JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABADDEPARTMENT OF MECHANICAL ENGINEERING

M. Tech. (Thermal Engineering)

2021-22 Admitted Batch

I Year I Semester

S. No	Code	Subject	L	T	P	Credits
1.	PC 1	Advanced Fluid Mechanics	3	0	0	3
2.	PC 2	Advanced Heat and Mass Transfer	3	0	0	3
3.	PE - I	1. Advanced Thermodynamics 2. Fuels and Combustion 3. Gas Dynamics	3	0	0	3
4.	PE - II	1. Energy Conservation and Management 2. Advanced Power Plant Systems 3. Experimental Methods in Thermal Engineering	3	0	0	3
5.	Laboratory - I	Advanced Thermal Engineering lab	0	0	4	2
6.	Laboratory - II	Advanced Heat and Mass Transfer Lab	0	0	4	2
7.	MLC	Research Methodology and IPR	2	0	0	2
8.	Audit Course - I	English for Research Paper Writing	2	0	0	0
Total Credits						**18**

I Year II Semester

S. No	Code	Subject	L	T	P	Credits
1.	PC 3	Advanced IC Engines	3	0	0	3
2.	PC 4	Computational Fluid Dynamics	3	0	0	3
3.	PE -III	1. Advanced Refrigeration and Air Conditioning 2. Turbulence Modelling 3. Optimization Techniques & Applications	3	0	0	3
4.	PE - IV	1. Finite Element Analysis 2. Hybrid Vehicles 3. Renewable Energy Sources and Technologies	3	0	0	3
5.	Laboratory - III	Computational Methods Lab	0	0	4	2
6.	Laboratory - IV	Advanced Refrigeration and Air Conditioning Lab	0	0	4	2
7.	Seminar	Technical Seminar	0	0	4	2
8.	Audit Course - II	Value Education	2	0	0	0
Total Credits						**18**

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
DEPARTMENT OF MECHANICAL ENGINEERING
M. Tech. (Thermal Engineering)
2021-22 Admitted Batch

II Year I Semester

S.No	Code	Subject	L	T	P	Credits
1.	PE - V	1. Equipment Design for Thermal systems 2. Cryogenic Engineering 3. Micro and nano Scale Heat Transfer	3	0	0	3
2.	Open Elective	Open Elective	3	0	0	3
3.	Dissertation	Dissertation Phase – I	0	0	20	10
Total Credits						**16**

II Year II Semester

S.No	Code	Subject	L	T	P	Credits
1.	Dissertation	Dissertation Phase - II	0	0	32	16
Total Credits						**16**

Open Elective:

1. Waste to Energy

ADVANCED FLUID MECHANICS
(PC- I)

M.Tech. (TE) (FT) I Year I Sem

L	T	P	C
3	0	0	3

Prerequisites: Fluid Mechanics

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:
Brief recapitulation of some preliminary concepts of Fluid Mechanics : Fluid Kinematics
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.
Condition for irrotationality, circulation & vorticity Accelerations in Cartesian systems normal and tangential accelerations,
Dynamics of Inviscid Flows and Reynolds Transport Theorem Euler's, Bernoulli equations – Dimensional analysis and Similitude

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 - Use of similarity parameters - 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

ADVANCED HEAT AND MASS TRANSFER
(PC-II)

M.Tech. (TE) (FT) – I Year I Sem

L	T	P	C
3	0	0	3

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 homogeneous boundary conditions

UNIT-II:
Transient heat conduction: Lumped system analysis-Infinite Bodies -Use of 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: Analogy – Similarity parameters and Pohlhausen solution. Approximate method-Von Karman Integral 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 – Flow across tube banks
Internal flows: Flow Classification based on hydrodynamic &thermal entry lengths- Fully developed flow: Determination of 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: Black body radiation – Properties of radiation surfaces – View Factor – Radiosity - Radiant heat exchange between grey and diffuse surfaces with transmitting and reflecting media.

