DEPARTMENT OF MECHANICAL ENGINEERING

COURSE STRUCTURE & SYLLABUS
M.Tech ME for
THERMAL ENGINEERING PROGRAMME

Semester I						
Sr. No.	**Core/Elective**	**Course Name**				**Credits**
			L	**T**	**P**	**Total**
1	20METE1	Advanced Thermodynamics	3	0	0	3
2	20METE2	Advanced Fluid Mechanics	3	0	0	3
3	20METEPE1	1. Computational Fluid Dynamics 2.Advanced I.C engine, Electric and Hybrid Vehicles 3. Gas Dynamics 4. Advanced Automobile Engineering	3	0	0	3
4	20METEPE2	1. Gas Turbines 2. Alternative Fuel Technologies 3. Energy Conservation and Management 4. Thermal And Nuclear Power Plants	3	0	0	3
5	20METE3	Research Methodology and IPR	2	0	0	2
6	20METE4	Computational Fluid Dynamics Lab - I	0	0	4	2
7	20METE5	Thermal Engineering Lab - I	0	0	4	2
8	20METEA1	English For Research Paper Writing	2	0	0	0
	Total Credits		**18**			
Semester II						
Sr. No.	**Core/Elective**	**Course Name**				**Credits**
			L	**T**	**P**	
1	20METE6	Advanced Heat Transfer	3	0	0	3
2	20METE7	Thermal Measurements and Process Controls	3	0	0	3
3	20METEPE3	1. Equipment Design for Thermal Systems 2. Solar Energy Technologies 3. Theory and Technology of Fuel Cells 4. Fuels, Combustion ,Emissions and Environment	3	0	0	3
4	20METEPE4	1. Renewable Energy Technologies 2. Cryogenic Engineering 3. Modeling of I.C engines 4.Jet Propulsion And Rocketry	3	0	0	3
5	20METE8	Computational Fluid Dynamics Lab - II	0	0	4	2
6	20METE9	Thermal Engineering Lab - II	0	0	4	2
7	20METE10	Mini Project with Seminar	0	0	4	2
8	20METEA2	Value Education	2	0	0	0
	Total Credits				**18**	

Semester III						
Sr. No.	**Core/Elective**	**Course Name**				**Credits**
			L	**T**	**P**	
1	20METEPE5	1. Advanced Optimization Techniques 2. Design and Analysis of Experiments 3. Convective Heat Transfer 4. Waste to Energy 5. Advanced finite element methods (OR) MOOCS/ NPTEL certification courses duly approved by the Department	3	0	0	3
2	20METEOE1	1. Waste as a source of energy 2. Operations Research 3. Advanced Numerical Methods 4. Composite Materials. (OR) MOOCS/ NPTEL certification courses duly approved by the Department	3	0	0	3
3	20METE11	Phase – I Dissertation	0	0	20	10
4	**Total Credits**					**16**

Semester IV						
Sr. No.	**Core/Elective**	**Course Name**				**Credits**
			L	**T**	**P**	
1	20METE12	Phase-II Dissertation	0	0	32	16
2	**Total Credits**					**16**

GRAND TOTAL CREDITS: - 68

20METE1 Advanced Thermodynamics

3 0 0 3

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

SNO	DESCRIPTION
CO.1	Explain Maxwell's and thermodynamic relations of gas mixtures.
CO.2	Identify the models to estimate the properties of real gases.
CO.3	Analyze chemical reaction and combustion of gas-mixtures
CO.4	Compare vapour and Gas power cycles.
CO.5	Apply the knowledge of Direct Energy Conversion of Fuel Cells.

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO.1	3	3	2	2	-	-	-	-	2	2	-	-	2	2
CO.2	3	3	2	2	-	-	-	-	2	2	-	-	2	2
CO.3	3	3	2	2	-	-	-	-	2	2	-	-	2	2
CO.4	3	3	2	2	-	-	-	-	2	2	-	-	2	2
CO.5	3	3	2	2	-	-	-	-	2	2	-	-	2	2

UNIT-I **10HOURS**

AVAILABILITY AND IRREVERSIBILITY: Quality of Energy, available and unavailable energy, availability, surroundings work, reversible work and irreversibility, availability in a closed system, availability in a SSSF process in an open system, second law efficiencies of processes, second law efficiency of cycles and exergy balance equations.

