R23-M.Tech (Thermal Power Engineering)-PG Course Structure and Syllabus

I SEMESTER

S.No	Course code	Course Title	Contact hours/week				Credits	Scheme of Valuation		
			L	T	P	Total		CIE	SEE	Total
1	23TPE01	Advanced Thermodynamics	3	-	-	3	3	40	60	100
2	23TPE02	Advanced Fluid Mechanics	3	-	-	3	3	40	60	100
3	**PROGRAM ELECTIVE-I**		3	-	-	3	3	40	60	100
	23TPE03	Advanced Heat Transfer								
	23TPE04	Power Plant Management								
	23TPE05	Analysis and Design of Turbo Machines								
4	**PROGRAM ELECTIVE-II**		3	-	-	3	3	40	60	100
	23TPE06	Advanced IC Engines and Emission control Systems								
	23TPE07	Thermal System Analysis								
	23TPE08	Advanced Numerical Methods								
5	23RM01	Research Methodology and IPR	2	-	-	2	2	40	60	100
6	23AC-01	Disaster Management	2	-	-	2	0	100	-	100
LABORATORY COURSES										
7	23TPE61	Thermal Systems Lab	-	-	4	4	2	40	60	100
8	23TPE62	Simulation – Lab	-	-	4	4	2	40	60	100
		Total	16	0	8	24	18	380	420	800

II SEMESTER

S.No	Course code	Course Title	Contact hours/week				Credits	Scheme of Valuation		
			L	T	P	Total		CIE	SEE	Total
1	23TPE09	Computational Fluid Dynamics	3	-	-	3	3	40	60	100
2	23TPE10	Renewable energy technolgy	3	-	-	3	3	40	60	100
3	**PROGRAM ELECTIVE-III**		3	-	-	3	3	40	60	100
	23TPE11	Equipment design for thermal systems								
	23TPE12	Thermal measurement and process control								
	23TPE13	Energy conservation and management								
4	**PROGRAM ELECTIVE-IV**		3	-	-	3	3	40	60	100
	23TPE14	Finite Element Methods in heat transfer								
	23TPE15	Pollution: sources, effects and control								
	23TPE16	Theory and technology of fuel cells								
5	23AC-02	English for Research Paper Writing	2	-	-	2	0	40	60	100
LABORATORY COURSES										
6	23TPI01	Mini Project	-	-	4	2	2	100	-	100
7	23TPE63	Renewable energy technology Lab	-	-	4	2	2	40	60	100
8	23TPE64	Computational Fluid Dynamics Lab	-	-	4	2	2	40	60	100
		Total	14	0	12	18	18	440	360	800

III SEMESTER

S.No	Course code	Course Title	Contact hours/week				Credits	Scheme of Valuation		
			L	T	P	Total		CIE	SEE	Total
1	**PROGRAM ELECTIVE-V**		**3**	**-**	**-**	**3**	**3**	**40**	**60**	**100**
	23TPE17	Design of experiments								
	23TPE18	Alternate Fuels for Internal Combustion Engines								
	23TPE19	Computational Heat Transfer								
2	**OPEN ELECTIVE/MOOCS**		**3**	**-**	**-**	**3**	**3**	**40**	**60**	**100**
3	23TPI02	Industrial/Research Internship	**-**	**-**	**4**	**4**	**2**	**100**	**-**	**100**
4	23TPI03	Project work & Dissertation (Phase-I)	**-**	**-**	**16**	**16**	**8**	**100**	**-**	**100**

		Total	6	0	20	26	16	220	180	400

IV SEMESTER

S.No	Course code	Course Title	Contact hours/week				Credits	Scheme of Valuation		
			L	T	P	Total		CIE	SEE	Total
1	23TPI04	Project Work & Dissertation (Phase-II)	-	-	32	32	16	40	60	100
		Total	0	0	32	32	16	40	60	100

List of Open Elective Courses offered by ME Department

S. No.	Course Code	Name of the Course
1	23TPE81	Optimization Methods in Engineering
2	23TPE82	Nano Technology
3	23TPE83	Waste Management and Energy Generation Techniques

List of Courses offered under Audit Course

S. No.	Course Code	Name of the Course
1	23AC01	Disaster Management
2	23AC02	English for Research Paper Writing
3	23AC03	Sanskrit for Technical Knowledge
4	23AC04	Value Education
5	23AC05	Constitution of India
6	23AC06	Pedagogy Methods
7	23AC07	Stress Management by Yoga
8	23AC08	Personality Development through Life Enlightenment Skills

Programme Outcomes for P.G Programme

R23-M.Tech (Thermal Power Engineering)

PO	PO Statement
PO1	An ability to independently carry out research / investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the programme. The mastery should be at a level higher than the requirements in the appropriate Bachelor programme.
PO4	Model and design thermal systems using computational and optimization techniques.
PO5	Adopt methods of energy conservation for sustainable development.

R23-Regulations(w.e.f A.Y.2023-24)

M.Tech-Thermal Power Engineering

Detailed Syllabus

(First Semester)

M.Tech(I Sem)			**23TPE01-ADVANCED THERMODYNAMICS**	**L**	**T**	**P**	**Cr**
			Program Core	3	-	-	3

Pre-requisites: Thermodynamics

COURSE EDUCATIONAL OBJECTIVES (CEOs):
The primary objective of this course is to provide students with an advanced understanding of thermodynamics and its applications.
The present course on Advanced Thermodynamics deals with review on laws of thermodynamics, thermodynamics relations, exergy involvement in thermal systems, reactive mixtures, and propulsion systems.

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

CO1: Distinguish the laws of thermodynamics applied to thermal systems (Understanding Level – L2).
CO2: Apply the thermodynamics laws to solve various thermal system problems (Applying Level - L3).
CO3: Analyse the thermodynamic properties of various thermal systems (Analysing Level - L4).
CO4: Compare the exergy and irreversibility of closed and open thermal systems (Analysing Level - L4).
CO5**:** Classifies the working of advanced power cycles (Understanding Level – L2).

UNIT - I
THERMODYNAMICS – Introduction, Review of Zeroth, First, Second and Third law of thermodynamics.

THERMODYNAMIC RELATIONS: Introduction – Reciprocity and cyclic relations – The Maxwell's relations – The Gibbs and Helmholtz relations - Relations involving enthalpy, internal energy, and entropy; Mayer relation, Clausius-Clapeyron equation, Joule-Thompson experiment.

UNIT- II
ENTROPY: Concept of reversibility; change in entropy in various thermodynamic processes, entropy balance for closed and open systems, mechanism of entropy generation

UNIT- III

AVAILABILITY AND EXERGY: Introduction - Availability of heat - Availability of a closed system - Availability of open system - Applications. Irreversibility for closed and open system – Effectiveness - Applications

UNIT – IV

REACTIVE GAS MIXTURES: Introduction- Fuels and Combustion-theoretical and actual combustion processes- Enthalpy of formation and Enthalpy of reaction- First and Second law analysis of reacting systems-Applications.

UNIT – V
ADVANCED POWER CYCLES AND POWER GENERATION:
Atkinson cycle, Lenoir cycle, - Applications. Irreversibilities in a power plant; advanced steam-turbine power plants; advanced gas-turbine power plants, combined steam turbine and gas turbine plants, second law analysis of vapor and gas power cycles, Working of Binary vapor, Cogeneration, and combined gas power cycles.

REFERENCES
1.Sonntag, Borgnakke, Van Wyllan, Fundamentals of Thermodynamics: 5th Edition John Wiley and Sons, 2010.
2. P.K.Nag, Engineering Thermodynamics: 4th Edition 2008, TMH
3. YunusA.Cengel & Michael Boles, Thermodynamics (An Engineering Approach) 7th Edition 2011, TMH
4. E.Rathakrishnan, Fundamentals of Engineering Thermodynamics 2nd Edition, EEE, PHI Publishers, 2010.
5. J.P.Holman, Thermodynamics, 9th Edition, 2012, TMH

L	T	P	Cr.
3	-	-	3

M.Tech. (I Sem.) **23TPE02 - ADVANCED FLUID MECHANICS**

Program Core

Pre-requisites : Mathematics, Fluid mechanics

COURSE EDUCATIONAL OBJECTIVES(CEOs): To make the students exposed to the study of compressible and incompressible flows of viscous and non-viscous fluids, boundary layer concepts, turbulent flows and gas dynamics.

Present course emphasizes on fluid mechanical principles and application of those principles to solve real life problems. Special attention is given towards deriving the governing equations starting from the fundamental principle. There is a well-balanced coverage of physical concepts, mathematical operations along with examples and exercise problems of practical importance. After completion of the course, the students will have a strong fundamental understanding of the basic principles of Fluid Mechanics and will be able to apply the basic principles to analyze the fluid mechanical systems.

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

CO1 Classify the fluid kinematics and dynamics principles and calculates the velocity, stream and vorticity functions in fluid mechanics.(Understanding - L2)

CO2 Distinguishes an importance of Navier Stokes equation, Hagen – Poiseuille flow and Couette-flow in laminar flows and apply to solve the fluid flow problems.(Understanding - L2)

CO3 Apply the concepts of boundary layer thickness, displacement thickness, momentum thickness and energy thickness for various velocity profiles.(Apply - L3)

CO4 Identify the flow patterns in compressible flows and apply the area velocity relations to solve the problems related to compressible flows(Understanding - L2)

CO5 Describes the working principles of microfluidic devices(Understanding - L2)

UNIT-I

BASIC CONCEPTS: Types of Fluid flows and Lines**,** Eulerian and Lagrangian descriptions. Euler equations for inviscid flows- Bernoullis equations – Examples of Bernoulli's equation, Derivation of general differential Continuity equation, Velocity Potential and Stream Function, Relationship between Velocity Potential and Stream Function, Circulation and Vorticity, Flow Nets.- Limitations of Flow Nets, Reynolds Transport equation.

UNIT-II

LAMINAR FLOW: Navier Stokes equation of motion for Viscous Fluids (Rectangular Coordinate Systems), Flow of viscous fluids in circular pipes- Hagen – Poiseuille flow, Flow of viscous fluids between two parallel plates- Couette-flows

UNIT-III

BOUNDARY LAYER THEORY: Boundary layer concepts on Boundary layer thickness, Displacement thickness, Momentum thickness and Energy thickness, Laminar Boundary layer, Turbulent Boundary layers, Prandtls approximations, Blassius solution for a flat plate without pressure gradient – momentum integral equation – Von-Karman relation – Total Drag due to laminar and turbulent layers, Boundary layer separation and control.

UNIT-IV

GAS DYNAMICS: Mach number, Flow pattern in compressible flow, classification of compressible flow, isentropic flow, stagnation properties. Compressible flow through duct and nozzles – area velocity relations. Flow through convergent and convergent divergent nozzles. Real nozzles flow at design conditions. Introduction to normal compression shocks – normal shock relations. Fannoline and Rayleigh equations.