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 THERMODYNAMICS
(PE-I)

M.Tech. (TE) (FT)–I Year I Sem

L	T	P	C
3	0	0	3

Pre Requisites: 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

FUELS AND COMBUSTION
(PE-I)

M. Tech. (TE) (FT) –I Year I Sem	**L**	**T**	**P**	**C**
	3	**0**	**0**	**3**

Prerequisites: Fuels and Combustion

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 gaseousfuels

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.

GAS DYNAMICS
(PE-I)

M.Tech. (TE) (FT) – I Year I Sem	L	T	P	C
	3	0	0	3

UNIT- I:
Basic Concepts: Introduction to compressible flow, A brief review of thermodynamics and fluid mechanics, Integral forms of conversion equations, Differential conversion equations, Continuum Postulates, Acoustic speed and Mach number, Governing equation for compressible flows.

UNIT – II:
One- dimensional compressible flow :One dimensional flow concepts, Isentropic flows, Stagnation/ Total conditions, Characteristics speeds of gas dynamics, Dynamic pressure and pressure coefficients, Normal Shock waves, Rankine-Hugonoit equations, Rayleigh flow, Fanno flow, Crocco' theorem.

UNIT – III:
Quasi-one dimensional flows: Governing equations, Area velocity relations, Isentropic flow through variable-area ducts, Convergent divergent (or De Laval) nozzles, Over-expanded and underexpanded nozzle, Diffusers.

UNIT- IV:
Two- dimensional Flow: Oblique shock wave and its governing equations, e-B-M relations, The Hodograph and Shock polar, Supersonic flow over wedges and cones, Mach line, Attached and Detached shock , Reflection and Interaction of oblique shock waves, Supersonic flow over convex and concave corners, Approximation of continuous expansion waves by discrete waves.

Unit V:
Unsteady wave motions: Moving normal shock waves, Reflected shock waves, Physical features of wave propagation, Elements of acoustic Thermal Engineering theory, Incident and reflected expansion waves, Finite compression waves, Shock tube relations.

Text Books:
1. Gas Dynamics by S.M. Yahya
2. Gas Dynamics by Radha Krishnan
3. Compressible Fluid Dynamic by B K Hodge, Keith Koenig, Pearson Publications, I Edition

Reference Books:
1. Gas Dynamics- Zucker
2. Dynamics and Thermodynamics of compressible fluid flow (Vol.I, II)-Ascher H.Shapiro
3. Elements of Gas dynamics -H. W. Liepmann, A. Roshko
4. Fundamentals of Gas Dynamics-V.Babu
5. Modern compressible flow – John.D. Anderson, Jr.

ENERGY CONSERVATION AND MANAGEMENT
(PE-II)

M.Tech. (TE) (FT) –I Year I Sem	L	T	P	C
	3	0	0	3

Pre Requisites: 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 principlesand 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

ADVANCED POWER PLANT SYSTEMS
(PE-II)

M.Tech. (TE) (FT) –I Year I Sem

L	T	P	C
3	0	0	3

Prerequisites: Basic Heat Transfer, Fluid Mechanics

Course Objective: The course is intended to
Understand various aspects of different types of Power Plants including site selection, layout, equipment features and functions, economics and instrumentation.

Course Outcomes: At the end of the course, the student will be able to:
- Describe the power generation scenario and sources of energy
- Describe nuclear fission and classify nuclear reactors
- Describe the working and layout of steam and hydro electric power plants and different systems comprising the plant
- Distinguish between cogeneration and combined cycle power plants
- Describe different power plant instruments and basic principles of economics of power generation

UNIT–I:
INTRODUCTION: Sources of energy, Types of Power plants. Direct energy conversion system, Energy sources in India, Recent developments in power generation, Combustion of coal, Volumetric analysis, Gravimetric analysis.
Steam Power Plant: Introduction. General layout of modern steam power plant, Power plant cycle – Super critical cycle, Fuel Handling, Combustion equipment, Ash handling, Dust collectors – Boilers - Boiler accessories - Feed water heaters - Cooling towers - Steam condensers- Jet and surface condensers – Steam power plants located in India and their features

UNIT-II:
Gas Turbine Power Plant – Applications of gas turbine plants, comparative analysis of gas turbine power plants over diesel and thermal power plants, combined gas turbine and steam power plants, combined gas turbine, diesel power plants, Cogeneration- IGCC – AFBC/PFBC cycles –Combined cycle plants in India and its salient features

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:
Hydro Power Generation : Advantages and dis advantages of water power, Site selection, Hydrological Cycle, Hydrographs, mass curve, flow duration curve, elements of hydroelectric power plant, Classification, Types of Dams, Water Hammer & Surge Tank, Cavitation, Hydro Power in India & future trends.

