic element shapes, interpolation function, Virtual energy principle, properties of stiffness matrix, treatment of boundary conditions, solution of system of equations 1-D structural axial bar element – load vector-temperature effects and shape functions and characteristics, Basic equations of elasticity, strain-displacement relations, quadratic shape functions.

UNIT-II:
ANALYSIS OF TRUSSES: Plane Trusses and Space Truss elements and problems
ANALYSIS OF BEAMS: Hermite shape functions – stiffness matrix – Load vector – Problems.

UNIT-III:
2-D PROBLEMS: CST, force terms, Stiffness matrix and load vectors, boundary conditions, Isoparametric elements – quadrilateral element, shape functions – Numerical Integration. Finite element modeling of Axi-symmetric solids subjected to Axi-symmetric loading with triangular elements.
3-D PROBLEMS: Tetrahedran element – Jacobian matrix – Stiffness matrix.

UNIT-IV:
SCALAR FIELD PROBLEMS: 1-D Heat conduction formulations -Slabs – fins - 2-D heat conduction problems

UNIT-V:
Dynamic considerations, Dynamic equations – consistent mass matrix for bar triangular elements – Eigen Values, Eigen vector, natural frequencies – mode shapes – modal analysis.

Text Books:
1. The Finite Element Methods in Engineering by SS Rao, Pergamon.
2. Introduction to Finite Elements in Engineering by Chandrupatla, Ashok and Belegundu, Prentice, Hall.

Reference Books:

1. Finite Element Methods: Basic Concepts and applications by Alavala, PHI
2. Applied Finite Element Analysis by Segerlind – Wiley India
3. Finite Element Modeling and Simulation with ANSYS Workbench by Chen & Lui, CRC
4. Finite Element Method by Zincowitz, Mc Graw Hill
5. Introduction to Fininte element analysis by S.Md.Jalaludeen, Anuradha Publications, print 2012
6. A First Course in the Finite Element Method by Daryl L Logan, Cengage Learning, 5th Edition
7. Finite Element Analysis – Theory & Programming by Krishna Moorthy, McGraw Hill
8. Finite Element Analysis by Bathe, PHI
9. Finite Element Method by Dhanraj & Nair, Oxford

RENEWABLE ENERGY SOURCES
(Programme Elective-I)

M.Tech. (TE) (FT)–I Sem

L	T	P	C
2	0	0	2

Prerequisites: Basics concepts of solar, wind, hydro, biomass, fuel cells and geothermal systems.

Course Objectives:
The course is intended to
- introduce to the technology of renewable sources of energy
- learn about the solar radiation, its applications and radiation measuring instruments
- learn about the various types of geothermal resources and its applications
- study the biomass energy resources , bio-mass systems
- learn the methods of energy extraction from the wind and oceans
- learn to the technology of direct energy conversion methods

Course Outcomes:
At the end of the course, the student will be able to:
- Identify the renewable energy sources and their utilization
- Understand the basic concepts of the solar radiation and analyze the solar Thermal systems for their utilization
- Understand the principle of working of solar cells and their modern
- manufacturing techniques
- Understand the concepts of the ocean thermal energy conversion systems and their applications
- Outline the methods of energy storage and identify the appropriate methods of energy storage for specific applications
- Understand the energy conversion from wind energy, geothermal energy, biomass, biogas, fuel cells and hydrogen

UNIT-I:
Introduction: Overview of the course, Examination and Evaluation patterns. Classification of energy resources, energy scenario in the world and India
Basic sun-earth relationships: Definitions. Celestial sphere, altitude-azimuth, declination-hour angle and declination-right ascension coordinate systems for finding the position of the sun, celestial triangle and coordinates of the sun. Greenwich Mean Time, Indian Standard Time, Local Solar Time, sun rise and sun set times & day length. Numerical problems
Solar radiation: Nature of solar radiation, solar radiation spectrum, solar constant, extra-terrestrial radiation on a horizontal surface, attenuation of solar radiation, beam, diffuse and global radiation. Measurement of global, diffuse and beam radiation. Prediction of solar radiation; Angstrom model, Page model, Hottel's model, Liu and Jordan model etc. Insolation on an inclined surface, angle of incidence, Illustrative problems

UNIT-II:
Solar thermal systems: Principle of working of solar water heating systems, solar cookers, solar desalination systems, solar ponds, solar chimney power plant, central power tower power plants etc.
Solar concentrating collectors: Classification of solar concentrators, Basic definitions such as concentration ratio, angle of acceptance etc., Tracking of the sun; description of different tracking modes of a solar collectors and the determination of angle of incidence of insolation in different tracking modes. Illustrative problems

Photovoltaic energy conversion: Introduction. Single crystal silicon solar cell, i-v characteristics, effect of insolation and temperature on the performance of silicon cells. Different types of solar cells. Modern technological methods of producing these cells. Indian and world photovoltaic energy scenario.

UNIT-III:

Energy storage: Necessity for energy storage. Classification of methods of energy storage. Thermal energy storage; sensible heat storage, latent heat storage. Reversible chemical reaction storage. Electromagnetic energy storage. Hydrogen energy storage. Chemical battery storage. Pumped hydel energy storage etc.

Wind energy: Origin of winds, nature of winds, wind data measurement, wind turbine types and their construction, wind-diesel hybrid system, environmental aspects, wind energy programme in India and the world.

UNIT-IV:

Ocean energy: Ocean thermal energy; open cycle & closed cycle OTEC plants, environmental impacts, challenges, present status of OTEC systems. Ocean tidal energy; single basin and double basin plants, their relative merits. Ocean wave energy; basics of ocean waves, different wave energy conversion devices, relative merits

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.

UNIT-V:

Biomass: Introduction, photosynthesis, biofuels, biomass resources, biomass conversion technologies, urban waste to energy conversion, biomass to ethanol conversion, biomass energy scenario in India.

Biogas: Biogas production, constant pressure and constant volume biogas plants, operational parameters of the biogas plant

Geothermal energy: Origin, applications, types of geothermal resources, relative merits

Text Books:

1. Non conventional Energy Resources by B.H.Khan, Tata McGraw Hill, New Delhi, 2012.
2. Energy Technology: Non-Conventional, Renewable and Conventional by S.Rao and B.B.Parulekar, Khanna Publishers, 2010.

Reference Books:

1. Solar Energy-Principles of Thermal Collection and Storage by S.P.Sukhatme and J.K.Nayak, TMH, 2008.
2. Solar Energy Thermal Processes by J.A.Duffie and W.A.Beckman, John Wiley, 2010

COMPUTER SIMULATION OF SI AND CI ENGINES
(Programme Elective-I)

M.Tech. (TE) (FT) – I Sem

L	T	P	C
2	0	0	2

Prerequisites: Advanced I.C Engines

Course Objective:
The course is intended to
- Understand the C/H/N/O system, flame temperature, the different types of reaction occurring in an engine, while combustion.
- Understand the simulation in an SI engine with fuel air as working medium.
- Know about how the pressure is being getting developed in an engine.
- Understand the simulation of a 2-stroke engine.
- Understand the simulation in an CI engine with fuel air as working medium

Course Outcomes:
At the end of the course, the student will be able to:
- To impart knowledge on simulation of various engine processes used in prime movers and power plants
- To learn the simulation of engine combustion based on first and second law of thermodynamics.

UNIT-I:
Computer Simulation and Thermodynamics of Combustion:
Introduction, Heat of reaction, complete combustion in C/H/O/N Systems, Constant volume adiabatic combustion, constant pressure adiabatic combustion. Calculation of adiabatic flame temperature.

UNIT-II:
SI Engine Simulation With Fuel-Air as Working Medium: Deviation between actual and air standard cycles of operation- problems, SI engine simulation with adiabatic constant volume combustion with fuel and air being considered, calculation of temperature drop due to fuel vaporization, calculation of mean effective pressure, torque and thermal efficiency at full throttle, part throttle and supercharged conditions.

UNIT-III:
Actual Cycle Simulation in SI Engines: Progressive combustion; gas exchange process, heat transfer process, friction. Procedure of validating computer code with experimental data based on performance parameters and pressure crank angle diagram.

UNIT-IV:
Simulation of 2-Stroke SI Engine: Simulation of the process, determination of the pressure-crank angle variation, computation of performance parameters.

UNIT-V:
Diesel Engine Simulation: Main difference between SI and CI engine simulation, differences between ideal and actual cycles, mathematical combustion model for diesel engine, heat transfer and gas exchange processes.

Text Books:
1. Computer Simulation of Spark Ignition Engine Process by Ganesan, V, Universities Press (I) Ltd, Hyderabad - 1996.
2. Computer Simulation of Compression Ignition Engine Process by Ganesan. V, Universities Press (I) Ltd, Hyderabad - 2000.

Reference Books:

1. Thermodynamic Analysis of Combustion Engine by Ashley Campbel, John Wiley and Sons, New York - 1986.
2. Internal Combustion Engines by Benson.R.S & Whitehouse. N.D., Pergamon Press, Oxford - 1979.
3. Modelling of Internal Combusion Engines Processes by Ramoss.A.L - McGraw-Hill Publishing Co., -1992.

NUMERICAL METHODS FOR ENGINEERS
(Programme Elective -II)

M.Tech. (TE) (FT)–I Sem

L	T	P	C
2	0	0	2

Pre-requisites: Mathematics, Differential Equations, Linear Algebra

Course Objectives:
- To solve mathematical and engineering problems by numerical methods
- To improve students programming skills in solving engineering problems by numerical methods

Course Outcomes: Students will understand basics of numerical analysis. Students will be able to find roots of polynomial equations using numerical analysis and solutions of ordinary differential equations including initial value problems, Boundary value problems and Numerical differentiation of data and functions. Students will be able to conduct numerical integration and differentiation and will be able to use numerical methods to solve engineering problems.