UNIT-II **10HOURS**

THERMODYNAMIC PROPERTY RELATIONS: Helmholtz and Gibbs Functions, two Mathematical Conditions for Exact Differentials, Maxwell Relations, Clapeyron Equation, Relations for Changes in Enthalpy, Internal Energy and Entropy, Specific Heat Relations, Generalized Relations/Charts for Residual Enthalpy and Entropy, Gibbs Function at zero Pressure: A Mathematical Anomaly, Fugacity, Fugacity Coefficient and Residual Gibbs Function, The Joule, Thomson Coefficient and Inversion Curve, Thermodynamic similarity.

UNIT-III **10HOURS**

NON-REACTING MIXTURES OF GASES AND LIQUIDS: Measures of Composition in Multi Component Systems.

Gas Mixtures: Mixtures of ideal Gases, Gas-Vapor Mixtures, Application of First Law to Psychometric Processes, Real Gas Mixtures.

Liquid Mixtures/Solutions: Ideal Solutions, Real Solutions.

Thermodynamic Relations for Real Mixtures: Partial Properties, Relation for Fugacity and Fugacity Coefficient in Real Gas Mixtures, Relations for Activity and Activity Coefficient in Real Liquid Mixtures/Solutions.

UNIT-IV **10HOURS**

PHASE EQUILIBRIUM :VAPOUR LIQUID EQUILIBRIUM OF MIXTURES: Phase Diagrams for Binary Mixtures, Vapor, Liquid Equilibrium in Ideal Solutions, Criteria for Equilibrium, Criterion foe phase Equilibrium, Calculation of Standard State Fugacity of Pure Component, Vapor Liquid Equilibrium at Low to Moderate Pressures, Determination of Constants of Activity Coefficient Equations, Enthalpy Calculations.

UNIT-V **10HOURS**

CHEMICAL REACTIONS AND COMBUSTION: Thermo chemistry, Measures of Composition in Chemical Reactions, Application of First Law of Thermodynamics to chemical Reactions, the Combustion Process-Standard Heat/Enthalpy of Combustion, Reactions at actual Temperatures, adiabatic Flame Temperature, Entropy Change of Reacting Systems, Application of second Law of Thermodynamics to chemical Reactions,chemical equilibrium-Advancement of Chemical Reactions, Equilibrium Criterion in Chemical Reactions, equilibrium Constant and Law of Mass Action, Equilibrium Constant for Gas Phase Reactions in the standard state.

TEXT BOOKS:

1. Basic and Applied Thermodynamics, P.K.Nag, TMH, 2019.
2. Thermodynamics, J.P Holman, Mc Graw Hill, 2017.
3. Thermodynamics ,CP Arora, Mc Graw Hill education (India pvt limited), 2016.

REFERENCES:

1. Engg. Thermodynamics, PL.Dhar, Elsevier, 2008.
2. Thermodynamics, Sonnatag & Van Wylen, John Wiley & Sons, 2004.
3. Thermodynamics for Engineers, Doolittle-Messe, John Wiley & Sons, 2018.
4. Irreversible thermodynamics, HR De Groff, .
5. Thermal Engineering, Soman, PHI, 2011.
6. Thermal Engineering, Rathore, TMH, 2010.
7. Engineering Thermodynamics, Chatopadyaya, 2010.

20METE2 Advanced Fluid Mechanics

3 0 0 3

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

SNO	DESCRIPTION
CO.1	Examine the various flow patterns and three dimensional continuity equations.
CO.2	Solve Navier-stoke's equation for the exact solutions of Coutte flow, Poisoulie flow and Hagen Poisoulie flow.
CO.3	Apply the boundary layer concept to the fluid flow problems.
CO.4	Compute the equations for lift on circular cylinders and smooth and rough boundaries for internal flow.
CO.5	Analyze the performance of nozzles, diffusers and Fanno, Raleigh flows along the shocks waves and Mach number flow regimes.