UNIT-V:

ECONOMICS OF POWER GENERATION: Factors affecting the economics, Loading factors, Utilization factor, Performance and operating characteristics of power plant, economic load sharing, Depreciation, Energy rate, Tariff for electrical energy

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 R.K.Rajput, Lakshmi Publications.
2. Power Plant Engineering by Arora and Domkundwar
3. Power Plant Engineering by P.K.Nag, TMH

Reference Books:

1. Power Plant Engineering by P.C.Sharma, Kotaria Publications.
2. Power Plant Technology by Wakil, **McGraw** Hill

EXPERIMENTAL METHODS IN THERMAL ENGINEERING
(PE - II)

M.Tech. (TE) (FT) –I Year I Sem

L	T	P	C
3	0	0	3

Prerequisites: Nil

Course Outcomes:

- Understand the concepts of errors in measurements, statistical analysis of data, regression analysis, correlation and estimation of uncertainty.
- Understand conceptual development of zero, first and second order systems.
- 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.

Unit I

Introduction – Generalized measurement system – standards – calibration – Dynamic measurements – System response – Distortion – Impedance matching – Fourier analysis – Experiment planning – causes and types of errors – Error analysis – Uncertainty analysis – Evaluation – Statistical analysis of experimental data – Probability distribution

Unit II

Data Acquisition – Data transmission – data storage and display

Variable resistance transducers, capacitive transducers, piezoelectric transducers, photoconductive transducers, photovoltaic cells, ionization transducers, Hall effect transducers

Unit III

Dynamic response considerations, Bridgman gauge, McLeod gauge, Pirani thermal conductivity gauge, Knudsen gauge, Alphatron.

Unit IV

Flow measurement by drag effects; hot-wire anemometers, magnetic flow meters, flow visualization methods, interferometer, Laser Doppler anemometer. Temperature measurement by mechanical effect, temperature measurement by radiation, transient response of thermal systems, thermocouple compensation, temperature measurements in high- speed flow.

Unit V

Thermal conductivity measurement of solids, liquids, and gases, measurement of gas diffusion, convection heat transfer measurements, humidity measurements, heat-flux meters. Detection of thermal radiation, measurement of emissivity, reflectivity and transmissivity, solar radiation measurement.

Text Books:

1. J. P. Holman, Experimental Methods for Engineers, 7th edition, Tata McGraw-Hill 2001.
2. T.G. Beckwith, J.H. Lienhard V, R. D. Marngoni, Mechanical Measurements, 5th edition, Pearson Education, 2010.
3. E.O. Doebelin, Measurement systems, Application and Design, 5th edition, Tata McGraw-Hill, 2008

ADVANCED THERMAL ENGINEERING LAB
(Laboratory –I)

M.Tech. (TE) (FT)–I Year I Sem

L	T	P	C
0	0	4	2

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 onmeasured properties
- Infer from property charts and tables and to apply the data for the evaluation ofperformance 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 Reheatand Regeneration
8. Simulation of Flow Network and Performance Evaluation of Brayton Cycle with Intercooling and Reheat
9. Simulation of Flow and Thermal Networks and Performance Evaluation of a Boiler alongwith Boiler, Economizer, Super heater and Reheater
10. Steady and Transient Simulation of Compressible Flow Network

ADVANCED HEAT AND MASS TRANSFER LAB
(Laboratory –II)

M.Tech. (TE) (FT)–I Year I Sem

L	T	P	C
0	0	4	2

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 usingunsteady 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

List of Experiments:

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 VerticalRod
4. Determination of Forced Convective Heat Transfer Coefficient of air usingForced 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 Dropwise 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.