UNIT-V

MICROFLUIDICS: Miniaturization, Scaling Laws, Physics of Fluids --Basic Principles Fluid Dynamics – Flow, Boundary Effects, Charge Driven Fluids: Electrokinetics, Electrowetting Microfabrication Technology, Micromachining of Silicon and Polymeric Chips Fabrication Techniques - Components of Microfluidic Devices - Miniaturized Systems, Actuators, Pumps, Valves, Micro-mixers, Sensors

REFERENCES

1. Fluid Mechanics, Fox, R. W., McDonald, A. T., & Pritchard, P. J., (Eighth Edition), John Wiley & Sons.

2. Foundations of Fluid Mechanics, Yuan S.W. Prentice Hall – Eastern economy edition, 1983.

3. Gas Dynamics, Zucrwo M.J. and Hoffman J.D.Vol-I & Vol-II, John Wiley and Sons Inc. 1977.

4. Fundamentals of Compressible Flow, - Yahya S.M. Wiley Eastern.

5. A Brief Introduction to Fluid Mechanics Young, Munsen and Okiisyi, 2nd Edition, John Wiley, 2000.

6. Fluid Mechanics, Frank.M.White 5th Edition – McGraw Hill, 2005.

M.Tech(I Sem)			23TPE03-ADVANCED HEAT TRANSFER	L	T	P	Cr
			Program Elective-I	3	-	-	3

Pre-requisites: Heat Transfer

COURSE EDUCATIONAL OBJECTIVES (CEOs):
The advanced heat transfer course builds upon the foundational principles of heat transfer and delves into more intricate and specialized topics in the field. The primary objective of this course is to provide students with an advanced understanding of heat transfer and its various applications.

COURSE OUTCOMES(COs): After the completion of the course, the student will be able to

- CO1 Apply the governing equations and boundary conditions for conduction, convection, radiation, boiling, condensation, and mass transfer problems.(Apply - L3)
- CO2 Solve problems related to 1-D and 2-D steady and unsteady state heat transfer.(Apply - L3)
- CO3 Formulate the heat transfer equations to solve problems of conduction, convection, and radiation.(Apply - L3)
- CO4 Apply conduction convection and radiation heat transfer phenomenon for various geometries.(Apply - L3)
- CO5 Evaluate the heat transfer aspects for various thermal systems.(Apply - L3)

UNIT - I
INTRODUCTION: Modes of Heat transfer- Governing equations–Applications of heat transfer
STEADY STATE HEAT TRANSFER: Fins of Uniform and Non-Uniform cross sections, Internal heat generation -plane, cylinder, and sphere.

UNIT- II
TRANSIENT HEAT CONDUCTION: General Lumped capacitance analysis, Transient heat flow in finite and semi-infinite solid, use of Heisler chart.

UNIT- III
FORCED-CONVECTION: General review, Laminar Flow: a similarity solution, turbulent flow, mixed boundary layer conditions, flow across cylinders and spheres, tube banks – inline and staggered arrangement.
FREE-CONVECTION: Inclined and horizontal plates – the flow pattern and heat transfer, tubes, enclosures, simplified free convection relations for air, combined free and forced convection, External flows, Internal flows.

UNIT – IV
HEAT TRANSFER WITH PHASE CHANGE: Boiling modes, Pool boiling, flow boiling, Phase change in vertical flat plates, condensation: Nusselt's theory, Film condensation, drop-wise condensation.

UNIT – V
RADIATION: Review of radiation principles - laws of thermal radiation - Surface properties - radiative heat exchange among diffuse, gray and non-gray surfaces separated by nonparticipating media, Radiation transfer in enclosures containing absorbing and emitting media - interaction of radiation with conduction and convection, Radiation shields.

REFERENCES:

1. R.C.Sachdeva, Fundamentals of engineering heat and mass transfer, 5th edition, New Age Pub 2017
2. Yunus Cengel, Heat Transfer a basic approach –TMH, 2007
3 J.P.Holman,Heat Transfer – TMH, 2010
4. P.K Nag, Heat & Mass Transfer, TMH
5. Incropera, F. P. and De Witt, D. P., Fundamentals of Heat and Mass Transfer, 5th Edition, John Wiley & Sons, New York, 2006.

M.Tech(I Sem)			23TPE04–POWER PLANT MANAGEMENT	L	T	P	Cr
			Program Elective-I	3	-	-	3

Pre-requisites: Thermodynamics, IC Engines

COURSE EDUCATIONAL OBJECTIVES(CEOs): The course aims to equip the students with the analytical tools of economics and apply the skills for managerial decision making. It seeks to develop economic way of thinking in dealing with practical problems and challenges.To provide an idea of modern approaches to manage the power plant.

COURSE OUTCOMES(COs): After the completion of the course, students should be able to

CO1	Understand the principles of managerial economics for power plants(Understanding - L2)
CO2	Apply replacement techniques for economic running of the power plant(Apply - L3)
CO3	Comprehend the various steps in budgetary control(Understanding - L2)
CO4	Analyze the power plant performance and operating characteristics with tarifs and curves(Understanding - L2)
CO5	Understand the different aspects of personnel management and maintnance of power plant equipment(Understanding - L2)

UNIT – I

MANAGERIAL ECONOMICS: Concept of cost – Nature of profit – profit measurement – profit forecasting – depreciation – Depreciation calculation – value time function – straight line method – sinking fund method – sum of the years method – fixed percentage method and service output method – Calculation of capital recovered plus return in the above methods – depletion.

UNIT - II

REPLACEMENT STUDIES: Types of replacement studies – annual cost present worth - rate of return – MAPT approach to replacement studies.

UNIT – III

BUDGETARY CONTROL: Various steps in budgetary control – basic concepts – break ever charts – setting targets for profits, sales – manufacturing – variable cost budgeting.

UNIT – IV

POWER PLANT ECONOMICS: Energy demand management energy cost and crisis – investors profits – types of tariffs – plant performance and operating characteristics – input curve – efficiency curve.

UNIT – V

PERSONNEL MANAGEMENT: Purposes of training – training techniques and aids – guide for selecting a trainer – training by induction. Maintenance Management- Functions and responsibilities of maintenance engineering department – preventive maintenance, equipment records and check lists – maintenance of power plant equipment – coal bunkers chutes. Pulverizing equipment – stokers – fuel oil equipment. Material management and inventory management Act, 1910 – the Indian electricity rules, 1956.

REFERENCES:

1. Robert Henderson Emerick, Power plant Management , McGraw Hill, New York, 1965.

2. Production Handbook , Carson - et al. – John willey & Sons, New York, 1974.

3. Tara Chand, Engineering Economics, Nem Chand & Bros., Roorkee, 1988.

4. Murthy, P.S.R., Power system operation & control, Tata McGraw Hill, New Delhi, 1989.

M.Tech(I Sem)			23TPE05 – ANALYSIS AND DESIGN OF TURBO MACHINES	L	T	P	Cr
			Program Elective-I	3	-	-	3

Pre-requisites: Fluid mechanics and hydraulic machines, Thermodynamics, Steam turbines and gas turbines

COURSE EDUCATIONAL OBJECTIVES(CEOs): To learn about the Dimensional Analysis for Turbo machines, Performance levels of various pumps, Characteristics of fans, blowers, axial compressors, gas and wind turbines performance.

COURSE OUTCOMES(COs): After the completion of the course, students should be able to

CO1	Categorize different types of Turbo machines and its importance in Real Industries.(Understanding - L2)
CO2	Solve problems related to real compressors difficulties, steam nozzles.(Apply - L3)
CO3	Comprehend the concepts of fans, blowers and compressors and apply the knowledge in solving the problems.(Understanding - L2)
CO4	Describe different technologies used in Gas Turbine and Aviation Industries.(Understanding - L2)
CO5	Solve the Wind Turbine Problems.(Apply - L3)

UNIT – I
INTRODUCTION: Types of Turbo machines, Applications of Turbo machines, Performance Characteristics, Methods of Analysis
DIMENSIONAL ANALYSIS: Dimensions and Dimensional Homogeneity, Buckingham Pi Theorem, Other Non-dimensional Parameters for Turbo machines.
ENERGY TRANSFER IN TURBO MACHINES: Review on Fluid Mechanics Related to Turbo machinery, Energy in Flowing Fluids, Euler Equations, Equations for Axial Flow Machines, Equations for Mixed and Radial Flow Machines. Degree of Reaction

UNIT - II
CENTRIFUGAL PUMPS: Basic Construction and Classification, Basic Working Principles, Performance Characteristics, Cavitation, Performance Modifications, Preliminary Design Procedure, Pump Performance Tests Axial.
STEAM NOZZLES: Convergent and Convergent – Divergent nozzles,Energy balance,effect of backpressure on the analysis

UNIT – III
CENTRIFUGAL FANS BLOWERS AND COMPRESSORS: Classification Performance Parameters and Characteristics, Change of Performance, Polytropic Efficiency, Preliminary Design of Centrifugal Compressors
AXIAL FLOW COMPRESSORS: Introduction. Basic Theory, Preliminary Design of Compressor Stage, Determination of Stage Efficiency, Axial Flow Compressor Performance, Surge and Stall in Compressor and the Remedies

UNIT – IV
GAS TURBINES: Introduction, Thermodynamics of Axial Flow Turbine, Degree of Reaction, Preliminary Design Procedure for Turbine Stage, Determination of Turbine Stage Efficiency, Axial Flow Turbine Performance, Compressor, Turbine Matching, Radial Inflow Gas Turbine, Thermodynamic Processes in Radial Inflow Gas Turbine.
COMBUSTION CHAMBERS: Gas turbine combustion systems - Introduction, Geometry, Factors affecting Design & Performance, Requirements of the Combustion Chamber.

UNIT – V

WIND TURBINES: Introduction to Wind Power, Actuator Theory, Types of Wind Turbines, Wind Turbines Characteristics and Preliminary Design Analysis, Variable Speed Performance of Wind Turbines, Wind Turbine Applications.

STEAM TURBINES: Introduction,classification,advantages of steam turbines over steam engines, common types of turbines, methods of reducing wheel, impulse turbine, reaction turbine.

REFERENCES:

1. William W Perg, Fundamentals of Turbo machinery: John Wiley & Sons, Inc.
2. D. G. Shepherd, Principles of Turbo Machinery, The Macmillan Company
3. Cohen, H., Rogers, G.E.C., and Saravanamuttoo, Gas Turbine Theory, H.I.H Longman Group Ltd, John Wiely, 5th Edition 2001.
4. Philip Hill and Carl Peterson Mechanics and thermodynamics of Propulsion-, Prentice Hall
5. Dixon,Fluid Mechanics, Thermodynamics of Turbo machinery, Pergamon Press
6. Ganesan, V, Gas Turbines, Tata McGraw-Hill, New Delhi.
7. Mattingly J D, Elements of Gas turbine Propulsion, McGraw Hill, 1st Edition.1997.
8. Ganesan, V., Gas Turbines 3/e, Tata McGraw Hill Book Company, New Delhi, 2010

M.Tech(I Sem)			23TPE06–ADVANCED INTERNAL COMBUSTION ENGINES AND EMISSION CONTROL SYSTEMS	L	T	P	Cr
Program Elective-II				3	-	-	3

Pre-requisites: Thermodynamics, IC Engines

COURSE EDUCATIONAL OBJECTIVES(CEOs): To make the students familiar with the engine design parameters, cycle analysis, combustion phenomenon of SI and CI engines, engine heat transfer and modern trends in I.C. Engines, Electric vehicles and engine pollutants and its control.

COURSE OUTCOMES(COs): After the completion of the course, students should be able to

CO1	Discuss the engine design parameters along with the engine cycle analysis.(Understanding-L2)
CO2	Analyze the combustion phenomenon in S.I and C.I engines(Apply-L3)
CO3	Describe the engine energy transfer and modern trends used in I.C. Engines(Understanding-L2)
CO4	Comprehend the EV concepts, EV configurations and various HEV parameters for better understanding of the EV technology.(Understanding-L2)
CO5	Analyze the various pollutants from engine and apply different pollution control techniques to reduce the emissions.(Understanding-L2)

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

COMBUSTION IN SI 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, super charging and Turbo charging.