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO.1	3	3	2	2	-	-	-	-	-	-	-	-	2	1
CO.2	3	2	1	2	-	-	-	-	-	-	-	-	2	1
CO.3	3	2	1	2	-	-	-	-	-	-	-	-	2	1
CO.4	3	3	2	2	-	-	-	-	-	-	-	-	2	1
CO.5	3	3	2	2	-	-	-	-	-	-	-	-	2	1

UNIT -I **10 HOURS**

INVISCID FLOW OF INCOMPRESSIBLE FLUIDS: Lagrangian and Eulerain Descriptions of fluid motion, Path lines, Stream lines, Streak lines, stream tubes – velocity of a fluid particle, types of flows, Equations of three dimensional continuity equation, Stream and Velocity potential functions.

Basic Laws of fluid Flow: Condition for irrotationality, circulation & vorticity Accelerations in Carte systems normal and tangential accelerations, Euler's, Bernouli equations in 3D– Continuity and Momentum Equations.

UNIT – II **10 HOURS**

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, Blasius solution.

UNIT –III **10 HOURS**

Boundary Layer Concepts : Prandtl's contribution to real fluid flows – Prandtl's boundary layer theory , Boundary layer thickness for flow over a flat plate – Approximate solutions – Creeping motion (Stokes) – Oseen's approximation,Von,Karman momentum integral equation for laminar boundary layer –– Expressions for local and mean drag coefficients for different velocity profiles.

UNIT-IV **10 HOURS**

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 and rough Pipes – Roughness of Commercial Pipes – Moody's diagram.

UNIT-V **10 HOURS**

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 / L.VictorSteeter / TMH
2. Fluid Mechanics / Frank M.White / MGH

REFERENCES:

1. Fluid Mechanics and Machines/Modi and Seth/Standard Book House
2. Fluid Mechanics/Cohen and Kundu/Elsevier/5th edition
3. Fluid Mechanics/Potter/Cengage Learning
4. Fluid Mechanics/William S Janna/CRC Press
5. Fluid Mechanics / Y.A Cengel and J.M Cimbala/MGH
6. Boundary Layer Theory/ Schlichting H /Springer Publications
7. Dynamics & Theory and Dynamics of Compressible Fluid Flow/ Shapiro.
8. Fluid Dynamics/ William F. Hughes & John A. Brighton/TMH
9. Fluid Mechanics / K.L Kumar /S Chand & Co.

20METEPE1 Computational Fluid Dynamics

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

SNO	DESCRIPTION
CO.1	To solve different FEM problems and corresponding governing equations using FEM differentiation methods
CO.2	Explore their knowledge & ability to solve Hyperbolic equations
CO.3	Identify & apply formulaes of Incompressible Viscous Flows to solve fluid flow problems
CO.4	Explore their knowledge on Finite Volume Method & ability to solve two and three dimensional problems
CO.5	Explore their knowledge on Standard Variational Methods & ability to solve linear and transient problems

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO.1	3	2	2	1	2	2	2	-	1	1	-	1	1	1
CO.2	3	2	2	1	2	2	2	-	1	1	-	1	1	1
CO.3	3	2	2	2	3	3	2	-	2	1	-	1	1	1
CO.4	3	2	2	2	3	3	2	-	2	1	-	1	1	1
CO.5	3	2	2	2	3	3	2	-	2	1	-	1	1	1

UNIT-I **10HOURS**

INTRODUCTION: Finite difference method, finite volume method, finite element method, governing equations and boundary conditions. Derivation of finite difference equations.

SOLUTION METHODS: Solution methods of elliptical equations – finite difference formulations, interactive solution methods, direct method with Gaussian elimination.
Parabolic equations, explicit schemes and Von Neumann stability analysis, implicit schemes, alternating direction implicit schemes, approximate factorization, fractional step methods, direct method with tridiagonal matrix algorithm.

UNIT-II **10HOURS**

HYPERBOLIC EQUATIONS: Explicit schemes and Von Neumann stability analysis, implicit schemes, multi step methods, nonlinear problems, second order one-dimensional wave equations. Burgers equations: Explicit and implicit schemes, Runge-Kutta method.