RESEARCH METHODOLOGY AND IPR
(MLC)

M.Tech. (TE) (FT)–I Year I Sem

L	T	P	C
2	0	0	2

Course Objectives:

- To understand the research problem
- To know the literature studies, plagiarism and ethics
- To get the knowledge about technical writing
- To analyze the nature of intellectual property rights and new developments
- To know the patent rights

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

- Understand research problem formulation.
- Analyze research related information
- Follow research ethics
- Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
- Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.
- Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

UNIT-I:

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

UNIT-II:

Effective literature studies approaches, analysis, Plagiarism, Research ethics

UNIT-III:

Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

UNIT-IV:

Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Copyleft and Creative Commons Licensing. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

UNIT-V:

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

TEXT BOOKS:

1. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students"
2. Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"

REFERENCES:

1. Ranjit Kumar, 2nd Edition , "Research Methodology: A Step by Step Guide for beginners"
2. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.
3. Mayall , "Industrial Design", McGraw Hill, 1992.
4. Niebel , "Product Design", McGraw Hill, 1974.
5. Asimov , "Introduction to Design", Prentice Hall, 1962.
6. Robert P. Merges, Peter S. Menell, Mark A. Lemley, " Intellectual Property in New Technological Age", 2016.
7. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008

ENGLISH FOR RESEARCH PAPER WRITING
(Audit Course - I)

M.Tech. (ED) (FT)–I Year I Sem

L	T	P	C
2	0	0	0

Course Objectives: To help students:
1. Understand the essentials of writing skills and their level of readability
2. Learn about what to write in each section
3. Ensure qualitative presentation with linguistic accuracy.

Course Outcomes: Students will be able to:
1. Understand writing skills and level of readability
2. Write title, abstract, different sections in research paper
3. Develop the skills needed while writing a research paper

Unit I: Overview of a Research Paper- Planning and Preparation- Word Order- Useful Phrases - Breaking up Long Sentences-Structuring Paragraphs and Sentences -Being Concise and Removing Redundancy - Avoiding Ambiguity.

Unit II: Essential Components of a Research Paper- Abstracts- Building Hypothesis-Research Problem - Highlight Findings- Hedging and Criticizing, Paraphrasing and Plagiarism, Chapterisation.

Unit III: Introducing Review of the Literature – Methodology - Analysis of the Data-Findings - Discussion- Conclusions-Recommendations.

Unit IV: Key skills needed for writing a Title, Abstract, and Introduction.

Unit V: Appropriate language to formulate Methodology, incorporate Results, put forth Arguments and draw Conclusions.

Suggested Reading:

1. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books)
Model Curriculum of Engineering & Technology PG Courses [Volume-I]
2. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press
3. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman’sbook .
4. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011

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ADVANCED I.C. ENGINES
(PC - III)

M.Tech. (TE) (FT) –I Year II Sem

L	T	P	C
3	0	0	3

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 theIdeal cycle.
- Apply principles of thermodynamics, fluid mechanics, and heat transfer to influence theengine'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 sparkignition 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 performanceparameters.
- 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.

COMPUTATIONAL FLUID DYNAMICS
(PC - IV)

M.Tech. (TE) (FT) –I Year II Sem

L	T	P	C
3	0	0	3

Prerequisites: 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 toapply appropriate numerical techniques
- Solve the simple heat transfer and fluid flow problems using different numericaltechniques
- 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 1DHyperbolic 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

ADVANCED REFRIGERATION AND AIR CONDITIONING
(PE - III)

M.Tech. (TE) (FT) – I Year 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 aswell 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 industrialapplications.

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 & Multistagesystems.

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 andapplications.

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

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 Hil

TURBULENCE MODELLING
(PE - III)

M.Tech. (TE) (FT) –I Year II Sem

L	T	P	C
3	0	0	3

Prerequisites: Thermodynamics

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 formof velocity triangles.
- Familiarize the basic concepts of gas dynamics and analyze the performance of axial flowgas 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 ofvarious 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, UniformEddy 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, Subgrid Scale 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 ofElsevier 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
(PE-III)

M.Tech. (TE) (FT) –I Year II Sem

L	T	P	C
3	0	0	3

Prerequisites: Operations Research

Course Objectives: The main objectives of the course are:

- Numerical optimization techniques for single variable and multi variable non-linearoptimization 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 varianceof 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 simulatedannealing & particle swarm optimization.