UNIT III

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.

UNIT IV

INTRODUCTION TO EV: Past, Present & Future of EV, Current Major Issues, Recent Development Trends, EV Concept, Key EV Technology, State-of-the Art EVs & HEVs, Comparison of EV Vs IC Engine. EV System: EV Configuration: Fixed & variable gearing, single & multiple motor drive, In-wheel drives, EV Parameters: Weight, size, force, energy & performance parameters.
INTRODUCTION TO HEV (Hybrid Electric Vehicle): Configuration of HEV (Series, Parallel, Series-parallel &Complex), Power Flow control, Power flow control in all HEV configurations.

UNIT V

POLLUTANT FORMATION AND CONTROL: Nature and extent of problems – Nitrogen Oxides, Carbon monoxide, unburnt Hydrocarbon and particulate – Emissions – Measurement – Exhaust Gas Treatment, Catalytic converter, Selective catalytic reduction, Particulate Traps, Lean, NO_X, Oxidation Catalysts, Diesel Particulate filters. Engine modifications to reduce emissions, Health and environmental effects of pollution,

REFERENCES:

1. John B. Heywood, Internal Combustion Engine Fundamentals, 3rd edition, McGraw-Hill series, 2008.
2. V.Ganesan, Internal Combustion Engines, 4th edition, Tata McGraw Hill Education Private Limited, 2013.
3. Paul Degobert, Automobiles and Pollution, SAE International, 1991.
4. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.
5. C.C Chan, K.T Chau: Modern Electric Vehicle Technology, Oxford University Press Inc., New York, 2001.
6. Ferguson C. R, Internal Combustion Engines, John Wiley ,1989.

M.Tech(I Sem)			23TPE07 – THERMAL SYSTEM ANALYSIS	L	T	P	Cr
			Program Elective-II	3	-	-	3

Pre-requisites: Thermodynamics, Heat Transfer and Fluid Mechanics

COURSE EDUCATIONAL OBJECTIVES(CEOs): Develop the awareness of thermodynamics, heat transfer and fluid mechanics in the design of integrated thermal systems. Design thermal systems to meet desired need within realistic limitations such as economic environmental, social, safety, manufacturability and sustainability.

COURSE OUTCOMES(COs): After the completion of the course, students should be able to

CO1	Understand principles of thermal system design principles(Understanding - L2)
CO2	Develop mathematical modelis for optimization systems(Apply - L3)
CO3	Apply modeling and simulation tools for thermal equipments(Apply - L3)
CO4	Comprehend the various programming methods for systems optimization(Apply - L3)
CO5	Analyze the dynamic behavoiur of thermal systems using different techniques(Apply - L3)

UNIT – I
DESIGN OF THERMAL SYSTEM: Design Principles, Workable systems, Optimal systems, Matching of system components, Economic analysis, Depreciation, Gradient present worth factor.

UNIT - II
MATHEMATICAL MODELLING: Equation fitting, Nomography, Empirical equation, Regression analysis, Different modes of mathematical models, selection, computer programmes for models.

UNIT – III
MODELING THERMAL EQUIPMENTS: Modelling heat exchangers, evaporators, condensers, absorption and rectification columns, compressor, pumps, simulation studies, information flow diagram, solution procedures.

UNIT – IV
SYSTEMS OPTIMIZATION: Objective function formulation, Constraint equations, Mathematical formulation, Calculus method, Dynamic programming, Geometric programming, Linear programming methods, solution procedures

UNIT – V
DYNAMIC BEHAVIOR OF THERMAL SYSTEM: Steady state simulation, Laplace transformation, Feedback control loops, Stability analysis, Non-linearties.

REFERENCES

1. J.N. Kapur, Mathematical Modelling, Wiley Eastern Ltd., New York, 1989.

2. W.F. Stoecker, Design of Thermal Systems, McGraw Hill, 1980.

3. W.F. Stoecker, Refrigeration and Airconditioning, TMH, 1985.

4. Fanger P.O., Thermal Comport, McGraw Hill, USA, 1972.

5. McQuiston FC & Parker TD, Heating, Ventilating and Air conditioning, Analysis and Design, John Wiley & Sons, USA, 1988

M.Tech(I Sem)			**23TPE08 – ADVANCED NUMERICAL METHODS**	**L**	**T**	**P**	**Cr**
Program Elective-II				3	-	-	3

Pre-requisites: Engineering Mathematics

COURSE EDUCATIONAL OBJECTIVES(CEOs): To impart knowledge on numerical methods that will come in handy to solve numerically the problems that arise in engineering and technology. This will also serve as a precursor for future research.

COURSE OUTCOMES(COs): After the completion of the course, students should be able to

CO1 Differentiate differential equations for solving engineering problems(Apply - L3)
CO2 Apply ordinary differential equations for FEM and FDM(Apply - L3)
CO3 Apply FDM for solving complex engineering problems.(Apply - L3)
CO4 Develop FDM for solving elliptical equations.(Apply - L3)
CO5 Analyze thermal systems using Finite element method (Apply - L3)

UNIT – I

ALGEBRAIC EQUATIONS: Systems of linear equations: Gauss Elimination method, pivoting techniques, Thomas algorithm for tridiagonal system – Jacobi, Gauss Seidel, SOR iteration methods - Systems of nonlinear equations: Fixed point iterations, Newton Method, Eigenvalue problems: power method, inverse power method, Faddeev – Leverrier Method.

UNIT - II

ORDINARY DIFFERENTIAL EQUATIONS: Runge Kutta Methods for system of IVPs, numerical stability, Adams-Bashforth multistep method, solution of stiff ODEs, shooting method, BVP: Finite difference method, orthogonal collocation method, orthogonal collocation with finite element method, Galerkin finite element method.

UNIT – III

FINITE DIFFERENCE METHOD FOR TIME DEPENDENT PARTIAL DIFFERENTIAL EQUATION: Parabolic equations: explicit and implicit finite difference methods, weighted average approximation - Dirichlet and Neumann conditions – Two dimensional parabolic equations – ADI method; First order hyperbolic equations – method of characteristics, different explicit and implicit methods; numerical stability analysis, method of lines – Wave equation: Explicit scheme- Stability of above schemes.

UNIT – IV

FINITE DIFFERENCE METHODS FOR ELLIPTIC EQUATIONS: Laplace and Poisson’s equations in a rectangular region: Five point finite difference schemes, Leibmann’s iterative methods, Dirichlet and Neumann conditions – Laplace equation in polar coordinates: finite difference schemes – approximation of derivatives near a curved boundary while using a square mesh

UNIT – V

FINITE ELEMENT METHOD: Partial differential equations – Finite element method - orthogonal collocation method, orthogonal collocation with finite element method, Galerkin finite element method.

REFERENCES

1. Saumyen Guha and Rajesh Srivastava, “Numerical methods for Engineering and Science”,
Oxford Higher Education, New Delhi, 2010.
2. Gupta S.K., “Numerical Methods for Engineers”, New Age Publishers, 1995
3. Burden, R.L., and Faires, J.D., “Numerical Analysis – Theory and Applications”, Cengage

Learning, India Edition, New Delhi, 2009.18

4. Jain M. K., Iyengar S. R., Kanchi M. B., Jain , "Computational Methods for Partial Differential Equations", New Age Publishers,1993.

5. Morton K.W. and Mayers D.F., "Numerical solution of partial differential equations", Cambridge University press, Cambridge, 2002.

M.Tech(I Sem)			23AC01 – DISASTER MANAGEMENT	L	T	P	Cr
			Audit Course-01	2	-	-	0

Pre-requisites: NIL

COURSE EDUCATIONAL OBJECTIVES(CEOs): To provide students an exposure to disasters, their significance and types, the relationship between vulnerability, understanding of approaches of Disaster Risk Reduction, awareness of institutional processes in the country and ability to respond to their surroundings with potential disaster response in areas where they live, with due sensitivity.

COURSE OUTCOMES(COs): After the completion of the course, students should be able to

CO1	Differentiate the types of disasters, causes and their impact on environment and society.(Understanding - L2)
CO2	Assess vulnerability and various methods of risk reduction measures as well as mitigation(Understanding - L2).
CO3	Understand inter-relationship between disasters and development.(Understanding - L2)
CO4	Comprehend disaster risk management in India.(Understanding - L2)
CO5	Realize disaster management applications, case studies and field works.(Understanding - L2)

UNIT – I
INTRODUCTION TO DISASTERS
Definition: Disaster, Hazard, Vulnerability, Resilience, Risks – Disasters: Types of disasters – Earthquake, Landslide, Flood, Drought, Fire etc – Classification, Causes, Impacts including social, economic, political, environmental, health, psychosocial, etc.- Differential impacts- in terms of caste, class, gender, age, location, disability – Global trends in disasters: urban disasters, pandemics, complex emergencies, Climate change- Dos and Don‘ts during various types of Disasters.

UNIT - II
APPROACHES TO DISASTER RISK REDUCTION (DRR)
Disaster cycle – Phases, Culture of safety, prevention, mitigation and preparedness community based DRR, Structural- non-structural measures, Roles and responsibilities of- community, Panchayati Raj Institutions/Urban Local Bodies (PRIs/ULBs), States, Centre, and other stake-holders- Institutional Processes and Framework at State and Central Level- State Disaster Management Authority(SDMA) – Early Warning System – Advisories from Appropriate Agencies.

UNIT – III
INTER-RELATIONSHIP BETWEEN DISASTERS AND DEVELOPMENT
Factors affecting Vulnerabilities, differential impacts, impact of Development projects such as dams, embankments, changes in Land-use etc.- Climate Change Adaptation- IPCC Scenario and Scenarios in the context of India – Relevance of indigenous knowledge, appropriate technology and local resources.

UNIT – IV
DISASTER RISK MANAGEMENT IN INDIA
Hazard and Vulnerability profile of India, Components of Disaster Relief: Water, Food, Sanitation, Shelter, Health, and Waste Management, Institutional arrangements (Mitigation, Response and Preparedness, Disaster Management Act and Policy – Other related policies, plans, programmes and legislation – Role of GIS and Information Technology Components in Preparedness, Risk Assessment, Response and Recovery Phases of Disaster – Disaster Damage Assessment

UNIT – V
DISASTER MANAGEMENT: APPLICATIONS, CASE STUDIES AND FIELD WORKS

Landslide Hazard Zonation: Case Studies, Earthquake Vulnerability Assessment of Buildings and Infrastructure: Case Studies, Drought Assessment: Case Studies, Coastal Flooding: Storm Surge Assessment, Floods: Fluvial and Pluvial Flooding: Case Studies; Forest Fire: Case Studies, Man Made disasters: Case Studies, Space Based Inputs for Disaster Mitigation and Management and field works related to disaster management.

REFERENCES:

1. Singhal J.P. Disaster Management, Laxmi Publications, 2010. ISBN-10: 9380386427 ISBN-13: 978-9380386423
2. Tushar Bhattacharya, Disaster Science and Management, McGraw Hill India Education Pvt. Ltd., 2012. ISBN-10: 1259007367, ISBN-13: 978-1259007361
3. Gupta Anil K, Sreeja S. Nair. Environmental Knowledge for Disaster Risk Management, NIDM, New Delhi, 2011
4. Kapur Anu Vulnerable India: A Geographical Study of Disasters, IIAS and Sage Publishers, New Delhi, 2010.
5. S. C. Sharma, Disaster management, Khanna Book Publishing Co. (P) Ltd, 2018, ISBN 10:9386173387, ISBN 13:9789386173386

		L	T	P	Cr.
M.Tech. (I Sem.)	**23TPI01 - MINI PROJECT**	-	-	4	2

**Pre-requisites : ** Knowledge in theory courses studied in First and Second Semesters

COURSE EDUCATIONAL OBJECTIVE(CEOs): To make the students plan and execute a mini project independently using the available resources in the institute.