UNIT–I:
Solution of Linear Algebraic Equations: Gaussian elimination - LU decomposition - Pivoting strategies - Operation Count - Matrix inversion- Special cases -Tridiagonal and block tridiagonal systems - Well conditioned and Ill conditioned system-Matrix and Vector norms Condition Number and its implications.

UNIT-II:
Solution of Non-linear Algebraic Equations: Bisection - Newton-Raphson and Secant method. **System of non-linear equations:** Basics of finite difference method Discretization of spatial and time derivatives using Taylor's series- Truncation error and order of discretization - Fourier (von Neumann) stability analysis.

UNIT-III:
Solution of Ordinary Differential Equations: Initial Value problems-Euler explicit and implicit methods - Runge-Kutta method – Predictor - Corrector methods - Boundary value problem - Shooting method - Finite difference method applied to pin fin heat dissipation - Stiff problems - Meaning of stiffness - Further insights into stiffness by the application of Euler explicit and implicit method to a stiff problem - Solution of stiff problem - Example – Chemical kinetics.

UNIT-IV:
Solution of Elliptic Partial Differential Equations: Physical problems governed by elliptic PDE's - Five-point and nine-point Discretization of Poisson's equation - Iterative methods - Point Iterative methods – Jacobi, Gauss-Seidel, and SOR - Detailed theory of the convergence of iterative methods - Global Iterative methods – Steepest Descent and Conjugate Gradient.

UNIT-V:
Classification of PDEs and characteristics of a PDE - **Solution of Parabolic Partial Differential Equations:** Physical problems governed by parabolic PDE's Operator splitting and ADI methods.

Text Books:
1. Numerical Mathematics and Computing, by Ward Cheney and David Kincaid, International Thomson Publishing Company
2. Applied Numerical Analysis, by Curtis Gerald and Patrick Wheatley, Addison-Wesley

Reference Books:

1. Analysis of Numerical Methods, by E. Isaacson & H. B. Keller, John Wiley & Sons
2. Numerical Solution of Partial Differential Equations : Finite Difference Methods, by G. D. Smith, Oxford University Press, 1985
3. Matrix Computations, by G. H. Golub, Johns Hopkins University Press Numerical Recipes, by W. H. Press et al

THERMAL AND NUCLEAR POWER PLANT
(Programme Elective-II)

M.Tech. (TE) (FT)–I Sem

L	T	P	C
2	0	0	2

Prerequisites: Basic Heat Transfer, Fluid Mechanics

Course Objective:
The course is intended to
- Provide in awareness about resources of energies available in India for Power Production by Thermal and Nuclear Processes.
- Understand and know the requirements for a Thermal Power Plant and Nuclear Power Plant, from sources to consumption and economics of power plants.
- Study and learn the processes and cycles followed in Thermal Power Plants and nuclear power plants and components used in the power plants
- Gain the knowledge on steam power plants, steam generators and gas turbine power plants, their analyses on fuel and fluidized bed combustion, ash handling systems,
- Learn the practices followed in Thermal Power Plant and Nuclear Power Plants, to better environmental conditions and the safety measures.
- Gain the knowledge on Power Load calculation, distribution and optimum loading. Etc.,
- Know various methods for the Economies of Power Generation and power plant instrumentation.

Course Outcomes:
At the end of the course, the student will be able to:
- Describe how fission is accomplished and the basics of how a nuclear reactor produces energy
- Discuss the thermal cycle and describe heat transfer and fluid flow
- Identify the major components of a nuclear power plant including generators, turbines, and cooling systems
- Examine nuclear power plant safety systems and the concepts of redundancy and defense-in-depth
- Describe the requirements associated with a refuel outage and nuclear fuel reload

UNIT–I:
INTRODUCTION: Sources of energy, Type of Power plants. Direct energy conversion system, Energy sources in India, Recent developments in power generation, Combustion of coal, Volumetric analysis, Gravimetric analysis. Fuel gas analysis.
Steam power plant: Introduction. General layout of steam power plant, Modern coal. Fired Steam, Steam power plant. Power plant cycle, Fuel Handling, Combustion equipment, Ash handling, Dust collectors.
Steam Generators: Types, Accessories. Feed water heaters, Performance of boiling, Water treatment, Cooling towers. Steam turbines. Compounding of turbines, Steam condensers, Jet and surface condensers.

UNIT-II:
GAS TURBINE POWER PLANT: Cogeneration. Combined cycle power plant, Analysis, Waste heat recovery, IGCC power plant, Fluidized bed, Combustion, Advantages, Disadvantages

UNIT-III:
NUCLEAR POWER PLANT: Nuclear physics, Nuclear Reactor, Classification, Types of reactors, Site selection. Method of enriching uranium. Application of nuclear power plant. Nuclear Power Plant Safety: Bi-Product of nuclear power generation, Economics of nuclear power plant, Nuclear power plant in India, Future of nuclear power.

UNIT-IV:

ECONOMICS OF POWER GENERATION: Factors affecting the economics, Loading factors, Utilization factor, Performance and operating characteristics of power plant, Point economic load sharing, Depreciation. Energy rate, Criteria for optimum loading. Specific economic energy problem

UNIT-V:

POWER PLANT INSTRUMENTATIONS: Classification, Pressure measuring instrument, Temperature measurement and Flow Measurement, Analysis of combustion gases, Pollution types, Methods of control.

Text Books:
1. Power Plant Engineering by P.K.Nag, TMH
2. Power Plant Engineering by R.K.Rajput, Lakshmi Publications.

Reference Books:
1. Power Plant Engineering by P.C.Sharma, Kotearia Publications.
2. Power Plant Technology by Wakil, McGraw Hill

NANO FLUIDS
(Programme Elective-II)

M.Tech. (TE) (FT) – I Sem

L	T	P	C
2	0	0	2

Prerequisites: Fluid Mechanics, Thermodynamics

Course Objectives:
The course is intended to
- Understanding of superior thermo physical properties of nanofluids
- Understanding of synthesis of nanofluids
- Comparison of heat transfer using nanofluids with conventional fluids
- Understanding of convection and boiling heat transfer
- Research on this new topic to design modern mini and micro channel heat exchangers with nanofluids exhibiting much higher thermal efficiency and saving energy

Course Outcomes:
At the end of the course, the student will be able to:
- To introduce the application of nanotechnology in the area of fluids and thermal engineering

UNIT-I:
Introduction to nanofluids, nanostructure materials, base fluids, dispersion, sonication and stable suspension. Various types of nanofluids-volumetric concentration. Thermophysical properties: Density; principles of measurement and apparatus. Theoretical equations and new empirical correlations to determine the density of different nanofluids. Viscosity: principles of measurement and apparatus. Andrade's and other theoretical equations and new empirical correlations to determine the viscosity of different nanofluids. Effect of volumetric concentration and temperature. Effect of subzero temperature on nanofluid viscosity.

UNIT-II:
Thermal conductivity: principles of measurement and apparatus. Hamilton-Crosser and other theoretical equations and new empirical correlations to determine the thermalconductivity of different nanofluids. Effect of volumetric concentration and temperature. Effect of Brownian motion on enhancing the thermal conductivity. Specific heat: principles of measurement and apparatus. Buongeorno's thermal equilibrium equation and other theoretical equationsand new empirical correlations to determine the specific heat of different nanofluids. Effect of volumetric concentration and temperature.

UNIT-III:
Combined effects of thermophysical properties of nanofluids on the thermal diffusivity, the Prandtl number, the Reynolds number and the Nusselt number. Basic understanding of their effects on frictional loss and Heat transfer. Convective heat transfer: Single-phase fluid equations, laminar flow, entry length and fully developed friction factor and heat transfer coefficient. Graetz number effect in the entry region. Correlations for friction factor and Nusselt number for nanofluids. Turbulent flow: Single phase fluid fully developed flow Dittus-Boelter and Glienilski equations. Blasius and other turbulent friction factor correlations. Their comparison with nanofluids data. New correlations for turbulent friction factor and Nusselt number for nanofluids.

UNIT-IV:
Principles of measurement and apparatus for the nanofluid convective heat transfer coefficient. Recent empirical relations for convection coefficient of various types of nanofluids. Effect of particle Peclet number. Effect of volumetric concentration. Application of nanofluids to various types of industrial heat exchangers. Heating capacity, mass flow, heat exchanger surface area, LMTD and pumping power for nanofluids versus conventional heat transfer fluids.

UNIT-V:

Application to building heating and cooling Comparison of nano-fluids performance with glycol solution in hydraulic coils. Application to automobile radiators. Comparison of the performance of nanofluids under arctic and sub-arctic temperatures with glycol solutions. Introduction to electronic cooling in micro channels with nano-fluids.