Course Outcomes: At the end of the course, the student is able to apply appropriateoptimization 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 optimalsolution 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 – Zeroor 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 - Problems. Introduction to Particle Swarm Optimization (PSO), Teaching Learning Based Optimization Algorithm (TLBO) – Problems.

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

FINITE ELEMENT ANALYSIS
(PE - IV)

M.Tech. (TE) (FT) – I Year II Sem

L	T	P	C
3	0	0	3

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 structuralproblem.
- 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 Analysisthe 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 natureof 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 heatconduction 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, print2012
6. A First Course in the Finite Element Method by Daryl L Logan, Cengage Learning, 5thEdition
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

HYBRID VEHICLES
(PE - IV)

M.Tech. (TE) (FT) – I Year II Sem

L	T	P	C
3	0	0	3

Prerequisites:

Course Objectives: To present a comprehensive overview of Hybrid Vehicles.

Course Outcomes: Upon successful completion of this course, students will be able to:

- Choose a suitable drive scheme for developing an electric of hybrid vehicle depending on resources.
- Design and develop basic schemes of electric vehicles and hybrid electric vehicles.
- Choose proper energy storage systems for vehicle applications.
- Identify various communication protocols and technologies used in vehicle networks.

UNIT I :

NEED FOR ALTERNATIVE SYSTEM Need of electric vehicles hybrid vehicles – comparative study of diesel, petrol, pure electric and hybrid vehicles. Limitations of electric vehicles. Specification of some electric and hybrid vehicles

UNIT II :

ENERGY SOURCES : BATTERIES AND FUEL CELLS Battery Parameters-Power requirement of electric vehicles- Different types of batteries - Lead acid-Nickel based-Sodium based-Lithium based- Metal Air based. Battery charging- Charger design-Quick charging devices- Battery Modeling. Different type of energy storage – Solar, wind, compressed fluid. Fuel Cell- Fuel cell characteristics- Fuel cell types-Hydrogen fuel cell-Connecting cell in series-water management in the PEM fuel cell- Thermal Management of the PEM fuel cell

UNIT III :

PROPULSION MOTORS AND CONTROLLERS Characteristic of permanent magnet and separately exited DC motors. AC single phase and 3-phase motor – inverters – DC and AC motor speed controllers.

UNIT IV :

VEHICLE DESIGN CONSIDERATIONS FOR ELECTRIC VEHICLES Aerodynamic-Rolling resistance- Transmission efficiency- Vehicle mass- Electric vehicle chassis and Body design considerations- Heating and cooling systems- Controllers- Power steering-Tyre choice-Wing Mirror, Aerials and Luggage racks

UNIT V:

HYBRID VEHICLES Types of Hybrid- Series, parallel, split – parallel, series - parallel - Advantages and Disadvantages. Power split device – Energy Management System - Design consideration - Economy of hybrid vehicles

TEXT BOOKS:

1. James Larminie and John Lowry, “Electric Vehicle Technology Explained “ John Wiley & Sons,2003 2. Iqbal Husain, “ Electric and Hybrid Vehicles-Design Fundamentals”, CRC Press,2003

3. Mehrdad Ehsani, “ Modern Electric, Hybrid Electric and Fuel Cell Vehicles”, CRC Press,2005

REFERENCES:

1. Ron HodKinson, “ light Weight Electric/ Hybrid Vehicle Design”, Butterworth Heinemann Publication,2005

2. Lino Guzzella, “ Vehicle Propulsion System” Springer Publications,2005

RENEWABLE ENERGY SOURCES AND TECHNOLOGIES (PE-IV)

M.Tech. (TE) (FT) –I Year II Sem	L	T	P	C
	3	0	0	3

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 systemsfor 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 theirapplications
- Outline the methods of energy storage and identify the appropriate methods of energystorage 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 inIndia 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 andB.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

COMPUTATIONAL METHODS LAB
(Laboratory –III)

M.Tech. (TE) (FT)–I Year II Sem

L	T	P	C
0	0	4	2

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

List of Experiments:

1. Perform Analysis of Simple Cantilever Beam with Uniform Distribution Load (UDL) and draw Shear Force and Bending Moment Diagrams and also Find the Deflections?