COURSE OUTCOMES(COs): After the completion of the course, students should be able to

CO1 Plan a technical task based on the domain of problem

CO2 Translate ideas in solving thermal problems by simulation work or making a working model

CO3 Develop the ability to execute a mini project independently

CO4 Prepare a well organized technical report

M.Tech. (I Sem.) **23TPE61 - THERMAL SYSTEMS LAB**

L	T	P	Cr.
-	-	4	2

Pre-requisites **:** Thermodynamics, Heat transfer, Internal combustion engines**.**

COURSE EDUCATIONAL OBJECTIVES(CEOs): The main objective of this laboratory is to familiarize the basic principles and its recent advancements in the area of Internal Combustion engines for Graduates and Post graduates. To study and analyze the various performance parameters such as fuel consumption, frictional power, mechanical efficiency etc. The graduates are empowered with principles of working and its performance analysis on Refrigerator, Air Conditioner, Air compressor, solar concentrator and fuel testing apparatus. It also focuses on to measure the amount of exhaust emissions coming from the engines and creating awareness among the graduates about its impact on the global environment.

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

CO1 Understand on the fuel characterization.(Understanding - L2)
CO2 Analyze the performance characteristics of an internal combustion engines(Apply - L3)
CO3 Evaluate the performance parameters of refrigeration systems(Apply - L3)
CO4 Analyze the air compressor characteristics (Apply - L3)
CO5 Evaluate the performance parameters of parabolic solar collector(Apply - L3)

LIST OF EXPERIMENTS

At least 10 Experiments are required to be conducted.

1. Performance test and analysis of exhaust gases on single cylinder 4-Stroke diesel Engine by using rope brake dynamometer.
2. Performance Test on Variable Compression Ratio on single cylinder 4-Stroke petrol Engine by using Eddy Current Dynamometer
3. Performance test on VCR System.
4. Performance test on Multi stage Air Compressor unit.
5. Performance test on Air conditioning unit.
6. Performance analysis of heat pipe.
7. Determination of thermal conductivity of composite material.
8. Critical Heat Flux Apparatus
9. Shell and Tube Heat Exchanger.
10. Counter Flow Heat Exchanger.
11. Combustion analysis of computer aided CI engine test rig.
12 Performance test on solar parabolic collector.
13. Determination of thermal conductivity of given liquid

		L	T	P	Cr.
M.Tech. (I Sem.)	**23TPE62 - SIMULATION LAB**	-	-	4	2

Pre requisites: Theory courses in Heat Transfer and Numerical Methods

COURSE EDUCATIONAL OBJECTIVES(CEOs): To make the student understand

1. solution of problems of heat conduction using fem software
2. solving problems involving heat transfer from fins by writing program codes in MAT lab software
3. solving problems containing flow and heat transfer using FVM software

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

CO1 Solve heat transfer problems and solve them using MAT lab (Apply - L3)

CO2 Compute heat transfer problems using FEM software(Apply - L3)

CO3 Simulate problems involving flow and heat transfer using ANSYS(Analyze - L4)

LIST OF NUMERICAL PROBLEMS:

The following problems are solved using MATLAB, FEM and FVM softwares.

Any TEN numerical problems.

1.Study of simulation software Like ARENA , MATLAB. FEM and FVM softwares.

2. Simulation of translational and rotational mechanical systems

3.Simulation of Queuing systems

4. Two dimensional steady state heat conduction in a slab.

5. One dimensional unsteady state heat conduction in a slab.

6. Heat transfer from a rectangular fin.

7. Heat transfer from a triangular fin.

8. Laminar flow through a rectangular duct.

9. Laminar natural convection from a vertical plate.

10. Parallel flow double pipe heat exchanger.

11. Counter flow heat exchanger.

12. Solution of a Tridiagonal matrix (TDM) using Thomas algorithm.

13. Solution of a second order ordinary differential equation by fourth-order Runge Kutta Method.

14. Solution of simultaneous first order ordinary differential equations by fourth-order Runge-Kutta Method.

R23-Regulations(w.e.f A.Y.2023-24)

M.Tech-Thermal Power Engineering

Detailed Syllabus
(Second Semester)

Pre-requisites: Fluid Mechanics, Fluid Dynamics

M.Tech(II Sem)			23TPE09–COMPUTATIONAL FLUID DYNAMICS	L	T	P	Cr
Program Core				3	-	-	3

COURSE EDUCATIONAL OBJECTIVES (CEOs):
To introduce numerical modeling in the field of heat transfer and fluid flow.
To enable the students to understand the various discretization methods and solving methodologies.
To solve complex problems in the field of heat transfer and fluid dynamics using high speed computers

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

CO1: Apply the Navier-Stokes equation to solve the fluid flow problems. (Applying Level – L3).
CO2: Solve the hyperbolic, elliptic problems using mathematical techniques. (Applying Level - L3).
CO3: Differentiates the FEM, FDM and FVM techniques (Understanding Level – L2).
CO4: Compute the fluid flow and heat transfer problems using CFD basics. (Applying Level – L3).
CO5: Estimate the error analysis in CFD applications. (Analysing Level – L4).

UNIT - I
COMPUTATIONAL FLUID DYNAMICS
What, When, and Why? CFD Advantages and Applications, Fundamental principles of conservation, Reynolds transport theorem, Conservation of mass, Conservation of linear momentum: Navier-Stokes equation, Conservation of Energy, General scalar transport equation. Approximate Solutions of Differential Equations: Error Minimization Principles, Functional involving higher order derivatives, Essential and natural boundary conditions,

UNIT- II
MATHEMATICAL DESCRIPTION OF PHYSICAL PHENOMENON
Introduction, Governing differential equations, Nature of the coordinates, Classification of Quasi-Linear Partial Differential Equations - Hyperbolic Equations, Parabolic Equations, Elliptic Equations, Time dependent methods.

UNIT- III
DISCRETIZATION METHODS
Finite Element Method and Finite difference methods: Well posed boundary value problem, Possible types of boundary conditions, Conservativeness, Boundedness, Transportiveness, Finite volume method (FVM), Illustrative examples and Some Conceptual Basics and Implementation of boundary conditions. Discretization of Unsteady State Problems: 1-D unsteady state diffusion problems: implicit, fully explicit and Crank - Nicholson scheme

UNIT – IV
FINITE DIFFERENCE APPLICATIONS IN FLUID FLOW, HEAT CONDUCTION AND CONNECTION

A Finite Volume Method to solve NS Equations in 3D Complex Geometry (Part-3); Turbulent Flow and Heat Transfer**,** Fundamentals of fluid flow modelling, elementary finite difference quotients, implementation aspects of finite difference equations, Discretization, consistency, stability, explicit and implicit methods, Conduction, steady heat conduction in a rectangular geometry, transient heat conduction finite difference application in convective heat transfer, Discretization, consistency, stability.

UNIT – V
SOLUTION OF SYSTEMS OF LINEAR ALGEBRAIC EQUATIONS
Criteria for unique solution, infinite number of solutions and no solution, Solution techniques for systems of linear algebraic equations: Elimination, Iteration and Gradient Search methods with examples. Norm of a vector, Norm of a matrix, Some important properties of matrix norm, Error analysis of elimination methods.

REFERENCES:

1. John. D. Anderson, Computational fluid dynamics – The basics with Applications - Mc Graw Hill 6th Edition 1995.

2. Dr. Atual Sharma, Introduction to Computational Fluid Dynamics: Developments, Applications and Analysis, Athena Academic and Wiley (UK), 1st Edition 2017.

3. K.A. Hoffman and Steve T Chiang, Computational Fluid Dynamics, Vol.I, 4th Edition, Engineering Education System Publications.

4. Suhas V Patankar, Numerical heat transfer and Fluid flow, Taylor and Francis, 1st Edition, 1980.

5. Tannehill, J.E., Anderson, D.A., and Pletcher, R.H., Computational Fluid Mechanics and Heat Transfer, 2nd ed., Taylor & Francis, 1997.

L	T	P	Cr.

M.Tech. (II Sem.)	23TPE10-RENEWABLE ENERGY TECHNOLOGY	3	-	-	3

Program Core

Pre-requisites: Non-conventional energy sources

COURSE EDUCATIONAL OBJECTIVES(CEOs): To make the student familiar in need of alternative energy resources, sensitize about solar energy radiation and measurement devices and also to recognize the source and potential of wind energy, geothermal, biomass and direct energy conversion systems.

COURSE OUTCOMES(COs): After the completion of the course, students should be able to

CO1: Identify the solar energy measurement devices and its applications.(Understanding - L2)
CO2: Analyse performance of non-concentrating and concentrating collectors.(Understanding- L2)
CO3: Estimate the power output of wind turbine and ocean energy conversion plants. (Understanding - L2)
CO4: Comprehend power generation from geothermal energy and bio-energy.(Understanding - L2)
CO5: Demonstrate the power generation from direct energy conversion systems and hydrogen as potential fuel.(Understanding - L2)

UNIT I
INTRODUCTION: Energy Scenario, Survey of energy resources. Classification and need for conventional energy resources. Sun , Earth relationship, Basic matter to waste heat energy circuit, Solar Radiation, Attention, Radiation measuring instruments.
SOLAR ENERGY APPLICATIONS: Solar water heating. Space heating, Active and passive heating. Energy storage. Selective surface. Solar stills and ponds, solar refrigeration, Photovoltaic power generation.

UNIT II
SOLAR THERMAL ENERGY TECHNOLOGY
Performance Analysis of Non-concentrating Solar Collectors, Useful Heat Output Of A Non-concentrating Solar Collector, Efficiency Of Non-concentrating Solar Collectors, Performance Analysis Of Concentrating Solar Collectors, Useful Heat Output of a Solar Concentrating Collector, Efficiency of Concentrating Solar Collectors, Performance Of A Line-Focus Concentrating Collector, Performance Of Point-Focus Concentrating Collectors, Solar Thermal Electrical Power Plants and its Performance Parabolic Trough Solar Power Plants, Solar Power Tower Power Plants, Parabolic Dish, Integrated Solar Combined-Cycle System (ISCC).

UNIT III
WIND ENERGY SYSTEMS
Rise of Wind Powered Electricity – Modern Era, Origin of Wind, Wind Types, Fundamental equation of wind power, Efficiency in extracting wind power, Power curve of a wind turbine, Lift and Drag forces of wind turbines, Wind Turbine types, Wind Power Control Systems and Electronics.
ENERGY FROM OCEANS: Tidal energy, Tides, Power from tides, Wave Energy, Waves, Theoretical energy available. Wave power systems, Submerged devices. Ocean thermal Energy, Principles.

UNIT IV
GEOTHERMAL ENERGY: Structure of earth, Geothermal Regions, Hot springs. Hot Rocks, Hot Aquifers. Analytical methods to estimate thermal potential. Harnessing techniques, Electricity generating systems.

BIO-ENERGY: Biomass energy sources. Plant productivity, Biomass wastes, aerobic and Anaerobic bioconversion processes, Raw material and properties of biogas, Biogas plant technology and status, the energetic and economics of biomass systems, Biomass gasification.

UNIT V

DIRECT ENERGY CONVERSION: Fuel cells and photovoltaic cell, Thermionic power generation, Thermoelectric generation, MHD power generator.