Text Books:

1. Microscale and Nanoscale Heat Transfer by C. Sobhan and G. Peterson, First edition, CRC Press
2. Fluid Mechanics by F. M. White, 5th Edition, McGraw-Hill
3. Heat Transfer by A. Bejan 2nd Edition, John Wiley

Reference Books:

1. Handbook of Nanostructured Materials and Nanotechnology by H.S.Nalwa, I edition, Vol. I and II, American Scientific Publishers
2. Springer Handbook of Nanotechnology by Bharat Bhushan, 1st edition, Springer-Verlag Publication

ADVANCED THERMAL ENGINEERING LAB
(Core Lab –I)

M.Tech. (TE) (FT)–I Sem

L	T	P	C
0	0	3	1.5

Prerequisites: Thermodynamics, Thermal Engineering

Course Objective: To apply the laws of Thermodynamics to analyze thermodynamic systems experimentally and perform parametric analysis

Course Outcomes: At the end of the course, the student should be able to

- Apply the laws of Thermodynamics to analyze thermodynamic systems based on measured properties
- Infer from property charts and tables and to apply the data for the evaluation of performance parameters of thermodynamic systems
- Simulation and Performance Evaluation of Thermal and Fluid Flow Systems

1. Performance test and analysis of exhaust gases of an I.C. Engine.
2. Heat Balance sheet, Volumetric Efficiency and air fuel ratio estimation of an I.C. Engine.
3. Evaluation of Performance Parameters for Axial Fan and Centrifugal Blower
4. Evaluation of Performance of a Nozzle and Determination of Nozzle Pressure Distribution
5. Determination of Performance Evaluation of Impulse and Reaction Turbines
6. Simulation of Flow Network for Basic Pipe Flow and Interconnection of Pipes
7. Simulation of Flow Network and Performance Evaluation of Rankine Cycle with Reheat and Regeneration
8. Simulation of Flow Network and Performance Evaluation of Brayton Cycle with Inter cooling and Reheat
9. Simulation of Flow and Thermal Networks and Performance Evaluation of a Boiler along with Boiler, Economizer, Super heater and Reheater
10. Steady and Transient Simulation of Compressible Flow Network

ADVANCED HEAT AND MASS TRANSFER LAB
(Core Lab –II)

M.Tech. (TE) (FT)–I Sem

L	T	P	C
0	0	3	1.5

Prerequisites: Heat and Mass Transfer

Course Objective: To apply the principles of Heat Transfer to determine various Heat transfer and Fluid Flow Parameters

Course Outcomes: At the end of the course, the student should be able to

- Determine the thermal property of the solids using energy balance and also using unsteady state analysis
- Determine the heat transfer coefficient of air in free and force convective conditions
- Determine the performance of Recuperative Type heat exchangers
- Determine the drag acting on different surfaces and its effects on pumping power
- Determine performance of thermal equipment like Heat Pipe

1. Determination of Thermal Conductivity of a Metal Rod using Searle's Apparatus
2. Determination of thermal Conductivity of a thin disc using Lee's Disc Apparatus
3. Determination of Free Convective Heat Transfer Coefficient of air Using Vertical Rod
4. Determination of Forced Convective Heat Transfer Coefficient of air using Forced Convection Apparatus
5. Determination of Performance of a Heat Pipe
6. Determination of the effectiveness of Parallel and Counter Flow Heat Exchanger
7. Determination of Condensation Heat Transfer Coefficient under Film and Drop wise Condensation Conditions
8. Heat exchanger service module with axillaries Tubular heat exchanger, shell & tube heat exchanger, plate heat exchanger, jacketed vessel with coil and stirrer.
9. Determination of Stefan Boltzmann Constant.
10. Determination of overall heat transfer coefficient using shell & tube heat exchanger.

ENGLISH FOR RESEARCH PAPER WRITING
(Audit Course - I)

M.Tech. (ED) (FT)–I Sem

L	T	P	C
2	0	0	0

Course objectives:
Students will be able to:
1. Understand that how to improve your writing skills and level of readability
2. Learn about what to write in each section
3. Understand the skills needed when writing a Title Ensure the good quality of paper at very first-time submission

Syllabus

Units	CONTENT	Hours
1.	Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness	4
2.	Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticizing, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction	4
3.	Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check.	4
4.	key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature,	4
5.	skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions	4
6.	useful phrases, how to ensure paper is as good as it could possibly be the first- time submission	4

Text Books:

1. Writing for Science, Yale University Press by Goldbort R (2006) (available on Google Books)
2. How to Write and Publish a Scientific Paper, by Day R (2006) Cambridge University Press
3. Handbook of Writing for the Mathematical Sciences, Highman N (1998), SIAM. Highman's book.
4. English for Writing Research Papers, Adrian Wall work, Springer New York Dordrecht Heidelberg London, 2011

ADVANCED REFRIGERATION AND AIR CONDITIONING
(Core-4)

M.Tech. (TE) (FT)–II Sem

L	T	P	C
3	0	0	3

Prerequisites: Thermodynamics

Course Objectives:

- To apply the principles of thermodynamics to analyze different types of refrigeration and air conditioning systems and to understand the functionality of the major components.

COURSE OUTCOMES:

- Differentiate between different types of refrigeration systems with respect to application as well as conventional & unconventional refrigeration systems.
- Thermodynamically analyze refrigeration and air conditioning systems and evaluate performance parameters.
- Apply the principles of psychometrics to design the air conditioning loads for industrial applications.

UNIT–I:

VAPOUR COMPRESSION REFRIGERATION: Performance of Complete vapor compression system. Actual Vs Ideal cycle - Effect of operating parameters on COP, **Components of Vapor Compression System:** The condensing unit – Evaporators – Expansion valve – Refrigerants – Properties – ODP & GWP - Load balancing of vapor compression Unit.

Compound Compression: Flash inter-cooling – flash chamber – Multi-evaporator & Multistage systems.

UNIT–II:

PRODUCTION OF LOW TEMPERATURE: Liquefaction system, Liquefaction of gases, Hydrogen and Helium, Cascade System – Applications– Dry ice system.

Vapor absorption system – Simple and modified aqua – ammonia system – Representation on Enthalpy –Concentration diagram.

Lithium – Bromide system Three fluid system – HCOP.

UNIT–III:

AIR REFRIGERATION: Applications – Air Craft Refrigeration -Simple, Bootstrap, Regenerative and Reduced ambient systems – Problems based on different systems.

Steam Jet refrigeration system: Representation on T-s and h-s diagrams – limitations and applications.

Unconventional Refrigeration system – Thermo-electric – Vortex tube & Pulse tube – working principles.

UNIT–IV:

AIR CONDITIONING: Psychometric properties and processes – Construction of Psychometric chart. Requirements of Comfort Air –conditioning – Thermodynamics of human body – Effective temperature and Comfort chart – Parameters influencing the Effective Temperature. Summer, winter and year round air – conditioning systems. Cooling load Estimation: Occupants, equipments, infiltration, duet heat gain fan load, Fresh air load.

UNIT–V:

AIR CONDITIONING SYSTEMS: All Fresh air, Re-circulated air with and without bypass, with reheat systems – Calculation of Bypass Factor, ADP, RSHF, ESHF and GSHF for different systems. **Components:** Humidification and dehumidification equipment – Systems of Air cleaning – Grills and diffusers – Fans and blowers – Measurement and control of Temperature and Humidity.

Text Books

1. Refrigeration & Air Conditioning by C.P. Arora, TMH
2. Refrigeration & Air Conditioning by Arora & Domkundwar, Dhanpat Rai
3. Refrigeration and Air Conditioning by Manohar Prasad
4. Refrigeration and Air Conditioning by Stoecker, Mc Graw Hill

Reference Books:

1. Basic Refrigeration & Air Conditioning by P.N. Ananthanarayanan, McGraw Hill
2. Refrigeration and Air Conditioning by Dr. S.S. Thipse, Jaico
3. Principles of Refrigeration by Dossat, Pearson
4. Refrigeration and Air Conditioning by Jordan& Preister, Prentice Hall
5. Refrigeration and Air Conditioning by Dossat, Mc Graw Hill

ADVANCED FLUID MECHANICS
(Core- 5)

M.Tech. (TE) (FT) – II Sem

L	T	P	C
3	0	0	3

Prerequisites: Fluid Mechanics & Hydraulic Machinery

Course Objectives:
The course is intended to
- Establish an understanding of the fundamental concepts of fluid mechanics.
- Understand and apply the potential flow equations to basic flows.
- Understand and apply the differential equations of fluid mechanics including the ability to apply and understand the impact of assumptions made in the analysis.
- Understand the boundary layer concepts with respect to fluid flow
- Understand and apply the compressible flow equations.

Course Outcomes:
At the end of the course, the student will be able to:
- Understanding the concept of fluid and the models of fluids
- Understanding the basic physical meaning of general equations
- Understanding the concept of stream function and potential function
- Ability to derive the equation for viscous flow, including laminar flow and turbulent flow
- Ability to address such problems in engineering, and to solve the problems

UNIT-I:
INVISCID FLOW OF INCOMPRESSIBLE FLUIDS: Lagrangian and Eulerain Descriptions of fluid motion- Path lines, Stream lines, Streak lines, stream tubes – velocity of a fluid particle, types of flows, Equations of three dimensional continuity equation- Stream and Velocity potential functions.
Basic Laws of fluid Flow: Condition for irrotationality, circulation & vorticity Accelerations in Cartesian systems normal and tangential accelerations, Euler's, Bernoulli equations in 3D– Continuity and Momentum Equations

UNIT-II:
Viscous Flow: Derivation of Navier-Stoke's Equations for viscous compressible flow – Exact solutions to certain simple cases: Plain Poisoulle flow - Coutte flow with and without pressure gradient - Hagen Poisoulle flow - Approximate solutions – Creeping motion (Stokes) – Oseen's approximation.

UNIT-III:
Boundary Layer Theory: Prandtl's contribution to real fluid flows – Prandtl's boundary layer theory - Boundary layer thickness for flow over a flat plate –- Von-Karman momentum integral equation - Blasius solution- Laminar boundary layer – Turbulent Boundary Layer –- Expressions for local and mean drag coefficients for different velocity profiles. – Total Drag due to Laminar & Turbulent Layers – Problems.

UNIT-IV:
Introduction to Turbulent Flow: Fundamental concept of turbulence – Time Averaged Equations – Boundary Layer Equations - Prandtl Mixing Length Model - Universal Velocity Distribution Law: Van Driest Model –Approximate solutions for drag coefficients – More Refined Turbulence Models – k-epsilon model - boundary layer separation and form drag – Karman Vortex Trail, Boundary layer control, lift on circular cylinders
Internal Flow: Smooth and rough boundaries – Equations for Velocity Distribution and frictional Resistance in smooth rough Pipes – Roughness of Commercial Pipes – Moody's diagram.
UNIT-V:

Compressible Fluid Flow – I: Thermodynamic basics – Equations of continuity, Momentum and Energy - Acoustic Velocity Derivation of Equation for Mach Number – Flow Regimes – Mach Angle – Mach Cone – Stagnation State

Compressible Fluid Flow – II: Area Variation, Property Relationships in terms of Mach number, Nozzles, Diffusers – Fanno and Releigh Lines, Property Relations – Isothermal Flow in Long Ducts – Normal Compressible Shock, Oblique Shock: Expansion and Compressible Shocks – Supersonic Wave Drag.