2. Performance Analysis of Simply Supported Beam with Point Loads and Draw Shear Force and Bending Moment Diagrams?

3. Performance Analysis Using Truss Elements and Draw the Shear Force and Bending Moment Diagram and also Deflection?

4. Performance Analysis for the Truss Element to Find Axial Stress and Deflection at Different Area?

5. Consider a Rectangle Plate with width 10cm and thickness 10mm Heat Transfer Coefficient is 500W/M^{2}K and T=25^{o}C Perform Thermal Analysis using Ansys. Temperature at each side is 100^{o}C and one side is subjected to Conventional and other is Insulated. Find the Temperature Distribution Across the Walls?

6. 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}and 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 center line temperature and velocity of fluid separately for both boundary conditions.

7. 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.

8. 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.

9. Simulation of temperature contours for a pin fin subjected to natural and forced convective conditions.

10. Simulation of Natural convection with and without radiation inside an enclosure.

ADVANCED REFRIGERATION AND AIR CONDITIONING LAB
(Laboratory –IV)

M.Tech. (TE) (FT)–I Year II Sem

L	T	P	C
0	0	4	2

Prerequisites: Thermodynamics

Course Objective: To apply the principles of Thermodynamics to analyse different types of refrigeration and air conditioning systems experimentally and evaluate performance parametersunder 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 applicationas 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 agiven 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 ConvectiveBoundary Conditions
10. Simulation of Flow and Thermal Networks and Performance Evaluation for any givenHeat Exchanger

VALUE EDUCATION
(AUDIT COURSE-II)

M.Tech. (TE) (FT)–I Year II Sem

L	T	P	C
2	0	0	0

Course Objectives: To help the students:
1. Understand value of education and self- development
2. Imbibe good values
3. Know about the importance of character

Course outcomes: Students will be able to:
1. Acquire knowledge about self-development
2. Learn the importance of Human values
3. Develop the overall personality

Unit I: Values and Self-development – Social Values and Individual Attitudes. Work Ethics, Indian Vision of Humanism. Ethical Standards and Principles. Value Judgments.

Unit II: Importance of Cultivating Values. Sense of Duty. Devotion, Self-reliance, Confidence, Concentration. Truthfulness, Cleanliness. Honesty, Humanity. National Unity. Patriotism. Love for Nature, Discipline.

Unit III: Personality and Behavior Development - Soul and Scientific Attitude- Integrity and Discipline. Punctuality- Compassion and Benevolence - Positive Thinking- Composure and Equipoise- Dignity of Labour.

Unit IV: Universal Brotherhood and Religious Tolerance. True Friendship. Happiness Vs Suffering- Aware of Self-destructive Habits. Association and Cooperation. Eco-friendly Consciousnes.

Unit V: Character and Competence – Values of Scriptures- Self-management and Good health. Science of Reincarnation. Equality, Nonviolence, Humility, Role of Women- Secular Thinking- Mind your Mind, Self-control- Non Ethnocentric Behavior.

Suggested Readings

1. Chakroborty, S.K. "*Values and Ethics for organizations Theory and practice*", Oxford University Press, New Delhi. 1998.
2. Dostoyevsky, Fyodor, Constance Garnett, and Ernest J. Simmons. *Crime and Punishment*. New York: Modern Library, 1950. Print.
3. Galsworthy, John. *Justice.* Czechia, Good Press, 2019.
4. TED Talks

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EQUIPMENT DESIGN FOR THERMAL SYSTEMS
(PE - V)

M.Tech. (TE) (FT) –II Year I Sem	**L**	**T**	**P**	**C**
	3	**0**	**0**	**3**

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, crossflow 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 theimportance 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 pipeoperation & 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.

CRYOGENIC ENGINEERING
(PE - V)

M.Tech. (TE) (FT) –IIYear ISem

L	T	P	C
3	0	0	3

UNIT -I:

Introduction to Cryogenic Systems: Mechanical Properties at low temperatures. Properties of Cryogenic Fluids.