HYDROGEN GAS AS FUEL: Production methods, Properties, I.C. Engine applications, Utilization strategy, Performance.

REFERENCES:

1. Renewable Energy Resources, Basic Principles and Applications/ G.N.Tiwari and M.K.Ghosal/ Narosa Publications,2001.
2. Renewable Energy Resources, Basic Principles and Applications/ G.N.Tiwari and M.K.Ghosal/ Narosa Publications, 2000.
3. Biological Energy Resources/ Malcolm Fleischer & Chris Lawis/ E&FN Spon, 2002.
4. Renewable Energy Sources / G.D Rai /Khanna Publishers. 1998.

M.Tech(II Sem)			23TPE11-EQUIPMENT DESIGN FOR THERMAL SYSTEMS	L	T	P	Cr
			Program Elective-III	3	-	-	3

Pre-requisites: Advanced Heat and Mass Transfer, Refrigeration and cryogenics

COURSE EDUCATIONAL OBJECTIVES(CEOs): To know the design procedure of heat exchangers related to different thermal applications like condensers, evaporators, cooling towers etc. and cooling of electronic components.

COURSE OUTCOMES(COs): After the completion of the course, students should be able to

CO1: Apply LMTD and NTU approaches to solve problems on parallel, counter, and cross flow heat exchangers. (Applying Level -L3).

CO2: Analyze the design procedures in shell and tube heat exchangers. (Analysis Level -L4).

CO3: Describe the working procedures and calculate the heat transfer aspects in condenser and evaporators. (Understanding Level -L2).

CO4: Distinguishes the performance parameters in cooling tower performance and heat pipe applications. (Understanding Level -L2).

CO5: Analyze the various techniques for cooling electronic equipment. (Analsysis Level -L4).

UNIT – I

CLASSIFICATION OF HEAT EXCHANGERS:

INTRODUCTION- Recuperation & Regeneration-Tubular heat exchangers-Double pipe, Shell and Tube heat exchangers, Plate heat exchanger Exchangers-Plate fin and Tubular fin heat exchangers

BASIC DESIGN METHODS OF HEAT EXCHANGERS: Basic equations in Design, Overall heat transfer coefficient-LMTD method for heat exchanger analysis-Parallel flow, counter flow, Multi pass,

CROSS FLOW HEAT EXCHANGER DESIGN CALCULATIONS – Effectiveness method (NTU))-Keys and London charts-Compact Heat exchangers – Heat Transfer optimization

UNIT - II

DOUBLE PIPE HEAT EXCHANGER:

Film coefficient for fluids in annulus, fouling factors, calorific temperature, Average fluid temperature, 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

CONDENSERS & EVAPORATORS:

Types of Condensers-Air cooled condenser –Water cooled condensers-Evaporative Condensers-Heat Transfer in condensers- Types of Evaporators-Heat transfer in Evaporators-Pool boiling – Heat transfer coefficient for Nucleate pool boiling-Flow or forced convection boiling-Forced convection boiling correlations.

UNIT – IV

DIRECT CONTACT HEAT EXCHANGERS:

Cooling towers, relation between wet bulb & dew bulb temperatures, and calculation of cooling tower performance. Heat Pipe: Gravity assisted thermo-syphons, micro heat pipes, pulsating heat pipes, loop heat pipe operation& working principles.

UNIT – V

COOLING OF ELECTRONIC EQUIPMENT: Introduction-The chip carrier-Printed circuit boards-Cooling load of electronic equipment

CONDUCTION COOLING: Conduction in chip carriers-conduction in printed circuit boards-heat frames.

AIR COOLING: Natural convection and radiation- Forced convection- Fan selection-cooling personal computers and Heat Pipes.

REFERENCES:

1. Necati Ozisik, Heat Transfer –TMH, 1985
2. C.P.Arora, Refrigeration & Air-Conditioning TMH, 2001
3. J.D. Gurney, Maclaren Cooling Towers – (London)
4. A.P. Frass and M.N. Ozisik, Heat Exchanger Design- John Wieley& Sons, New York
5. Arora &Domkundwar., Heat and mass transfer by Dhanpat Rai and Company
6. Stoecker, Refrigeration & Air-Conditioning by McGrawHill Company
7. Dossat, Refrigeration & Air Conditioning by Prentice Hall of India CompanyCourse

M.Tech. (II Sem.)

L	T	P	Cr.

23TPE12–THERMAL MEASUREMENT AND PROCESS CONTROL

Program Elective-III

3	-	-	3

Pre-requisites : ** Fluid Mechanics,** Instrumentation

COURSE EDUCATIONAL OBJECTIVES(CEOs): To familiarize the various methods of measuring temperature, pressure and velocity using advanced techniques.

COURSE OUTCOMES(COs): After the completion of the course, students should be able to

- CO1 Identify the concepts of temperature measurements.(Remembering - L1)
- CO2 Comprehend the various techniques of pressure measurement.(Understanding - L2)
- CO3 Understand the various principles for velocity measurement.(Understanding - L2)
- CO4 Discuss the Analog methods used in Electro-Mechanical Systems.(Understanding - L2)
- CO5 Describe the digital techniques in Mechanical Measurements. (Understanding - L2)

UNIT – I

THERMOMETRY AND HEAT FLUX MEASUREMENT: Overview of thermometry, Thermoelectric temperature measurement and measurement of thermal EMF, Resistance thermometry, Pyrometer, Other methods, issues in measurements Heat flux measurement.

UNIT - II

PRESSURE AND FLOW MEASUREMENT: Introduction, Barometers, Manometers, Dial type pressure gauge, Pressure Transducers, Pitot, Static, and Pitot-Static Tube and Its characteristics, Flow measurement, flow obstruction methods, magnetic flow meters and Low-Pressure Measurement Gauges

UNIT – III

VELOCITY MEASUREMENT: Introduction, Velocity & Mach number from pressure measurements, Laser droplet anemometer- LDA Principle, Doppler shift equation, Reference beam system, Fringe system. Measurement of velocity by Hot-Wire Anemometer, Measurement of velocity using vortex shedding Technique, Fluid Jet Anemometer, Mass & volume flow measurement

UNIT – IV

ANALOG METHODS: Introduction, Hale-Shaw Apparatus, Electrolytic Tank, Hydraulic Analogy, Hydraulic Jumps -Simple Harmonic Relations-circular and cyclic Frequency

UNIT – V

DIGITAL TECHNIQUES IN MECHANICAL MEASUREMENTS: Fundamental Digital Circuit Elements, Binary Codes , Simple Digital Circuitry-Digital computer as a measurements system tool-Data Processors, Microcomputers-Analog to Digital and Digital to Analog Conversion

REFERENCES

1. Bechwith-Marangoni-Lienhard –Mechanical Measurements –5th Edition
2. E. Rathakrishnan, Instrumentation, Measurements and Experiments in Fluids, CRC press, 2007.
3. Jack Philip Holman, Walter J. Gajda, Experimental methods for Engineers, 4th Edition: McGraw-Hill, 1984.
4. Ernest, O. D., Measurement Systems - Applications and Design, Tata McGraw Hill Book Company, New Delhi, 2011
5. Beckwith, Nelson Lewis Buck, Mechanical Measurements, Thomas GE 5th Edition: Wesley Pub. Co., 1961.
6. Holman, J. P., Experimental Methods for Engineers, Tata McGraw Hill Book Company, New Delhi, 2010.

M.Tech. (II Sem.)	23TPE13 – ENERGY CONSERVATION AND MANAGEMENT	L	T	P	Cr.
	Program Elective-III	3	-	-	3

Pre-requisites: Thermodynamics, Thermal engineering, Heat Transfer, MEFA

COURSE EDUCATIONAL OBJECTIVES(CEOs):
To provide detailed understanding of energy conservation and management, 3Es (Energy, Economics and Environment) and their interaction, energy audit and financial management.

COURSE OUTCOMES(COs): At the end of the course, the student will be able to
CO1: Discuss the fundamentals of energy management and energy conservation (Understanding - L2)
CO2: Comprehend the energy audit procedures for energy conservation.(Understanding - L2)
CO3: Analyze the performance of various thermal systems and methods of energy conservation for waste heat recovery in various thermal systems.(Apply - L3)
CO4: Evaluate energy projects on the basis of economic and financial criteria.(Apply - L3)
CO5: Discuss the climate policy and associated developments around the globe.(Remembering - 1)

UNIT – I
ENERGY CONSERVATION: Principles of energy conservation, Energy conservation act 2001 and its features. Available resources of non renewable energy and scope of conversion. Need for organizing and managing energy management program. Energy policy, energy pricing and need for energy security.

UNIT – II
ENERGY AUDIT: Concept and types of energy audits, Audit process Guidelines for writing energy audit report, data presentation in report, finding recommendations, impact of renewable energy on energy audit recommendations and energy audit report. Energy audit recommendations of building systems, Lighting systems, HVAC systems, water heating systems. Instruments for conducting energy audit and monitoring energy savings.

UNIT – III
ENERGY CONSERVATION IN THERMAL UTILITEIES: Energy conservation in boilers and furnaces, Energy conservation in steam and condensate systems. Concept of co generative systems and types of co generative systems
WASTE HEAT RECOVERY: Potential benefits of waste heat recovery, Quantifying waste heat, Classification of waste heat by its quality. Storage of waste heat and equipment for waste heat recovery.

UNIT – IV
ENERGY ECONOMICS: Time value of money, cash flow diagrams, formulae relating present and future cash flows- single amount, uniform series and uniform gradient series. Life cycle cost analysis: Simple payback period, net present worth, net annual worth, internal rate of return, benefit cost ratio.

UNIT – V
CLIMATE POLICY: Kyoto protocol, clean development mechanism (CDM), Geo policies of GHG control; Carbon market

REFERENCES:

1. Energy Management Hand book, W.C Turner, John Wiley and sons, A wiley inter science publication.
2. Hand book of Energy Audits, Albert Thumann, 6th edition, The fair mount press
3. Bureau of Energy Efficiency Reference book: 1,2,3,4
4. Energy Engineering and Management, Amlan Chakrabarti, PHI learning private limited.

M.Tech. (II Sem.)

23TPE14 - FINITE ELEMENT METHODS IN HEAT HEAT TRANSFER

Program Elective-IV

L	T	P	Cr.
3	-	-	3

Pre-requisites : Mathematics, Fluid mechanics and heat transfer

COURSE EDUCATIONAL OBJECTIVES(CEOs): To make the students exposed to the study of finite element methods to solve the structural and thermal problems of various geometries.

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

- CO1 Develop different types of formulation techniques and static analysis of bars.(Apply - L3)
- CO2 Describe the principles of governing equations' in fluid flows and exposure upon the growth of boundary layer(Understanding - L2)
- CO3 Calculate velocity fields potentials and forces in fluid flows (Apply - L3)
- CO4 Develop the idea about the compressible fluid flows and gives ability to solve the problems related to compressible flows.(Apply - L3)
- CO5 Develop the ability in design of fluid flow systems(Apply - L3)

UNIT - I

FORMULATION TECHNIQUES: Potential energy method, Raleigh Ritz method, Galerkin and weighted residual methods, calculus of variations, Essential and natural boundary conditions, introduction to FEM.

1-D STATIC ANALYSIS OF BARS: Element matrices, assembling of global stiffness matrix, Application of boundary conditions, Elimination and penalty approaches, solution for displacements, reaction, stresses, temperature effects, Stiffness matrix for a Quadratic Element.