Text Books:

1. Fluid Mechanics and Fluid Machines by S K Som and G Biswas, TMH
2. Fluid Mechanics **by** Joseph H Spurk and Nuri Aksel, Springer
3. Compressible Fluid Dynamics by B K Hodge and Keith Koenig, Pearson
4. Fluid Mechanics by Potter, Cengage Learning

Reference Books:

1. Fluid Mechanics by Jog, Cambridge
2. Fluid Mechanics and Machinery by Khan, Oxford
3. Fluid Mechanics by Cohen and Kundu, Elsevier, 5th edition
4. Fluid Mechanics by William S Janna, CRC Press
5. Dynamics & Theory and Dynamics of Compressible Fluid Flow by Shapiro.
6. Fluid Dynamics by William F. Hughes & John A. Brighton, TMH

FUELS AND COMBUSTION
(Core -6)

M.Tech. (TE) (FT) – II Sem

L	T	P	C
3	0	0	3

Prerequisites: Thermodynamics, Thermal Engineering I & II

Course Objectives:
The course is intended to make a post graduate students to understand
- The fundamental of combustion phenomena in general
- The different combustion process, its thermodynamics and kinetics
- The combustion mechanism in different types of combustion
- The burner design for efficient combustion
- Different combustion models
- The effect of quantity & quality of fuel and engine technology on exhaust emissions
- The concept of laminar and turbulent flame propagation
- Different methods to reduce air pollution

Course Outcomes:
At the end of the course, the student will be able to**:**
- Understand the concepts of combustion phenomena in energy conversion devices
- Apply the knowledge of adiabatic flame temperature in the design of combustion devices
- Identify the phenomenon of flame stabilization in laminar and turbulent flames
- Analyze the pollution formation mechanisms in combustion of solid, liquid and gaseous fuels

UNIT–I:
FUELS: Detailed classification – Conventional and Unconventional Solid, Liquid, gaseous fuels and nuclear fuels – Origin of Coal – Analysis of coal.
Coal – Carborisation, Gasification and liquification – Lignite: petroleum based fuels – problems associated with very low calorific value gases: Coal Gas – Blast Furnace Gas Alcohols and Biogas.

UNIT–II:
PRINCIPLES OF COMBUSTION: Chemical composition – Flue gas analysis – dew point of products – Combustion stoichiometry.
Chemical kinetics – Rate of reaction – Reaction order – Molecularity – Zeroth, first, second and third order reactions - complex reactions – chain reactions. Theories of reaction Kinetics – General oxidation behavior of HC's.

UNIT–III:
LAMINAR AND TURBULENT FLAMES PROPAGATION AND STRUCTURE: Burning velocity of fuels – Measurement of burning velocity – factors affecting the burning velocity.

UNIT–IV:
Flame Stability, Combustion of fuel, droplets and sprays – Combustion systems – Pulverized fuel furnaces – fixed, Entrained and Fluidised Bed Systems.

UNIT–V:
ENVIRONMENTAL CONSIDERATIONS: Air pollution – Effects on Environment, Human Health etc. Principal pollutants – Legislative Measures – Methods of Emission control.

Text Books:
1. Combustion Fundamentals by Roger A Strehlow, Mc Graw Hill
2. Fuels and combustion by Sharma and Chander Mohan, Tata Mc Graw Hill

Reference Books:

1. Combustion Engineering and Fuel Technology by Shaha A.K., Oxford and IBH.
2. Principles of Combustion by Kanneth K.Kuo, Wiley and Sons.
3. Fuels & Combustion by Sameer Circar, Mc. Graw Hill.
4. An Introduction to Combustion by Stephen R. Turns, Mc. Graw Hill International Edition.
5. Combustion Engineering by Gary L. Berman & Kenneth W. Ragland, Mc. Graw Hill International Edition.

ENERGY CONSERVATION AND MANAGEMENT
(Programme Elective - III)

M.Tech. (TE) (FT) – II Sem

L	T	P	C
2	0	0	2

Prerequisites: Environment Studies, Elements of Mechanical Engineering, Thermodynamics

Course Objectives:
The course is intended to
- Demonstrate the importance and role of energy management in the functional areas like Manufacturing Industry, Process Industry,. Commerce and Government
- To know the different energy resources
- Understand thermodynamic power cycles and the associated processes and fuels
- Understand the economics of energy conversion
- Enable the students to understand the basic energy conversion and management principles and to identify sources of energy loss and target savings
- Enable students in carrying out budgeting and risk analysis
- Analyze the performance of the wind turbine

Course Outcomes:
At the end of the course, the student will be able to:
- Explain the fundamentals of energy management and its influence on environment
- Describe methods of energy production for improved utilization.
- Apply the principles of thermal engineering and energy management to improve the performance of thermal systems.
- Analyze the methods of energy conservation and energy efficiency for buildings, air conditioning, heat recovery and thermal energy storage systems.
- Assess energy projects on the basis of economic and financial criteria.

UNIT-I:
INTRODUCTION: Principles of energy management. Managerial organization, Functional areas for i) manufacturing industry, ii) Process industry, iii) Commerce, iv) Government, Role of Energy manager in each of these organizations. Initiating, Organizing and managing energy management programs

UNIT–II:
ENERGY AUDIT: Definition and concepts. Types of energy audits, Basic energy concepts, Resources for plant energy studies. Data gathering, Analytical techniques. Energy Conservation: Technologies for energy conservation, Design for conservation of energy materials, Energy flow networks. Critical assessment of energy usage. Formulation of objectives and constrains, Synthesis of alternative options and technical analysis of options. Process integration.

UNIT-III:
ECONOMIC ANALYSIS: Scope, Characterization of an investment project. Types of depreciation, Time value of money. Budget considerations, Risk analysis.

UNIT-IV:
METHODS OF EVALUATION OF PROJECTS: Payback, Annualized costs, Investor's rate of return, Present worth, Internal rate of return, Pros and cons of the common method of analysis, Replacement analysis.

UNIT-V:
ALTERNATIVE ENERGY SOURCES: SOLAR ENERGY: Types of devices for solar energy collections, Thermal storage system, Control systems. Wind Energy, Availability, Wind Devices, Wind Characteristics, performance of turbines and systems.

Text Books:
1. Energy Management Hand Book by W.C. Turner (Ed)
2. Energy Management Principles by CB Smith, Pergamon Press

Reference Books:
1. Energy Management by W.R.Murthy and G.Mc.Kay, BS Publication
2. Management by H.Koontz and Cyrill Donnel, McGraw Hill
3. Financial Management by S.C.Kuchhal, Chaitanya Publishing House

JET PROPULSION AND ROCKET ENGINEERING
(Programme Elective-III)

M.Tech. (TE) (FT)–II Sem

L	T	P	C
2	0	0	2

Prerequisites: Thermodynamics & Thermal Engineering

Course Objectives:
- To understand and analyze various components & processes of jet & rocket propulsion systems.

Course Outcomes:
At the end of the course, student should be able to:
- Apply the principles of thermodynamics to analyze the various components of propulsion systems.
- To apply the principles of compressible flow to design nozzles.
- To apply the principles of combustion to analyze combustion chambers.
- To analyze different rocket propulsion systems.

UNIT-I:
TURBO JET PROPULSION SYSTEM: Gas turbine cycle analysis – layout of turbo jet engine. Turbo machinery- compressors and turbines, combustor, blade aerodynamics, engine off design performance analysis.
Flight Performance: Forces acting on vehicle – Basic relations of motion – multi stage vehicles.

UNIT-II:
PRINCIPLES OF JET PROPULSION AND ROCKETRY: Fundamentals of jet propulsion, Rockets and air breathing jet engines – Classification – turbo jet , turbo fan, turbo prop, rocket (Solid and Liquid propellant rockets) and Ramjet engines.
Nozzle Theory and Characteristics Parameters: Theory of one dimensional convergent – divergent nozzles – aerodynamic choking of nozzles and mass flow through a nozzle – nozzle exhaust velocity – thrust, thrust coefficient, A_c / A_t of a nozzle, Supersonic nozzle shape, non-adapted nozzles, summer field criteria, departure from simple analysis – characteristic parameters – 1) characteristic velocity, 2) specific impulse 3) total impulse 4) relationship between the characteristic parameters 5) nozzle efficiency, combustion efficiency and overall efficiency.

UNIT-III:
AERO THERMO CHEMISTRY OF THE COMBUSTION PRODUCTS: Review of properties of mixture of gases – Gibbs – Dalton laws – Equivalent ratio, enthalpy changes in reactions, heat of reaction and heat of formation – calculation of adiabatic flame temperature and specific impulse – frozen and equilibrium flows.
Solid Propulsion System: Solid propellants – classification, homogeneous and heterogeneous propellants, double base propellant compositions and manufacturing methods. Composite propellant oxidizers and binders. Effect of binder on propellant properties. Burning rate and burning rate laws, factors influencing the burning rate, methods of determining burning rates.

UNIT-IV:
Solid propellant rocket engine – internal ballistics, equilibrium motor operation and equilibrium pressure to various parameters. Transient and pseudo equilibrium operation, end burning and burning grains, grain design. Rocket motor hard ware design. Heat transfer considerations in solid rocket motor design. Ignition system, simple pyro devices.

Liquid Rocket Propulsion System: Liquid propellants – classification, Mono and Bi propellants, Cryogenic and storage propellants, ignition delay of hypergolic propellants, physical and chemical characteristics of liquid propellant. Liquid propellant rocket engine – system layout, pump and pressure feed systems, feed system components. Design of combustion chamber, characteristic length, constructional features, and chamber wall stresses. Heat transfer and cooling aspects. Uncooled engines, injectors – various types, injection patterns, injector characteristics, and atomization and drop size distribution, propellant tank design.