UNIT-III **10HOURS**

FORMULATIONS OF INCOMPRESSIBLE VISCOUS FLOWS: Formulations of incompressible viscous flows by finite difference methods, pressure correction methods, vortex methods.

TREATMENT OF COMPRESSIBLE FLOWS: Potential equation, Eluer equations, Navier- Stokes system of equations, flow-field, dependent variation methods, boundary conditions.

UNIT-I V **10HOURS**

FINITE VOLUME METHOD: Finite volume method via finite difference method, formulations for two and three, dimensional problems.

UNIT-V **10HOURS**

STANDARD VARIATIONAL METHODS: Linear fluid flow problems, steady state problems, Transient problems.

TEXT BOOKS:

1. Computational fluid dynamics, T. J.Chung, Cambridge University press,2002.

2. Computational Fluid Dynamics by John D. Anderson, McGraw Hill Book Company 2017.

REFERENCE:

1. Text book of fluid dynamics, Frank Chorlton, CBS Publishers &distributors, 1985.

2. Computational Techniques for Fluid Dynamics, Volume 1& 2 By C. A. J. Fletcher, Springer

Publication, 2012.

20METEPE1 Advanced I.C engine, Electric and Hybrid Vehicles

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

SNO	DESCRIPTION
CO.1	Calculate the volumetric efficiency, quasi static effects, combined quasi static and dynamic effects variation of the gas exchange processes
CO.2	Explain the Intake Jet Flow, Mean velocity and turbulence characteristics
CO.3	Distinguish between SI and CI engines of normal and abnormal combustion
CO.4	Describe Electric Vehicles.
CO.5	Discuss about Hybrid Vehicles and Fuel Cell Vehicles.

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO.1	3	3	2	2	-	-	-	-	2	2	-	-	2	2
CO.2	3	3	2	2	-	-	-	-	2	2	-	-	2	2
CO.3	3	3	2	2	-	-	-	-	2	2	-	-	2	2
CO.4	3	3	2	2	-	-	-	-	2	2	-	-	2	2
CO.5	3	3	2	2	-	-	-	-	2	2	-	-	2	2

UNIT-I **10HOURS**

GAS EXCHANIGING PROCESSES:
Inlet and exhaust processes in the four stroke cycle volumetric efficiency quasi static effects combined quasi static and dynamic effects variation with speed and valve area lift and timing–flow through valves poppet valve geometry and timing flow rate and discharge coefficients, residual gas fraction , exhaust gas flow rate and temperature variation, scavenging in two stroke cyclic engines, scavenging parameters and models actual scavenging processes , flow through ports, super charging and turbo changing – methods of power boosting basic relationships compressors, turbines wave compression devices.

UNIT-II **10HOURS**

CHARGE MOTION WITHIN THE CYLINDER:
Intake Jet Flow, Mean velocity and turbulence characteristics definitions application to engine velocity data swirl – swirl measurement, swirl generation during induction swirl modification within the cylinder squish pre chamber engine flows crevice flows and blowby flows generated by piston –cylinder wall interaction.

UNIT-III **10HOURS**

COMBUSTION IN S.I AND C.I ENGINES:

Review of normal and abnormal combustion in SI and CI engine cyclic variation in combustion of SI engine , analysis of cylindrical pressure data in SI and CI engine ,MPFI in SI engines common rail fuel injection system in CI engines fuel spray behavior in CI engines.

UNIT-I V **10HOURS**

ELECTRIC VEHICLES:

Introduction: Limitations of IC Engines as prime mover, History of EVs, EV system, components of EV-DC and AC electric machines: Introduction and basic structure, Electric vehicle drive train, advantages and limitations, Permanent magnet and switched reluctance motors

BATTERIES: Battery: lead, acid battery, cell discharge and charge operation, construction, advantages of lead, acid battery, Battery parameters: battery capacity, discharge rate, state of charge, state of discharge, depth of discharge, Technical characteristics, Ragone plots.

UNIT-V **10HOURS**

HYBRID VECHILES: Configurations of hybrids, Series and Parallel, advantages and limitations, Hybrid drive trains, sizing of components Initial acceleration, rated vehicle velocity, Maximum velocity and maximum gradeability, Hydrogen: Production, Hydrogen storage systems, reformers.