UNIT - II

1-D STEADY-STATE HEAT TRANSFER: FE Formulation using linear and quadratic elements, Numerical problems in composite walls and fins of uniform cross section using linear elements.

1-D TRANSIENT HEAT TRANSFER: Derivation of element matrices, solution techniques, A numerical problem with 2 elements.

UNIT - III

2-D STEADY-STATE HEAT TRANSFER: FE Formulation using linear triangle elements, Problem modeling and boundary conditions.

Isoparametric formulation, Numerical integration (1-D, 2-D).

UNIT - IV

INTERPOLATION FUNCTIONS: Compatibility and completeness requirements, Selection of polynomials and derivation of interpolation functions for 1-D and 2-D elements

UNIT - V

APPLICATIONS IN FLUID MECHANICS: Finite Element formulation of 1-D and 2-D Steady, incompressible, inviscid, irrotational fluid flows, Problem modeling and boundary conditions.

REFERENCES:

1. David V.Hutton – Fundamentals of Finite Element Analysis, Tata Mc Graw Hill
2. S.S. Rao – The finite element method in Engineering- BH Publication
3. Chandraputla & Belagondu –Introduction to Finite elements in Engineering
4. J.N. Reddy - Finite element method in Heat transfer and fluid dynamics, CRC press

M.Tech. (II Sem.)	23TPE15 - POLLUTION: SOURCES, EFFECTS AND CONTROL Program Elective-IV	L	T	P	Cr.
		3	-	-	3

Pre-requisites: ICGT

COURSE EDUCATIONAL OBJECTIVES (CEOs): To impart knowledge on the atmosphere and eco legislations, classification of air, water and land pollution and their sources, pollution sampling and analysis, hazardous waste management and controlling pollution in industries.

COURSE OUTCOMES (COs): After completion of the course, the student will be able to

CO1: Understand the atmospheric pollutants and eco legislations. (Applying– L3)

CO2: Classify air, water and land pollutants and sources. (Understanding - L2)

CO3: Analyse various pollutants from industries. (Analyse– L3)

CO4: Manage hazardous wastes in industries. (Understanding - L2)

CO5:Understand various methods of controlling pollution in industries. (Understanding -L2)

UNIT I

POLLUTION CONTROL PHILOSOPHY: chemical pollution of the aquatic environment-regulation of direct discharge-regulation. Chemistry and pollution of marine environment-sources, movement and behavior of pollutants.

UNIT II

WATER POLLUTION BIOLOGY: chemical contaminants - drinking water quality and health-sources ofcontamination-drinking water standards-microbiological quality.Sewage treatment processes - Sludge treatment and disposal. Sources and types of toxic wastes-treatment of toxic waste-disposal of toxic wastes.

UNIT III

AIR POLLUTION: sources, concentration and measurements, Air quality management-indoor air quality. Effects of air pollution on health, crops, trees and ecosystems. Control of air pollution- emission standards. Chemistry and climate change in Troposphere, Stratosphere. Atmospheric dispersal of pollutants and Modelling of air pollution.

UNIT IV

SOIL POLLUTION AND LAND CONTAMINATION: sources-properties-consequences of soil pollution-case studies-Solid waste management.Radioactivity in the environment-types of radiation-effects of radiation-radioactive waste treatments and disposal.Noise pollution – sources and effects - standards and control.

UNIT V

CLEAN TECHNOLOGIES AND INDUSTRIAL ECOLOGYL: environmental behavior of persistent organic pollutants. Integrated pollution prevention and control-design for the environment. Pollution prevention planning- Legal control of pollution-National Law-trends and issues in pollution legislation.

REFERENCES:

1. Harrison, RM., *Pollution causes, effects and control*, 4th Edition, Royal Society of Chemistry,2001.
2. Bishop, P., *Pollution Prevention: Fundamentals and Practice*, McGraw-Hill International Edition, McGraw-Hill book Co, Singapore, 2000.
3. Sincero AP., and Sincero, GA., *Environmental Engineering – A Design Approach*, PrenticeHall of India Pvt Ltd, New Delhi, 2002.

4. Rao, CS., *Environmental pollution engineering*, Wiley Eastern Limited, New Delhi, 1992.
5. Mahajan, SP., *Pollution control in process industries*, Tata McGraw Hill Publishing Company,New Delhi, 1993.
6. Masters G., *Introduction to Environmental Engineering and Science*, Prentice Hall of India PvtLtd, New Delhi, 2003.

M.Tech. (II Sem.) 23TPE16-THEORY&TECHNOLOGY OF FUEL CELL

Program Elective-IV

L	T	P	Cr.
3	-	-	3

Pre-requisites : Thermodynamics, Fluid mechanics, Engineering chemistry

COURSE EDUCATIONAL OBJECTIVES(CEOs): The main objective of this course is to understand the principle of operation and constructional features of fuel cells.

COURSE OUTCOMES(COs): After completion this course, student will be able to

- CO1 Describe the principle of operation of fuel cell technology.(Ubderstanding - L2)
- CO2 Understand the electrochemistry of fuel cells.(Ubderstanding - L2)
- CO3 Analyze the characteristics of fuel cell systems.(Apply - L3)
- CO4 Design a fuel cell system.(Apply - L3)
- CO5 Apply the economics of fuel cell technology.(Apply - L3)

UNIT - I

INTRODUCTION TO THE PRINCIPLES AND OPERATION OF FUEL CELL TECHNOLOGY- Fundamental aspects of fuel cell systems-Types of fuel cells- Stack configurations-Relative advantages and disadvantages of different types of fuel dells.

UNIT - II

ELECTROCHEMISTRY OF FUEL CELLS- Introduction-General characteristics of principal types of fuel cells-Thermodynamics and electrode kinetics of fuel cells-Elements of the fuel cells.

UNIT - III

CHARACTERISTICS OF FUEL CELL SYSTEMS- Efficiency-Cell efficiency-Carnot machines and fuel cells-Part load characteristics-Response time, Spinning reserve capability-Emissions-Modularity-Life time-Safety and Materials.

UNIT - IV

SYSTEM DESIGN AND OPTIMIZATION- Introduction- The importance of fuel cell system Integration-The Design of a fuel cell systems- The optimization of a fuel cell systems- Load response- Cogeneration

UNIT - V

FUEL CELL SYSTEM ECONOMICS-Introduction-Installed cost estimating and cost reduction-Sensitivity analyses- Comparison with conventional power generation technologies

REFERENCES:

1. Fuel Cell System, edited by Leo J.M.J. Blomen and michael N. Mugerwa, New York, Plenum Press, 1993.
2. Fuel Cell Handbook, by A. J. Appleby and F. R. Foulkers, Van Nostrand, 1989.
3. Fuel Cell Handbook, by EG & G Technical services , Inc

	L	T	P	Cr.
M.Tech. (II Sem.) **23AC02 - ENGLISH FOR RESEARCH PAPER WRITING**	2	-	-	0

Audit Course-02

Pre-requisites **:** English

COURSE E D U C A T I O N A L OBJECTIVES(CEOs): To develop technical writing skills necessary to communicate informationgained through a process of technical or experimental work.

COURSE OUTCOMES(COs): After the completion of the course, students should be able to

CO1	Identify appropriate research topics for college classes. (Remembering - L1)
CO2	Draft detailed outlines for research papers and find source material for researchpapers. (Understanding - L2)
CO3	Develop and organize good practices for research. (Understanding - L2)
CO4	Apply appropriate academic tone and language. (Apply - L3)
CO5	Identify plagiarism status of resources. (Understanding - L2)

UNIT – I

INTRODUCTION TO QUALITATIVE RESEARCH: Introduction, The Qualitative Researcher, Quantitative vs. qualitative research, History of qualitative research, the process of qualitative research, Major paradigms & perspectives, Dominant paradigms of qualitative research, Interpretivist thinking, Verstehen, Constructivism, Properties of constructions, Constructivism: Sub paradigms, Criticisms of interpretivism & constructivism.

UNIT – II

CRITICAL THEORY: Characteristics of critical theory, Critiques of critical theory, Strategies of inquiry, Introduction to qualitative inquiry, Qualitative research design, Ethnography, Auto ethnography, Case studies, Analyzing interpretive practice, Grounded Theory, Participatory Action Research.

UNIT – III

METHODS OF COLLECTING & ANALYSING EMPIRICAL MATERIALS:

Observations,interviewing, Interpretation of documents & material culture, Images & visual methods, Auto ethnography, personal narrative & reflexivity.

UNIT – IV

ANALYZING TALK & TEXT, DATA MANAGEMENT & ANALYSIS METHODS:

Software & qualitative research, Interpretation, evaluation & presentation, The problem of criteria, Interpretation, Writing, Evaluation and social programs, Qualitative research and social policy, What, why and how of technical and research writing.

UNIT – V

LITERATURE REVIEW: Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check. 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. useful phrases, how to ensure paper is as good as it could possibly be the first- time submission.

REFERENCES:

1. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books)

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 DordrechtHeidelberg London, 2011

M.Tech. (II Sem.) **23TPE63-RENEWABLE ENERGY TECHNOLOGY LAB**

L	T	P	Cr.
-	-	4	2

Pre-requisites **:** Renewable Energy Sources

COURSE EDUCATIONAL OBJECTIVES(CEOs): This laboratory is mainly focused to make the students to understand the basic concepts involved in solar thermal systems, i.e., Flat plate collector, concentrator and solar PV systems and its calculation procedures.

COURSE OUTCOMES(COs): After the completion of the course, students should be able to

CO1	Discuss the principles of renewable energy conversion techniques.(Understanding-L2)
CO2	Estimate the performance characteristics of renewable energy devices. (Apply - L3)
CO3	Estimate the performance of renewable energy devices. (Apply - L3)
CO4	Comprehend the performance parameters of the renewable energy devices. (Understanding - L2)

LIST OF EXPERIMENTS

1. To evaluate the performance of a solar parabolic trough system under different atmospheric and design parameters with water and oil used as working fluids.
2. The solar PV training system covers the fundamentals of solar PV system as well as basic research on PV system
3. A Solar Grid-tied System is a grid connected PV system which links solar power generated by the PV modules to the mains.
4. Solar PV Emulator is a programmable power supply designed to emulate solar panels.
5. Efficiency and other transport measurements in the presence of light of photovoltaic modules, materials and devices
6. Effects of temperature of PEM Fuel cell and electrolyzer system.
7. Comparing the effects of electrical load on fuel cell and rechargeable batteries
8. Compare the polymer Electrolyte Membrane and Direct Methanol fuel cells.
9. Study of renewable energy cost analysis on solar, wind, photovoltaic cells
10. Biomass energy converter

M.Tech. (II Sem.) **23TPE64-COMPUTATIONAL FLUID DYNAMICS LAB**

L	T	P	Cr.
-	-	4	2

Pre-requisites: Computational Fluid Dynamics

COURSE EDUCATIONAL OBJECTIVES(CEOs): To solve the problems of fluid flow and heat transfer and build up the skills in the actual implementation of CFD methods for 1D and 2D heat conduction and convection problems and aquire skills in thermal analysis of the same.