Gas Liquefaction: Minimum work for liquefaction. Methods to protect low temperature. Liquefaction systems for gages other than Neon. Hydrogen and Helium.

UNIT II:

Liquefaction Systems for Neon, Hydrogen and Helium: Components of Liquefaction systems. Heat exchangers. Compressors and expanders. Expansion valve, Losses in real machines.

UNIT-III:

Gas Separation and Purification Systems: Properties of mixtures, Principles of mixtures, Principles of gas separation, Air separation systems.

UNIT-IV:

Cryogenic Refrigeration Systems: Working Medium, Solids, Liquids, Gases, Cryogenic fluid storage & transfer, Cryogenic storage systems, Insulation, Fluid transfer mechanisms, Cryostat, Cryo Coolers

UNIT-V:

Applications: Space technology, In-Flight air separation and collection of LOX, Gas industry, Biology, Medicine, Electronics.

REFERENCES:

1. Cryogenic Systems/ R.F.Barren/ Oxford University Press
2. Cryogenic Engineering- Thomas Flynn- CRC Press-2nd Edition
3. Cryogenic Research and Applications: Marshal Sitting/ Von Nostrand/ Inc. New Jersey
4. Cryogenic Heat Transfer/ R.F.Baron
5. Cryogenic Engineering Edit / B.A. Hands/ Academic Press, 1986
6. Cryogenic Engineering/ R.B.Scottm Vin Nostrand/ Inc. New Jersey, 1959
7. Experimental Techniques in Low Temperature Physics- O.K. White, Oxford Press, 1968
8. Cryogenic Process Engineering/ K.D. Timmerhaus & TM Flynn/ Plenum Press, 1998
9. Hand Book of Cryogenic Engineering – J.G.Weisend –II, Taylor and Francis, 1998

MICRO AND NANO SCALE HEAT TRANSFER
(PE - V)

M.Tech. (TE) (FT) – II Year ISem	L	T	P	C
	3	0	0	3

Prerequisites: Fluid Mechanics, Thermodynamics

Course Objectives: The course is intended to

To understand the concepts of Micro an Nanoscale Heat Transfer

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

- To introduce the application of micro and nano scale heat tarsnfer in the area of fluids and thermal engineering

UNIT-I:

Introduction to Microscale Heat transfer - Introduction to micro/nano scale transport phenomena, Material waves and energy quantization, Energy states in Solids, Statistical Thermodynamics and Thermal Energy Storage, Energy Transfer by waves, Particle description of transport process: Classical laws, Boltzmann transport equation – Basics of molecular dynamics modelling – Applications of Micro Scale Heat Transfer

Microscale Heat Conduction – Conduction in Microscale – Space and time scales – Thermal conductivity models – Thermal conductivity prediction using Molecular Dynamics - Boltzmann equation and Phonon transport – Heat conduction in electronic devices - Measurement of heat conduction in microscale

UNIT II

Microscale Heat Convection – Thermodynamic considerations – Continuum approach – Conservation laws and governing equations Single phase forced convection – flow regimes – entry lengths -Non conventional analysis methods – Single phase liquid and gas flow – Measurements

Unit III

Microscale Radiative heat transfer – Macro Vs Microscopic approach – Spatial and temporal scales – radiation interaction and scattering with micro structures and materials – Modeling of microscale radiation – radiation properties in microscale regime

UNIT-IV:

Introduction to Nanoscale Heat Transfer – Length scales for nanoscale heat transfer – Heat transfer modes - 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. Thermal conductivity: principles of measurement and apparatus. Hamilton-Crosser and other theoretical equations and new empirical correlations to determine the thermalconductivity of different nanofluid.

UNIT-V:

Preparation of Nanofluids – Forced convection - 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 - **Applications**

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 2^{nd} 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, 1^{st} edition, Springer-Verlag Publication

WASTE TO ENERGY
(Open Elective)

M.Tech. (TE) (FT) –II Year I Sem

L	T	P	C
3	0	0	3

Prerequisites: 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, an d 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 project

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.