UNIT-V:

RAMJET AND INTEGRAL ROCKET RAMJET PROPULSION SYSTEM: Fuel rich solid propellants, gross thrust, gross thrust coefficient, combustion efficiency of ramjet engine, air intakes and their classification – critical, super critical and sub-critical operation of air intakes, engine intake matching, classification and comparison of IIRR propulsion systems.

Text Books

1. Rocket propulsion elements by Sutton, John Wiley & Sons, 8^{th} Edition
2. Gas Turbines by Ganesan, TMH
3. Gas Turbines & Propulsive Systems by Khajuria & Dubey, Dhanpat Rai & Sons

Reference Books:

1. Mechanics and Dynamics of Propulsion by Hill and Peterson, John Wiley & Sons
2. Rocket propulsion by Bevere
3. Jet propulsion by Nicholas Cumpsty
4. Elements of Gas Turbine Propulsion by Jack D. Mattingly, TMH
5. Turbines, Compressors and Fans by S M Yahya, MGH

TURBULENCE MODELLING
(Programme Elective-III)

M.Tech. (TE) (FT)–II Sem

L	T	P	C
2	0	0	2

Prerequisites: Thermodynamics 1 & 2

Course Objectives:
The course is intended to
- Understand the fundamental concepts of turbo machines
- Apply concepts of fluid mechanics in turbo machines.
- Understand the thermodynamic analysis of steam nozzles and turbines.
- Understand the different types of compressors and evaluating their performances in the form of velocity triangles.
- Familiarize the basic concepts of gas dynamics and analyze the performance of axial flow gas turbines

COURSE OUTCOMES: At the end of the course, the student will be able to:
- To design and analyze the performance of Turbo machines for engineering applications
- To understand the energy transfer process in Turbo machines and governing equations of various forms.
- To understand the structural and functional aspects of major components of Turbo machines.
- To design various Turbo machines for power plant and aircraft applications
- Understand the design principles of the turbo machines
- Analyze the turbo machines to improve and optimize their performance

UNIT-I:
INTRODUCTION AND ORIGIN OF TURBULENCE: Properties of laminar flow, Properties of turbulent flow. Boundary Layer: Boundary Layer, Growth rate of Boundary layer for Laminar and Turbulent Flows. Characteristics of Turbulent Flow: The Origin of Turbulence, Nature of Turbulence, Swirling Structure, Mean Motion and Fluctuations, Consequences of Turbulence, Homogeneous Isotropic Turbulence.
CORRELATION FUNCTIONS, KOLMOGOROV HYPOTHESIS AND PROBABILITY DENSITY FUNCTION: Correlation Functions, Ideas about eddy size, Intensity of Turbulence or Degree of Turbulence. Kolmogorov Hypothesis and Energy Cascade: Kolmogorov Universal Law for the Fine Structure, Energy Cascade, Kolmogorov Length Scale, Kolmogorov's First Hypothesis, Kolmogorov's Second Hypothesis. Probability Density Functions and Averaging: Introduction, Probability density function, Averaging used in the analysis of turbulent flows.

UNIT -II:
REYNOLDS AVERAGED NAVIER-STOKES EQUATIONS AND CLASSICAL IDEALIZATION OF TURBULENT FLOWS: Reynolds' Decomposition, Examples of Turbulent Fluctuations, Some Measurements on Fluctuating Components. Measurements on Fluctuating Components: Shear Stress due to the Fluctuations, The boundary layer measurements of Klebanoff. Turbulent Boundary Layer Equations: Turbulent Boundary Layer Equations for a two dimensional flow. Classical Idealization of Turbulent Stresses: Introduction, The Boussines or eddy viscosity model, Eddy viscosity.

UNIT-III:
VORTICITY DYNAMICS: Introduction, Vorticity and the equations of motion, Reynolds stress and vorticity. Vortex Stretching. The Vorticity Equation, Vorticity in Turbulent Flows.
DYNAMICS OF TURBULENT KINETIC ENERGY AND IMPORTANT SCALING RELATIONS: Kinetic Energy of the Mean Flow. Kinetic Energy of Fluctuations. Scaling Relations.

UNIT-IV:

WALL BOUNDED FLOWS AND FREE SHEAR FLOWS: The Law of the Wall for Wall Bounded Flows, The Universal Velocity Profile. Free Shear Flows, Turbulent Jets, Uniform Eddy Viscosity model.

SPECTRAL DYNAMICS: Correlation Functions and Spectra. Correlation Functions and Spectra.

LARGE - EDDY SIMULATION OF TURBULENT FLOWS: RANS Equations and Eddy Viscosity: Introduction Reynolds Averaged Navier-Stokes (RANS) Equations, Eddy Viscosity Models, Zero-Equation Models. One-Equation Model: One-Equation Model, Two-Equation Model. Two Equation Models: k - ω Model, SST (Shear Stress Transport) Turbulence Model. Discussion on Applicability

UNIT-V:

LARGE - EDDY SIMULATION OF TURBULENT FLOWS: Low Reynolds number k - ε model: Special Features of Near Wall Flow, Near Wall Treatment in Transport Equation based Models, Wall Function Approach, Low Reynolds number version of k - ε model: Asymptotic Consistency, Damping Functions. RNG k - ε Model and Kato-Launder Model. The Realizable k - ε Model, Reynolds Stress Models (RSM), Large Eddy Simulation (LES). Mathematical Modeling of Turbulent Flows: The Filtered Navier-Stokes Equations, SubgridScale Closure, Standard Subgrid-Scale Model. Dynamic Model of LES. Direct Numerical Simulation.

Text Books:

1. A First Course in Turbulence by H. Tennekes and J.L. Lumley, 1987, The MIT Press, Cambridge, Massachusetts, and London, England.
2. Fluid Mechanics by P.K. Kundu and I.M. Cohen, 2002, Academic Press (An Imprint of Elsevier Science, USA.

Reference Books:

1. Turbulent Flows by S.B. Pope, 2000, Cambridge University Press, UK.
2. Turbulent Flows: Fundamentals, Experiments and Modeling by G. Biswas and V. Eswaran, 2002, Narosa Publishing House, New Delhi, India.

OPTIMIZATION TECHNIQUES AND APPLICATIONS
(Programme Elective-IV)

M.Tech. (TE) (FT)–II Sem

L	T	P	C
2	0	0	2

Pre-requisites; Operations Research

Course Objectives: The main objectives of the course are:

- Numerical optimization techniques for single variable and multi variable non- linear optimization problems.
- Sensitivity analysis on LPP queuing
- Simulation of annexing problem & inventory problem.
- Geometry cutting plane method & branch bound method for linear IPP.
- Meaning of stochastic programming problem simple problems for finding mean variance of random variables chance constrained algorithm.
- Formulation of GP model and solving it using arithmetic geometric inequality theorem.
- State of art nontraditional optimization technique, namely genetic algorithm simulated annealing & particle swarm optimization.

Course Outcomes: At the end of the course, the student is able to apply appropriate optimization techniques and solve.

- Based on the type of optimization problem like single variable or multivariable,
- Make sensitivity analysis to study effect of changes in parameters of LPP on the optimal solution without reworking.
- Simulate the system to estimate specified performance measures.
- Solve integer programming problem by either geometry cutting plane algorithm or branch band method.
- Apply chance constrained algorithm and solve stochastic linear programme.
- Formulate GP model and solve it.
- Solve given optimization problem by genetic algorithm or simulated annealing or PSO.

UNIT-I:
Single Variable Non-Linear Unconstrained Optimization: Elimination methods: Uni-Model function-its importance, Fibonacci method & Golden section method. Interpolation methods: Quadratic & Cubic interpolation methods.

UNIT-II:
Multi variable non-linear unconstrained optimization: Direct search methods – Univariant method, Pattern search methods – Powell's, Hook -Jeeves, Rosenbrock search methods. Gradient methods: Gradient of function& its importance, Steepest descent method, Conjugate direction methods: Fletcher-Reeves method & variable metric method.

UNIT-III:
Linear Programming – Formulation, Simplex method & Artificial variable optimization techniques: Big M & Two phase methods. Sensitivity analysis: Changes in the objective coefficients, constants& coefficients of the constraints. Addition of variables, constraints.
Simulation – Introduction – Types- steps – applications: inventory & queuing – Advantages and disadvantages

UNIT-IV:
Integer Programming- Introduction – formulation – Geometry cutting plane algorithm – Zero or one algorithm, branch and bound method
Stochastic Programming: Basic concepts of probability theory, random variables- distributions- mean, variance, correlation, co variance, joint probability distribution. Stochastic linear programming: Chance constrained algorithm.

UNIT-V:

Geometric Programming: Posynomials – Arithmetic - Geometric inequality – unconstrained G.P- constrained G.P (≤ type only)

Non Traditional Optimization Algorithms: Genetics Algorithm-Working Principles, Similarities and Differences between Genetic Algorithm & Traditional Methods. Simulated Annealing-Working Principle-Simple Problems. Introduction to Particle Swarm Optimization (PSO) (very brief)

Text Books:

1. Optimization theory & Applications by S.S.Rao, New Age International.
2. Optimization for Engineering Design by Kalyanmoy Deb, PHI

Reference Books:

1. Operations Research by S.D. Sharma
2. Operation Research by H.A.Taha, TMH
3. Optimization in operations research by R.LRardin
4. Optimization Techniques by Benugundu & Chandraputla, Pearson Asia.
5. Optimization Techniques theory and practice by M.C.Joshi & K.M. Moudgalya, Narosa Publications

ALTERNATE FUELS AND POLLUTIONS
(Porgramme Elective-IV)

M.Tech. (TE) (FT)–II Sem

L	T	P	C
2	0	0	2

Prerequisites: Hydrogen and Fuel Cells, Biodiesel - Production and Properties

Course Objectives:
- Gain knowledge of various alternative fuels
- Know about Natural gas, LPG, hydrogen and bio gas.