COURSE OUTCOMES(COs): After the completion of the course, students should be able to

CO1: Develop codes for numerical methods to tackle simple problems. (Apply - L3)

CO2: Build up the skills in the actual implementation of CFD methods for 1D and 2D heat conduction problems (Apply - L3)

CO3: Analyze and validate output of written codes with analytical solution. (Analyze - L4)

CO4: Develop skill in CFD analysis to real engineering designs. (Analyze - L4)

LIST OF EXPERIMENTS

1. Steady state heat transfer analysis through circular fins
2. 2D heat conduction analysis of rectangular slab using ansys fluent
3. Fluid flow analysis of rotating cylinder using ansys fluent
4. 2D periodic simulation of heat exchanger using ansys fluent
5. CFD simulation of a pipe in ansys fluent
6. Transient thermal analysis of convection of bar in air
7. A turbulent fluid flow and heat transfer problem in a mixing elbow using ansys fluent
8. Fluid flow analysis of a radiator using ansys fluent
9. Fluid flow fluent analysis of a helical coil
10. Fluid flow fluent analysis of two phase flow in a Horizontal pipe
11. Analysis of water flow in a converging pipe using ansys fluent
12. Analysis of two dimensional laminar flow using ansys fluent

M.Tech. (III Sem.) **23TPE17 - DESIGN OF EXPERIMENTS**

Program Elective-V

L	T	P	Cr.
3	-	-	3

Pre-requisites : Probability and Statistics, Mathematics

COURSE EDUCATIONAL OBJECTIVES(CEOs):
This course provides the concepts of analyzing the experimental data and design of experiments. It covers the basics of probability, sampling and analyzing the experimental data, concepts of single and several factors experimental design criteria. Further, the regression analysis and optimization of the parameters are addressed in this course.

COURSE OUTCOMES(COs): After the completion of this course, the student will be able to:

- CO1 Identify the need for the strategies of design of experiments and probability.
- CO2 Acquire the knowledge of random variables used in the experimental strategies
- CO3 Analyze the vast experimental data using the sampling criteria.
- CO4 Design the experiments with single factor and several factors.
- CO5 Apply the regression analysis and response surface methods to optimize the parametric data.

UNIT-I
INTRODUCTION: Strategy of experimentation, some typical applications of experimental design, Basic principles, Guidelines for designing experiments, a brief history of statistical design, using statistical design in experimentation.
BASICS OF PROBABILITY: Random experiments, sample space and events, interpretation of probability, axioms of probability, conditional probability, probability rules, Baye's theorem.

UNIT-II
RANDOM VARIABLES: Definition, attributes of a random variable, types of random variables, examples
DISCRETE RANDOM VARIABLES: Introduction, probability distributions and probability mass functions, cumulative distribution function, mean and variance of a discrete random variable, Binomial and Poisson distribution.
CONTINUOUS RANDOM VARIABLES: Introduction, probability distributions and probability density functions, cumulative distribution function, mean and variance of a continuous random variable, normal distribution.

UNIT-III
SIMPLE COMPARATIVE EXPERIMENTS: Introduction, Basic statistical concepts, Sampling and Sampling Distribution, Inferences about the Differences in means, randomized designs, paired comparison Designs, Inferences about the Variances of Normal Distributions.

UNIT-IV
DESIGN AND ANALYSIS OF EXPERIMENTS WITH SINGLE FACTOR: Basic principles and guidelines of design of experiments, single factor experiments, Analysis of Variance (ANOVA), block design
DESIGN AND ANALYSIS OF EXPERIMENTS WITH MULTIPLE FACTORS: Introduction to Factorial design, the two factor factorial design, general factorial design, 2^k factorial designs, confounding and blocking in factorial designs

UNIT-V
REGRESSION ANALYSIS: Introduction, simple linear regression analysis, multiple linear regression model, model adequacy checking.
RESPONSE SURFACE METHODOLOGY: Response surface methodology, parameter, optimization, robust parameter design and its application to control of processes with high variability.

REFERENCES:

1. Montgomery D.C., Runger G. C., Applied Statics and Probability for Engineers, John Wiley
2. Montgomery D.C., Design and Analysis of Experiments, John Wiley.
3. Robert L. Mason, Richard F. Gunst, James L. Hess, Statistical Design and Analysis of Experiments: With Applications to Engineering and Science, John Wiley.
4. Montgomery D.C., Peck E.A., Vining G.G., Introduction to Linear Regression Analysis, John Wiley.
5. Myres R.H., Montgomery D.C., Anderson-Cook C.M., Response Surface Methodology: Process and Product Optimization Using Designed Experiments, John Wiley.

L	T	P	Cr.
3	-	-	3

M.Tech. (III Sem.) **23TPE18 - ALTERNATE FUELS FOR IC ENGINES**

Program Elective-V

Pre-requisites: IC Engines

COURSE EDUCATIONAL OBJECTIVES(CEOs): To expose students to the area of alternate fuels necessity and applications in IC engines.

COURSE OUTCOMES(COs): After the completion of the course, students should be able to
CO1: Understand the biofuel production methods and their characterization using various equipments. (Understanding - L2)

CO2: Describe the technique of reformation of biofuel fuel and alcohol fuel and its utilization in internal combustion engines.(Understanding - L2)

CO3: Analyze the fuel characterization for combustion and emission (Analyze - L4)

CO4: Understand the scenario of bio gas fuel utilization and their performance features in internal combustion engine.(Understanding - L2)

CO5: Understand prospects of various gaseous fuels utilization in the transportation system(Understanding - L2)

UNIT-I
BIO FUEL PRODUCTION AND CHARACTERIZATION:
Vegetable oil – biofuel production methods – pyrolysis, fermentation, catalytic cracking and transesterification process – characterization of fuel – physical and chemical properties, Gas Chromatograph and Mass Spectroscopy (GC-MS) analysis, Fourier Transformation Infrared (FTIR) analysis, Thermo Gravimetric (TG) analysis and elemental analysis – suitability – merits and demerits

UNIT-II
REFORMATION OF LIQUID FUEL:
Reformation of liquid fuels – requirements and utilisation techniques – emulsions preparation – surfactant – ignition accelerators – nano particles in blends and neat form – storage and safety - characterization fuel - engine modification – dual fuelling – fuel induction mechanism – surface ignition – performance and emission characteristics of SI and CI engine56

UNIT-III
ALCOHOL FUEL AND FUEL ADDITIVES
Ethanol utilization in SI engine – prospects of methanol usage in CI engine – various methods of preparing bio additives – DEE, DME, and DIPE – cetane improvers – fuel oxygenates – bio surfactant – nanoparticles usage in biofuel – characterization of fuel – Scanning Electron Microscopic (SEM) analysis, Electron Dispersive Spectrum (EDS) analysis

UNIT-IV
BIOGAS UTILIZATION
Biomass sources – biogas production, collection and storage – gas analysis – GC-MS analysis – gas composition – cleaning of gas – non combustible gases and water vapour – engine modification and method of induction – gas carburettors – dual fuel mode in CI engine – performance feature of biogas on CI engine – merits and demerits of biogas utilization

UNIT-V
GASEOUS FUEL
Hydrogen – Natural Gas (NG) and Liquefied Petroleum Gas (LPG) – Compressed Natural Gas (CNG) – gas analysis – properties – storage and safety precautions – engine modification – fuel induction method – gas

injectors – injection methods – electronic engine management – performance of gaseous fuelled engine – combustion, performance and emission characteristics – merits and demerits

REFERENCES:

1. Osamu Hiarao and Richard K. Pefiey, Present and Future Automotive Fuels. John Wiley and Sons, 1988.

2. Duffy Smith, Auto fuel systems, the Good Heart Willcox Company Inc. Publishers, 1987

3. Ashok V.Desai, Alternative Liquid Fuels, New Age International Publishers, 2004.

4. V Ganesan, Internal Combustion Engines (Fourth Edition)Tata McGraw-Hill Education Pvt. Ltd, 2013

L	T	P	Cr.
3	-	-	3

M.Tech. (III Sem.) **23TPE19 - COMPUTATIONAL HEAT TRANSFER**

Program Elective-V

Pre-requisites: Advanced Heat Transfer, Computational Fluid Dynamics

COURSE EDUCATIONAL OBJECTIVES(CEOs): To expose students to the computational methods to solve conduction and convection heat transfer problems using FDM, FEM techniques

COURSE OUTCOMES(COs): After the completion of the course, students should be able to

CO1: Understand the fundamental mathematical concepts related to computational heat transfer(Understanding - L3)

CO2: Apply the fundamental mathematical concepts for fluid flow and heat transfer(Apply - L3)

CO3: Analyze the usage of computational codes for conduction and convection(Analyze - L4)

CO4: Apply the CFD techniques to convection and diffusion problems.(Apply - L3)

CO5: Apply FEM to solve various fluid and heat transfer problems(Apply - L3)

UNIT-I

MATHEMATICAL DESCRIPTION OF PHYSICAL PHENOMENA: Governing Differential Equation - Energy Equation - Momentum Equation - Nature of Co-ordinates - Discretization Methods

UNIT-II

FINITE DIFFERENCE METHODS IN PARTIAL DIFFERENTIAL EQUATIONS: Parabolic Equations - Explicit, Implicit and Crank Nicholson Methods. Finite Differences in Cartesian and Polar Co-ordinates. Local Truncation Error - Consistency Convergence - Stability - ADI Methods. Elliptic Equations - Laplace's Equation. Laplace's Equation in a Square - Non rectangular Regions - Mixed Boundary Condition - Jacobi - Gauss- Siedel and SOR Methods. Necessary and Sufficient Conditions for Iterative Methods Finite Difference

UNIT-III

APPLICATIONS IN HEAT CONDITION AND CONVECTION: Control Volume Approach - Steady and Unsteady One Dimensional Conduction Two and Three Dimensional Situations - Solution methodology.

UNIT-IV

CONVECTION AND DIFFUSION: Upwind Scheme - Exponential Scheme. Hybrid Scheme - Power Law Scheme : Calculation of the Flow Field - Simpler Algorithm.

UNIT-V

FINITE ELEMENT METHOD CONCEPT: General Applicability of the Method using one dimensional heat transfer equation - Approximate Analytical Solution - Raleigh's Method. Galerikin Method, Solution Methods. 42 Finite Element Method Packages - General Procedure - Discretisation of the domain - Interpolation Polynomials - Formulation of Element Characteristic Matrices and Vectors - Direct, Variational and Weighted - Residual Approach - Higher Order Isoparametric Element Formulations Conduction and Diffusion Equations - Heat Transfer Packages - Heat 2, HEATAX, RADIAT, ANSYS.

REFERENCES:

1. Subash V.Patankar, Numerical Heat Transfer and Fluid Flow, Hemisphere Publishing Corporation, 1980

2. Jaluria and Torrance, Computational Heat Transfer - Faluria and Torrance, Hemisphere Publishing Corporation, 1986.

3. Mitchell A.R and Grifths D.F., Finite Difference Method in Partial Differential Equations, John Wiley & Sons, 1980.

4. Rao S.S., The Finite Element Methode in Engineering, Pergamon Press – 1989.

5. Zienkiewicz O.C. and Taylor R.L., The Finite Element Method IV Edition - Vol. I & II, McGraw Hill International Edition, 1991

L	T	P	Cr.
3	-	-	3

M.Tech. (III Sem.) 23TPE81 - OPTIMIZATION METHODS IN ENGINEERING

Open Elective

Pre-requisites : Operations Research, Probability and Statistics

COURSE EDUCATIONAL OBJECTIVES(CEOs): Introduce the concepts of numerical optimization algorithms and formulate the engineering design problems as a mathematical optimization problem.

COURSE OUTCOMES(COs): At the end of the course the student able to

CO1	Demonstrate knowledge and understanding of the basic ideas underlying optimization techniques.
CO2	Demonstrate knowledge and understanding of some of the most common standard optimization models.
CO3	Develop mathematical optimization models for a range of practical problems.
CO4	Formulate large-scale linear and integer programming problems and then solve the problem.
CO5	Solve complex thermal engineering problems by using mathematical models.