Course Outcomes:
At the end of the course, the student will be able to:
- Identify the need of alternate fuels and list out some prospective alternate fuels
- Categorize, interpret and understand the essential properties of fuels for petrol and diesel engines
- Infer the storage and dispensing facilities requirements
- Analyze the implement limitations with regard to performance, emission and materials compatibility
- Identify and understand possible harmful emissions and the legislation standards

UNIT-I:
Need for alternate fuel : Availability and properties of alternate fuels, general use of alcohols, LPG, hydrogen, ammonia, CNG and LNG, vegetable oils and biogas, merits and demerits of various alternate fuels, introduction to alternate energy sources. Like EV, hybrid, fuel cell and solar cars.

UNIT-II:
Alcohols: Properties as engine fuel, alcohols and gasoline blends, performance in SI engine, methanol and gasoline blends, combustion characteristics in CI engines, emission characteristics, DME, DEE properties performance analysis, performance in SI & CI Engines.

UNIT-III:
Natural Gas, LPG, Hydrogen and Biogas: Availability of CNG, properties, modification required to use in engines, performance and emission characteristics of CNG using LPG in SI & CI engines, performance and emission of LPG. Hydrogen; storage and handling, performance and safety aspects.

UNIT-IV:
Technical Background of Diesel/Bio-diesel fuels-Oil feed stocks- Transesterification-Bio-diesel production from Vegetable oils and waste cooking oil-High blend levels of bio-diesel-Testing, Bio diesel-Oxidation stability-Performance in Engines, Properties of bio-fuels and their importance in the context of IC Engines. Vegetable Oils: Various vegetable oils for engines, esterification, performance in engines, performance and emission characteristics, bio diesel and its characteristics

UNIT-V:
Electric, Hybrid, Fuel Cell and Solar Cars: Layout of an electric vehicle, advantage and limitations, specifications, system components, electronic control system, high energy and power density batteries, hybrid vehicle, fuel cell vehicles, solar powered vehicles.

Text Books:

1. Alternate Fuels by Dr. S. S. Thipse, Jaico Publications
2. Alternative Fuels Guide BooK by Richard.L & Bechfold, SAE International Warrendale - 1997.

Reference Books:

1. Energy Today & tomorrow by Maheswar Dayal, 1 & B Horishr India-1982.
2. Power Plant Engineering by Nagpal, Khanna Publishers, 1991.
3. Alcohols as motor fuels progress in technology, Series No. 19 - SAE Publication USE - 1980.
4. SAE paper nos. 840367, 841333, 841334, 841156, Transactions, SAE, USA
5. Alternative Fuels Guidebook by Bechtold R.

COMPUTATIONAL FLUID DYNAMICS
(Programme Elective-IV)

M.Tech. (TE) (FT) – II Sem

L	T	P	C
2	0	0	2

Pre-requisite: Heat Transfer, Fluid Mechanics

Course Objective: To apply the principles of Heat Transfer and Fluid Mechanics to solve simple heat transfer and fluid flow problems using different numerical techniques

Course Outcomes: At the end of the course, the student should be able to
- Differentiate between different types of Partial Differential Equations and to be able to apply appropriate numerical techniques
- Solve the simple heat transfer and fluid flow problems using different numerical techniques
- Understand and to appreciate the need for validation of numerical solution

UNIT-I:
Review of Governing Equations in Heat Transfer and Fluid Flow: Conservation Laws – Differential Form of Equations – Characteristics of Governing Equations - Solution Methods : Analytical, Experimental and Numerical Methods – Review of Boundary Conditions
Introduction to Numerical Methods - Brief about Finite Difference, Finite Element and Finite Volume Methods – Solution of Linear Algebraic Equations – Direct and Iterative Approaches
Mathematical Behavior of Partial Differential Equations: Classification of Partial Differential Equations – Illustrations
Finite Difference Method: Taylor's series – Derivation of Finite Difference Formulae for Partial Derivative Terms - FD formulation of 1D Elliptic PDEs - 1D steady state heat transfer problems – Cartesian, cylindrical and spherical co-ordinate systems –- boundary conditions

UNIT-II:
Finite Difference Method : 2D Elliptic PDEs – 2D Steady State Heat Conduction Problems.
Parabolic PDEs - Transient heat conduction – Errors and Stability - Explicit Method – Stability Analysis – Implicit and Crank Nickolson method – 2-D Parabolic PDEs - Finite Difference formulation – ADI Method and explicit Method – Finite Difference Formulation of 1D Hyperbolic PDEs - Wave Equation

UNIT-III:
Finite Volume Method: Formation of Basic rules for Finite Volume approach – General Nodal Equation - Interface Thermal Conductivity -– Treatment of Source Term and Treatment of Nonlinearity.
Solution of 1D and 2D Elliptic PDEs - Heat conduction problems - Solution of 1D Parabolic PDEs – Explicit Method and Implicit Methods- Transient Heat conduction problems

UNIT-IV:
FVM to Convection and Diffusion: General Form of Governing Equations for Fluid Flow and Heat transfer – Burger's equation - Steady 1D Convection Diffusion – Discretization Schemes and their assessment – Treatment of Boundary Conditions

UNIT-V:
Calculation of Flow Field: Vorticity & Stream Function Method – Advantages and Disadvantages – Treatment of Boundary Conditions - Staggered Grid as Remedy for representation of Flow Field - Pressure Velocity Coupling - SIMPLE & SIMPLER (revised algorithm) Algorithms.
Compressible Flows: Introduction - Pressure, Velocity and Density Coupling.

Text Books:
1. Numerical heat transfer and fluid flow – S.V. Patankar (Hemisphere Pub. House)
2. An Introduction to Computational Fluid Dynamics – FVM Method – H.K.Versteeg, W. Malalasekhara (PHI)
3. Computational Fluid Flow and Heat Transfer by Muralidharan & Sundarajan (Narosa Pub)
4. Computational Fluid Dynamics and Heat Transfer by P. S. Ghoshdastidar, Centage Pub

Reference Books:
1. Computational Fluid Dynamics by Hoffman and Chiang, Engg Education System
2. Computational Fluid Dynamics by Anderson, TMH
3. Computational Methods for Fluid Dynamics by Ferziger, Peric, Springer
4. Computational Fluid Dynamics by T.J. Chung, Cambridge University
5. Computational Fluid Dynamics by A Practical Approach – Tu, Yeoh, Liu, Elsevier
6. Text Book of Fluid Dynamics by Frank Chorlton, CBS Publishers

COMPUTATIONAL METHODS LAB
(Core Lab-III)

M.Tech. (TE) (FT)–II Sem

L	T	P	C
0	0	3	1.5

Pre-requisite: Heat Transfer and Fluid Mechanics

Course Objective: To apply the principles of Heat Transfer and Fluid Mechanics to solve simple heat transfer and fluid flow problems using commercial CFD software

Course Outcomes: At the end of the course, the student should be able to

- Solve the simple heat transfer and fluid flow problems
- Understand and to appreciate the need for validation of numerical solution

1. Simulation of Couette flow when the upper plate is moving with a velocity of 40 m/s. Take the distance between the plates as 4 cm. Properties of fluid are; v = 0.000217 m^2/s, ρ= 800 kg/m^3. Make simulations for a pressure gradient of 0-30000 N/m^2/m and 20000 N/m^2/m and report the variation of velocity contours for each case.
2. Simulation of a channel flow (Tube flow) for a tube of diameter, 5 cm and take the fluid as water at 30^{0}C at the entry of the tube of length 0.7 m. A heat flux of 30000 W/m^2 is imposed along the wall. Obtain the contours of velocity and temperature along the length of the tube and also obtain the centre line temperature and velocity of fluid.
3. Simulation of a channel flow (Tube flow) for a tube of diameter, 5 cm and take the fluid as water at 30^{0}C at the entry of the tube of length 0.7 m. A constant wall temperature of 300^{0}C is imposed along the wall. Obtain the contours of velocity and temperature along the length of the tube and also obtain the centre line temperature and velocity of fluid.
4. Unsteady simulation of compressible flow of air through 2D a convergent – divergent nozzle, with inlet and outlet of 0.2 m size and both are joined by a throat section where the flow area is reduced by 10% and is of sinusoidal shape. Air enters the nozzle at a pressure of 0.9 atm and leaves at 0.73 atm. Obtain the contours of velocity, pressure and Mach number.
5. Simulation of flow over a circular cylinder of size 5 cm for different Reynold's number values of air and plotting the contours of velocity and vorticity.
6. Simulation of temperature contours for a square plate of size 0.2 m and subjected to different types of boundary conditions.
7. Simulation of temperature contours for a pin fin subjected to natural and forced convective conditions.
8. Simulation of Natural convection with and without radiation inside an enclosure.
9. Simulation of Lid driven cavity problem.
10. Structural analysis for beams and trusses
    The experiments are to be conducted using ANSYS – CFX or equivalent software

ADVANCED REFRIGERATION AND AIR CONDITIONING LAB
(Core Lab-IV)

M.Tech. (TE) (FT)–II Sem

L	T	P	C
0	0	3	1.5

Pre-requisite: Thermodynamics

Course Objective: To apply the principles of Thermodynamics to analyse different types of refrigeration and air conditioning systems experimentally and evaluate performance parameters under actual conditions in relation to the ideal conditions.

Course Outcomes: At the end of the course, the student should be able to

- Differentiate between different types of refrigeration systems with respect to application as well as conventional and unconventional refrigeration systems
- Thermodynamically analyze refrigeration and air conditioning systems and evaluate performance parameters based on the measured properties by using property charts
- Simulation and Analysis of Refrigeration and Air conditioning systems and Components

1. Determination of performance parameters of Vapor Compression Refrigeration System
2. Experimental Evaluation of performance parameters of Mechanical Heat Pump
3. Determination of performance parameters of using Air conditioning Lab unit
4. Determination of CoP of Vapor Absorption Refrigeration system
5. Determination of CoP of Vortex Tube Refrigerator
6. Determination of Performance Evaluation of a Cooling Tower
7. Steady and Transient Simulation of Vapor Compression Refrigeration Cycle using a given Refrigerant and Operating Conditions
8. Transient Simulation of Air Conditioner for given Inside Operating Conditions
9. Simulation of Thermal Network for a Composite Slab/Insulation System with Convective Boundary Conditions
10. Simulation of Flow and Thermal Networks and Performance Evaluation for any given Heat Exchanger

VALUE EDUCATION
(Audit Course-II)

M.Tech. (TE) (FT)–II Sem

L	T	P	C
0	0	2	0

Course Objectives

Students will be able to

1. Understand value of education and self- development
2. Imbibe good values in students
3. Let the should know about the importance of character

Course outcomes

Students will be able to

1. Knowledge of self-development
2. Learn the importance of Human values
3. Developing the overall personality

Unit	Content	Hours
1.	• Values and self-development –Social values and individual attitudes. Work ethics, Indian vision of humanism.	4
2.	• Moral and non- moral valuation. Standards and principles. • Value judgements	
3.	• Importance of cultivation of values. • Sense of duty. Devotion, Self-reliance. Confidence, Concentration. Truthfulness, Cleanliness. • Honesty, Humanity. Power of faith, National Unity. • Patriotism.Love for nature,Discipline	6
4.	• Personality and Behavior Development - Soul and Scientific attitude. Positive Thinking. Integrity and discipline. • Punctuality, Love and Kindness. • Avoid fault Thinking. • Free from anger, Dignity of labour. • Universal brotherhood and religious tolerance. • True friendship. • Happiness Vs suffering, love for truth. • Aware of self-destructive habits. • Association and Cooperation. • Doing best for saving nature	6
5.	• Character and Competence –Holy books vs Blind faith. • Self-management and Good health. • Science of reincarnation. • Equality, Nonviolence, Humility, Role of Women. • All religions and same message. • Mind your Mind, Self-control. • Honesty, Studying effectively	6

Text Books:

1. Chakroborty, S.K. "Values and Ethics for organizations Theory and practice", Oxford University Press, New Delhi

EQUIPMENT DESIGN FOR THERMAL SYSTEMS
(Programme Elective-V)

M.Tech. (TE) (FT)–III Sem

L	T	P	C
2	0	0	2

Prerequisites: Advanced Heat and Mass Transfer

Course Objective:
The course is intended to

- Design and analyze the heat exchangers parallel flow, counter flow, multipass and, cross flow heat exchanger
- Design and analyze the Shell and tube heat exchanger
- Enable to carry out the performance of heat exchanger with the extended surfaces.
- Design and analyze the cooling towers.

Course Outcomes:
At the end of the course, the student will be able to:

- Understand the physics and the mathematical treatment of typical heat exchangers.
- Apply LMTD and Effectiveness methods in the design of heat exchangers and analyze the importance of LMTD approach over AMTD approach.
- Analyze the performance of double-pipe counter flow (hair-pin) heat exchangers.
- Design and analyze the shell and tube heat exchanger.
- Understand the fundamental, physical and mathematical aspects of boiling and condensation.
- Classify cooling towers and explain their technical features.

UNIT -I:
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 Tubular 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:

UNIT-II:
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.

UNIT-III:
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.

UNIT-IV:
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.

UNIT-V:

DIRECT CONTACT HEAT EXCHANGERS: Cooling towers, relation between wet bulb & dew bulb temperatures, calculation of cooling tower performance.

Heat Pipe: Gravity assisted thermo-syphans, micro heat pipes, pulsating heat pipes, loop heat pipe operation & working principles.

Text Books:

1. Process Heat Transfer by D.Q.Kern, TMH
2. Heat Exchanger Design by A.P.Fraas and M.N.Ozisick, John Wiely & sons, New York.

Reference Books:

1. Cooling Towers by J.D.Gurney and I.A. Cotter, Maclaren
2. Heat Pipe Science & Technology, Amir Faghri, Taylor & Francis
3. Heat Pipe Technology and Applications by J.P Peterson, John wiky & sons.

THERMAL MEASUREMENTS AND PROCESS CONTROL
(Programme Elective-V)

M.Tech. (TE) (FT)–III Sem

L	T	P	C
2	0	0	2

Prerequisites: Basics of differential equations, material and energy balance

Course Objectives:
The course is intended to
- Educate the student with operating principles and function of measuring instruments used in Engineering and process industries
- Make the student conversant with various working principles of instruments
- Understand and analyze the behavioral characteristics of instruments
- Make the student learn about calibration procedure the instrument
- Educate the student about the fundamental aspects of control systems and their use in the context of industry applications

Course Outcomes:
At the end of the course, the student will be able to:
- Understand the concepts of errors in measurements, statistical analysis of data, regression analysis, correlation and estimation of uncertainty.
- Describe the working principles in the measurement of field and derived quantities.
- Analyze sensing requirements for measurement of thermo-physical properties, radiation properties of surfaces, and vibration.
- Understand conceptual development of zero, first and second order systems.
- Interpret International Standards of measurements (ITS-90) and identify internationally accepted measuring standards for measurands.

UNIT-I:
GENERAL CONCEPTS: Fundamental elements of a measuring instrument. Static and dynamic characteristics – errors in instruments – Different methods of measurement and their analysis – Sensing elements and transducers.
Measurement of pressure – principles of pressure measurement, static and dynamic pressure, vacuum and high pressure measuring – Measurement of low pressure, Manometers, Calibration methods, Dynamic characteristics- design principles.

UNIT-II:
MEASUREMENT OF FLOW: Obstruction meters, variable area meters. Pressure probes, compressible fluid flow measurement, Thermal anemometers, calibration of flow measuring instruments. Introduction to design of flow measuring instruments.

UNIT-III:
TEMPERATURE MEASUREMENT: Different principles of Temperature Measurement, use of bimetallic thermometers – Mercury thermometers, Vapor Pressure thermometers,
Thermo positive elements, thermocouples in series & parallel, pyrometry, measurement of heat flux, calibration of temperature measuring instruments. Design of temperature measuring instruments.

UNIT-IV:
Level Measurement: Direct & indirect methods, manometric methods, float level meters, electrical conductivity, Capacitive, Ultrasonic, and Nucleonic Methods.
Measurement of density – Hydrometer, continuous weight method, Gamma rays, Gas impulse wheel. Velocity Measurement – Coefficient of viscosity, Ostesld method, free fall of piston under gravity, torque method. Measurement of moisture content and humidity. Measurement of thermal conductivity of solids, liquids and gases.

UNIT-V:

PROCESS CONTROL: Introduction and need for process control principles, transfer functions, block diagrams, signal flow graphs, open and closed loop control systems – Analysis of First & Second order systems with examples of mechanical and thermal systems.

Control System Evaluation – Stability, steady state regulations, transient regulations.

Text Books:

1. Mechanical Measurements by Beckwith, Leinhard & Marangoni, Pearson
2. Measurement System, Application & Design by E.O. Doeblin.

Reference Books:

1. Mechanical and Industrial Measurements by R.K. Jain, Khanna Publishers.
2. Mechanical Measurements by Buck & Beckwith, Pearson.
3. Control Systems, Principles & Design by M. Gopal – 2nd Edition, TMH.
4. Principles of Measurement Systems by John Bentley, Pearson

ADVANCED MATERIALS FOR THERMAL SYSTEMS
(Programme Elective-V)

M.Tech. (TE) (FT)–III Sem

L	T	P	C
2	0	0	2

Prerequisites: Materials science, Mechanical Engineering

Course objectives:
The course is intended to
- to identify, design and develop new materials and composites for compact thermal energy storage,
- to develop measuring and testing procedures to characterize new storage materials reliably and reproducibly
- to improve the performance, stability, and cost-effectiveness of new storage materials,
- to develop multi-scale numerical models, describing and predicting the performance of new materials in thermal storage systems,
- to develop and demonstrate novel compact thermal energy storage systems employing the advanced materials
- to assess the impact of new materials on the performance of thermal energy storage in the different applications considered, and
- to disseminate the knowledge and experience acquired in this task

Course Outcomes:
At the end of the course, the student will be able to:
- Successfully apply advanced concepts of materials engineering to the analysis, design and development of materials, devices, systems, and processes to meet desired needs of society professionally and ethically.
- Be continuously aware of contemporary issues and research opportunities/challenges in the field of materials engineering as related to energy and sustainability and engage in life-long learning in the field and in the fundamentals of other related disciplines.
- Use advanced materials characterization techniques, skills, and modern scientific and engineering tools.
- Communicate effectively in written and oral form, both, individually and as a member of a multidisciplinary team.

UNIT–I:
Review of MECHANICAL PROPERTIES: FUNDAMENTALS AND TENSILE, HARDNESS, AND IMPACT TESTING: The Tensile Test: Use of the Stress – Strain Diagram, True Stress and True Strain, The Bend Test for Brittle Materials, Hardness of Materials, Strain Rate effects and Impact Behaviour Heat Treatment of Steels and Cast Irons: Designations and Classification of Steels, Simple Heat treatments, Isothermal Heat treatments, Quench and Temper Heat treatments, Surface treatments, Weldability of Steel. FRACTURE MECHANICS, FATIGUE, AND CREEP BEHAVIOUR: Fracture Mechanics, The Importance of Fracture Mechanics, Micro structural Features of Fracture in Metallic Materials, Micro structural Features of Fracture in Ceramics, Glasses, and Composites, Fatigue, Result of the Fatigue test, Application of Fatigue test, Creep, Stress Rupture, and Stress Corrosion, Evaluation of creep Behaviour

UNIT-II:
Nuclear Power Plant and Their Materials: Nuclear reactor, pressurized reactor, breeder reactor. Materials for fuel, control rods, coolant, moderator, shielding. Effects of Radiation on Materials Properties: Effects of α, β, γ rays on creep, fatigue, tensile, and other properties of metals, alloys, ceramics, polymers, rubbers etc. Effects on electrical, electronic and magnetic behaviour of materials, Effects on crystal structure, grain size etc.