UNIT - I

LINEAR PROGRAMMING: Introduction to Linear Programming, Two phase Simplex method, Big-M method ,duality, interpretation, applications.

UNIT - II

ASSIGNMENT PROBLEMS: Hungarian's algorithm, Degeneracy, applications, unbalanced problems, travelling salesman problem.

CLASSICAL OPTIMIZATION TECHNIQUES: Single variable optimization with and without constraints, multi-variable optimization without constraints, multi-variable optimization with constraints-method of Lagrange multipliers, Kuhn- Tucker conditions.

UNIT -III

NUMERICAL METHODS FOR OPTIMIZATION: Nelder Mead's Simplex search method, Gradient of a function, steepest descent method, Newton's method, types of penalty methods for handling constraints.

UNIT - IV

GENETIC ALGORITHM (GA): Introduction, Differences and similarities between conventional and evolutionary algorithms, working principle, reproduction, crossover, mutation, termination criteria, different reproduction and crossover operators, GA for constrained optimization, draw backs of GA.

UNIT - V

APPLICATIONS OF OPTIMIZATION IN DESIGN AND MANUFACTURING SYSTEMS: Some typical applications like optimization of path synthesis of a four-bar mechanism, minimization of weight of a cantilever beam, optimization of springs and gears, general optimization model of a machining process, optimization of arc welding parameters, and general procedure in optimizing machining operations sequence.

REFERENCES:

1. Rao, S. S., Optimization Theory and Applications, Wiley Eastern Ltd., 2nd Edition, 2004.

2. Fox, R. L., Optimization Methods for Engineering Design, Addison Wesley, 2001.

3.JasbirArora, Optimal design McGraw-Hill Publishers

4.Kalyanmoy Deb, Optimization for Engineering Design- PHI publishers

5.S.S.Rao, Engineering Optimization- New Age Publishers

6.D.E. Goldberg, Genetic algorithms in Research, Optimization and Machine learning- Addison Wesley Pub

7.J.R.Koza,M.A.keane,J.Yu,F.H.Bennett, Genetic Programming, 2000-Springer

	L	T	P	Cr.
	3	-	-	3

M.Tech. (III Sem.) **23TPE82 - NANO TECHNOLOGY**

Open Elective

**Pre-requisites : ** Engineering Physics, Engineering Chemistry

COURSE EDUCATIONAL OBJECTIVES(CEOs): To make the students exposed to the study of nano materials, nano material preparation and characterization and its applications.

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

- CO1 Acquire knowledge upon the basics of nano materials.
- CO2 Get an exposure upon various types of synthesis adopted to prepare a nano material.
- CO3 Know the fabrication of nano material using different techniques.
- CO4 Develop the idea about the various ways of nano material availability and applications.
- CO5 Get an exposure to the thermal characterization of nano materials for thermal systems.

UNIT – I

INTRODUCTION TO NANOMATERIALS: Properties of materials & nanomaterials, role of size in nanomaterials, nanoparticles, semiconducting nanoparticles, nanowires, nanoclusters, quantum wells, conductivity and enhanced catalytic activity compared to the same materials in the macroscopic state.

UNIT – II

CHEMICAL ROUTES FOR SYNTHESIS OF NANOMATERIALS: Chemical precipitation and co-precipitation; Metal nanocrystals by reduction, Sol-gel synthesis; Microemulsions or reverse micelles, myle formation; Solvothermal synthesis; Thermolysis routes, Microwave heating synthesis; Sonochemical synthesis; Electrochemical synthesis, Photochemical synthesis, Synthesis in supercritical fluids.

UNIT – III

FABRICATION OF NANO MATERIALS BY PHYSICAL METHODS: -Inert gas condensation, Arc discharge, Plasma arc technique, RF plasma, MW plasma, Ion sputtering, Laser ablation, Laser pyrolysis, Ball Milling, Molecular beam epitaxy, Chemical vapour deposition method and Electro deposition.

NANOCOMPOSITES: An Introduction: Types of Nano composite (i.e. metal oxide, ceramic, glass and polymer based); Core-Shell structured nano composites Super hard Nano composite: Synthesis, applications and milestones.

UNIT – IV

NANO CERAMICS: Dielectrics, ferroelectrics and magneto ceramics, Magnetism; Dia-, Para-, Ferro-, Anti ferro-, Ferri-magnetism, Magnetic properties; Gaint magneto resistance, Tunneling magneto resistance, Colossal magneto resistance, Super paramagnetism High Tc materials: YBCO and Bi-systems (Brief idea), Superconducting nano-materials & their properties and applications. Carbon Nano Structures: DLCs, Fullerenes, C60, C80 SWNT and MWNT; Properties: Mechanical, Optical and Electrical properties.

UNIT – V

THERMO ELECTRIC MATERIALS (TEM): Concept of phonon, Thermal conductivity, Specific heat, Exothermic & Endothermic processes. Bulk TEM Properties, Different types of TEM; One dimensional TEM; Composite TEM; Applications.

REFERENCES:

1. Nanochemistry:A chemical approach to nanomaterials by G.A.Ozin,A.C.Aresnault, L.Cadematriri,RSC Publishing
2. Microfabrication and Nanomanufacturing- Mark James Jackson
3. Chemistry Of nanomaterials : Synthesis, Properties and applications by CNR Rao et.al.
4. Nanoparticles: From Theory to applications– G.Schmidt, Wiley Weinheim 2004.
5. Fabrication Of fine pitch gratings by holography, electron beam lithography and nano - Imprint lithography (Proceedings Paper) Author(s): Darren Goodchild; Alexei Bogdanov; Simon Wingar; Bill Benyon; Nak Kim; Frank Shepherd
6. A Three Beam Approach To TEM Preparation Using In- Situ Low Voltage Argon Ion Final Milling
7. Instrument E L Principe, P Gnauck and P Hoffrogge, Microscopy and Microanalysis (2005),11:830 - 831 Cambridge University Press.
8. Processing & Properties of structural nano materials - Leon L. Shaw (editor)
9. Nanochemistry: A Chemical approach to Nanomaterials Royal Society of Chemistry, CambridgeUK2005.1.Nanocomposite science and technology P.M.Ajayan, L.S.Schadler, P.V.Braun,Wiley,NewYork.

M.Tech. (III Sem.)	23TPE83 - WASTE MANAGEMENT AND ENERGY GENERATION TECHNIQUES	L	T	P	Cr.
		3	-	-	3

Open Elective

Pre-requisites: Power Plant Engineering

COURSE EDUCATIONAL OBJECTIVES (CEOs): To impart knowledge on the atmosphere and eco legislations, classification of air, water and land pollution and their sources, pollution sampling and analysis, hazardous waste management and controlling pollution in industries.

COURSE OUTCOMES (COs): After completion of the course, the student will be able to

CO1: Understand the recent energy generation techniques (Understanding - L2)

CO2: Describe various methods of waste management (Understanding - L2)

CO3: Analyse recent technologies of waste disposal and energy generatio. (Analyse– L3)

CO4: Realize on the importance of healthy environment (Understanding - L2)

CO5: Understand the problem in a sensible and realistic manner (Understanding -L2)

UNIT-I

SOLID WASTE: Definitions - Sources, Types, Compositions, Properties of Solid Waste - Municipal Solid Waste - Physical, Chemical and Biological Property - Collection - Transfer Stations - Waste Minimization and Recycling of Municipal Waste

UNIT-II

WASTE TREATMENT: Size Reduction - Aerobic Composting - Incineration - Furnace Type & Design, Medical / Pharmaceutical waste Incineration -Environmental Impacts - Measures to Mitigate Environmental effects due to Incineration.

UNIT-III

WASTE DISPOSAL: Land Fill Method of Solid Waste Disposal - Land Fill Classification, Types, Methods & Siting Consideration - Layout & Preliminary Design of Land Fills - Composition, Characteristics, generation, Movement and Control of Landfill Leachate & Gases Environmental Monitoring System for Land Fill Gases

UNIT-IV

HAZARDOUS WASTE MANAGEMENT: Definition & Identification of Hazardous Waste - Sources and Nature of Hazardous Waste - Impact on Environment - Hazardous Waste Control - Minimization and Recycling - Assessment of Hazardous Waste Sites - Disposal of Hazardous Waste, Underground Storage Tanks Construction, Installation & Closure Energy Generation from Waste: Types - Biochemical Conversion - Sources of Energy Generation - Industrial Waste, Agro Residues.

UNIT-V

ANAEROBIC DIGESTION: Biogas Production - Types of Biogas Plant Thermochemical Conversion - Sources of Energy Generation - Gasification - Types of Gasifiers - Briquetting - Industrial Applications of Gasifiers - Utilization and Advantages of Briquetting - Environmental Benefits of Biochemical and Thermochemical Conversion

REFERENCES:

1. Parker, Colin, & Roberts, Energy from Waste - An Evaluation of Conversion Technologies, Elsevier Applied Science, London, 1985

2. Shah, Kanti L., Basics of Solid & Hazardous Waste Management Technology, Prentice Hall, 2000.

3. Manoj Datta, Waste Disposal in Engineered Landfills, Narosa Publishing House, 1997

4. Rich, Gerald et.al., Hazardous Waste Management Technology, Podvan Publishers, 1987

5. Bhide AD., Sundaresan BB, Solid Waste Management in Developing Countries, INSDOC New Delhi, 1983

M.Tech. (III Sem.) **23TPI02 - INDUSTRY/RESEARCH INTERNSHIP**

L	T	P	Cr.
-	-	4	2

Pre-requisites : Knowledge in the courses studied in first and second semester

COURSE EDUCATIONAL OBJECTIVES(CEOs): To make the students undergo internship training in a core industry independently and submit a report.

COURSE OUTCOMES(COs): After the completion of the course, students should be able to

CO1	Apply the course concepts to take up a technical task in industry
CO2	Acquires the knowledge on the mechanism and process of the system/plant.
CO3	Develop the ability to interpret the technical data independently
CO4	Ability to prepare a well organized technical report.

M.Tech. (III Sem.) **23TPI103 - PROJECT WORK & DISSERTATION (PHASE-I)**

L	T	P	Cr.
-	-	16	8

Pre-requisites : Knowledge in the courses studied in first and second semester

COURSE EDUCATIONAL OBJECTIVE(CEO): To make the students plan and execute a mini project independently using the available resources in the institute.

COURSE OUTCOMES(COs): After the completion of the course, students should be able to

CO1 Identify a topic in advanced areas of thermal engineering

CO2 Review literature to identify gaps and define objectives & scope of the work

CO3 Employ the ideas from literature and develop research methodology

CO4 Develop a model, experimental set-up and / or computational techniques necessary to meet the objectives.

M.Tech. (IV Sem.) 23TPI104 - PROJECT WORK & DISSERTATION (PHASE-II)

L	T	P	Cr.
-	-	32	16

Pre-requisites : Knowledge in the courses studied in first and second semester and the knowledge gained in executing the Dissertation phase-I

COURSE EDUCATIONAL OBJECTIVE(CEO): To make the students plan and execute a mini project independently using the available resources in the institute.

COURSE OUTCOMES(COs): After the completion of the course, students should be able to

CO1 Identify methods and materials to carry out experiments/develop code

CO2 Reorganize the procedures with a concern for society, environment and ethics

CO3 Analyze and discuss the results to draw valid conclusions

CO4 Prepare a report as per the recommended format and defend the work.

CO5 Explore the possibility of publishing papers in peer reviewed journals/conference proceedings.