UNIT-III:
Materials in Fuel cells and Solar Cells Electrocatalyst materials for low temperature fuel cells, Conductive membranes for low-temperature fuel cells, Materials for high temperature fuel cells, silicon, quantum dots for solar energy, nanomaterials for solar thermal energy and photovoltaic.

UNIT-IV:
Materials in Thermal Power Generation Super alloys, steels, ceramics, TBC, hydrogen membrane materials, sensor and sensor materials, biomass, coal, flyash, etc.

UNIT-V:
Energy storage-Artificial photosynthesis/solar to fuels, CO_2 separation and utilization, Safer nuclear waste disposal, biofuels production, biological fuel cell technologies, reduction of energy use in manufacturing processes, Improved grid technologies, sustainable energy economy

Text Books:

1. Introduction to Nuclear Science by Bryan, J. C., CRC Press.
2. Fundamentals of Radiation Materials Science by G.S. Was, Springer

Reference Books:

1. Nuclear Reactor Materials and Applications by B.M. Ma, Van Nostrand Reinhold Company.
2. Nuclear Reactor Materials by C.O. Smith, Addison-Wesley Publishing Company.
3. Fundamentals Aspects of Nuclear Fuel Elements by D.R. Olander.
4. Structural Materials in Nuclear Power Systems by J. T. A. Roberts, Plenum Press.
5. Handbook of Fuel Cells, Wolf Vielstich by Arnold Lamm, Hubert A. Gasteiger, and Harumi Yokokawa, John Wiley and Sons, Inc.
6. Advanced power plant materials, design and technology, Edited by D Roddy, Woodhead Publishing Series in Energy No. 5 and CRC Press.

MICROPROCESSORS IN AUTOMATION
(Open Elective)

M.Tech. (TE) (FT)–III Sem

L	T	P	C
2	0	0	2

Prerequisites: Introduction to Logic Design, Programming and Introductory Data Structures
Course Objectives: To introduce the basic concepts of Digital circuits, Microprocessor system and digital controller
Course Outcomes: Students who have done this course will have a good idea of the use of microprocessors for automation

UNIT-I:
Introduction to Number Systems, codes, digital electronics: Logic Gates, combinational circuits design, Flip-flops, Sequential logic circuits design: Counters, Shift registers.

UNIT-II:
Introduction to 8085 Functional Block Diagram, Registers, ALU, Bus systems, Timing and control signals, Machine cycles, instruction cycle and timing states, instruction timing diagrams, Memory interfacing.

UNIT-III:
Assembly Language Programming: Addressing modes, Instruction set, simple programs in 8085; Concept of Interrupt, Need for Interrupts, Interrupt structure, Multiple Interrupt requests and their handling, Programmable interrupt controller.

UNIT-IV:
Interfacing peripherals: Programmable peripheral interface (8255), Interfacing Analog to Digital Converter & Digital to Analog converter, Multiplexed seven segments LED display systems, Stepper Motor Control, Data Communication: Serial Data communication (8251), Programmable Timers (8253); 8086/8088 Microprocessor and its advanced features.

UNIT-V:
Introduction to Digital Control: Sampling theorem, Signal conversion and Processing, Z-Transform, Digital Filters, Implementation of Digital Algorithm.

Text Books:
1. Digital Computer Electronics: An Introduction to Microcomputers by Albert Pual Malvino, Tata McGraw-Hill Publishing Company Ltd.
2. Digital Electronics: An Introduction to Theory and Practice by William H. Gothmann, PHI Learning Private Limited

Reference Books:
1. Microprocessor Architecture, Programming, and Applications with the 8085 by Ramesh Gaonkar, PENRAM International Publishers.
2. Digital Control Systems by Benjamin C. Kuo, Oxford University Press (2/e, Indian Edition, 2007).
3. Digital and Microprocessor Engineering by S.J.Cahill, Wllis Horwood Limited (John Wiley & Sons)
4. Microprocessors and Interfacing: Programming and Hardware by Douglas V. Hall
5. Microcomputer Experimentation with the Intel SDK-85 by Lance A. Leventhal, Prentice Hall

COMPOSITE MATERIALS
(Open Elective)

M.Tech. (TE) (FT)– III Sem

L	T	P	C
2	0	0	2

Prerequisite: Structure and properties of composite materials and design procedures for composite structures

Course objectives:
To identify the properties of fiber and matrix materials used in commercial composites as well as some common manufacturing teaching and to predict the elastic properties of both long and short fiber and understand the stress-strain relations and establish the failure criteria for laminated structures.

Course Outcomes: At the end of the course the students will be able to

- Understanding of types, manufacturing processes, and applications of composite materials.
- Basic understanding of linear elasticity with emphasis on the difference between isotropic and anisotropic material behavior.
- Ability to analyze problems on macro and micro mechanical behavior of lamina
- Ability to analyze problems on macro mechanical behavior of laminate
- An ability to predict the loads and moments that cause an individual composite layer and a composite laminate to fail and to compute hygro thermal loads in composites.
- An ability to compute the properties of a composite laminate with any stacking sequence.
- An ability to use the ideas developed in the analysis of composites towards using composites in aerospace design.

UNIT-I:
Introduction to Composite Materials: Introduction ,Classification Polymer Matrix Composites, Metal Matrix Composites, Ceramic Matrix Composites, Carbon–Carbon Composites, Fiber-Reinforced Composites and nature-made composites, and applications .

UNIT-II:
Reinforcements: Fibers- Glass, Silica, Kevlar, carbon, boron, silicon carbide, and born carbide fibers. Particulate composites, Polymer composites, Thermoplastics, Thermosetts, Metal matrix and ceramic composites.
Manufacturing methods: Autoclave, tape production, moulding methods, filament winding, man layup, pultrusion, RTM.

UNIT-III:
Macro mechanical Analysis of a Lamina: Introduction, Definitions Stress, Strain, Elastic Moduli, Strain Energy. Hooke's Law for Different Types of Materials, Hooke's Law for a Two-Dimensional Unidirectional Lamina, Plane Stress Assumption, Reduction of Hooke's Law in Three Dimensions to Two Dimensions, Relationship of Compliance and Stiffness Matrix to Engineering Elastic Constants of a Lamina.

UNIT-IV:
Macro mechanical Analysis of Laminates: Introduction , Laminate Code , Stress–Strain Relations for a Laminate, In-Plane and Flexural Modulus of a Laminate , Hygrothermal Effects in a Laminate, Warpage of Laminates.

UNIT-V:
Failure, Analysis, and Design of Laminates: Introduction, Special Cases of Laminates, Failure Criterion for a Laminate, Design of a Laminated Composite, Other Mechanical Design Issues.

Text Books:

1. Mechanics of Composite Materials, Second Edition (Mechanical Engineering), By Autar K.Kaw, **Publisher:** CRC.
2. Engineering Mechanics of Composite Materials by Isaac and M Daniel, Oxford University Press, 1994.

Reference Books:

1. Analysis and performance of fibre Composites by B. D. Agarwal and L. J. Broutman, Wiley-Interscience, New York, 1980.

WASTE TO ENERGY
(Open Elective)

M.Tech. (TE) (FT)–III Sem

L	T	P	C
2	0	0	2

Prerequisite: An introductory knowledge of solid and hazardous waste along with some basic understanding of solid waste management at industries

Course Objectives: To prepare the students for successful career in the energy industry, energy service companies, energy utility and consultancy agencies and in the academic and R&D institutions. To produce graduates strong in understanding on energy resources, technologies and systems, energy management fundamentals, and capable in innovative technological intervention towards the present and potential future energy issues. To produce energy professionals, who are sensitive to, and well aware of, the energy issues and concerns, and who can apply their specialized knowledge for the sustainable development.

Course Outcomes: Understood and acquired fundamental knowledge on the science and engineering of energy technologies and systems. Acquired the expertise and skills required for energy auditing and management, economical calculation of energy cost, development, implementation, maintenance of energy systems. Become capable of analysis and design of energy conversion systems. Acquired skills in the scientific and technological communications and project preparation, planning and implementation of energy projects

UNIT-I:
Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste – MSW – Conversion devices – Incinerators, gasifiers, digestors.

UNIT-II:
Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal- Methods – Yields and application- Manufacture of pyrolytic oils and gases, yields and applications. Biomass Gasification: Gasifiers- Fixed bed system- Downdraft and updraft gasifiers- Fluidized bed gasifiers- Design, construction and operation- Gasifiers burner arrangement for thermal heating- Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

UNIT-III:
Biomass Combustion: Biomass stoves- Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, Inclined grate combustors, Fluidized bed combustors, Design, construction and operation- Operation of all the above biomass combustors.

UNIT-IV:
Biogas: Properties of biogas (Calorific value and composition)- Biogas plant technology and status- Bio energy system – Design and constructional features- Biomass resources and their classification- BIOMASS CONVERSION PROCESS.

UNIT-V:
Thermo chemical conversion – Direct combustion – biomass gasification- pyroloysis and liquefaction- biochemical conversion- anerobic digestion- Types of biogas Plants- Applications- Alcohol production from biomass- Bio diesel production- Urban waste to energy conversion- Biomass energy programme in India.

Text Books:

1. Non Conversional Energy by Desai, Ashok V., Wiley Eastern Ltd., 1990.
2. Biogas Technology – A Practical Hand Book by Khandelwal, K.C and Mahdi, S.S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.

Reference Books:

1. Food, Feed and Fuel from Biomass by Challal, D.S., IBH Publishing Co. Pvt. Ltd., 1991.
2. Biomass Conversion and Technology by C.Y. WereKo- Brobby and E.B. Hagan, John Wiley & Sons, 1996.