FUEL CELL VECHILES: Introduction, Fuel cell characteristics, Thermodynamics of fuel cells, Fuel cell types: emphasis on PEM fuel cell.

TEXT BOOKS:

1. J.B. Heywood Internal Combustion Engine Fundamentals, McGraw Hill Co.1988
2. Seth Leitman and Bob Brant Build your own electric vehicle McGraw Hill Co.2009.
3. F. Barbir PEM Fuel Cells-Theory and Practice Elsevier Academic Press,2005.

REFERENCES:

1. W.W. Pulkrabek Engineering Fundamentals of IC Engine, PHI Pvt. Ltd 2002

20METEPE1 Gas Dynamics

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

SNO	DESCRIPTION
CO.1	Describe the Basic concepts for compressible flow, A brief review of thermodynamics and fluid mechanics and understand the equations for flow.
CO.2	Explore their knowledge & ability to solve for One-dimensional compressible flow.
CO.3	Identify & apply fundamentals to solve problems on Two-dimensional flows.
CO.4	Explore their knowledge & ability to solve for Quasi-one dimensional flows.
CO.5	Explain the concepts on Unsteady wave motions and experimental facilities.

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO.1	3	2	2	1	2	2	2	-	1	1	-	1	1	1
CO.2	3	2	2	1	2	2	2	-	1	1	-	1	1	1
CO.3	3	2	2	2	3	3	2	-	2	1	-	1	1	1
CO.4	3	2	2	2	3	3	2	-	2	1	-	1	1	1
CO.5	3	2	2	2	3	3	2	-	2	1	-	1	1	1

UNIT-I **10HOURS**

BASIC CONCEPTS : Introduction to compressible flow, A brief review of thermodynamics and fluid mechanics, Integral forms of conservation equations, Differential conservation equations, Continuum Postulates, Acoustic speed and Mach number, Governing equations for compressible flows.

UNIT-II **10HOURS**

ONE-DIMENSIONAL COMPRESSIBLE FLOW: One dimensional flow concept, Isentropic flows, Stagnation/Total conditions, Characteristic speeds of gas dynamics, Dynamic pressure and pressure coefficients, Normal shock waves, Rankine , Hugonoit equations, Rayleigh flow, Fanno flow, Crocco's theorem.

UNIT-III **10HOURS**

TWO-DIMENSIONAL FLOWS: Oblique shock wave and its governing equations, θ,B,M relations, The Hodograph and Shock Polar, Supersonic flow over wedges and cones, Mach line, Attached and Detached shock, Reflections and interaction of oblique shock waves, Expansion waves, Prandtl , Meyer flow and its governing equations, Supersonic flow over convex and concave corners, Approximation of continuous expansion waves by discrete waves.

UNIT-IV **10HOURS**

QUASI-ONE DIMENSIONAL FLOWS: Governing equations, Area velocity relations, Isentropic flow through variable, area ducts, convergent, divergent (or De Laval) nozzles, Over, expanded and under, expanded nozzles, Diffusers.

UNIT-V **10HOURS**

UNSTEADY WAVE MOTIONS: Moving normal shock waves, Reflected shock waves, Physical features of wave propagation, Elements of acoustic theory, Incident and reflected waves, Shock tube relations, Piston analogy, Incident and reflected expansion waves, Finite compression waves, Shock tube relations.

INTRODUCTION TO EXPERIMENTAL FACILITIES: Subsonic wind tunnels, Supersonic wind tunnels, Shock tunnels, Free, piston shock tunnel, detonation, driven shock tunnels, and Expansion tubes.

TEXT BOOKS:

1. Gas Dynamics by S.M Yahya, 2017
2. Gas Dynamics by E. Radha Krishnan, Prentice Hall India Learning Private Limited

REFERENCES:

1. Fundamentals of Gas Dynamics by Robert D. Zucker, John Wiley & Sons, INC.
2. Dynamics and Thermodynamics of compressible fluid flow (Vol. I, II) by AscherH.Shapiro.
3. Elements of Gas Dynamics by H.W. Liepmann and A. Roshko, Wiley.
4. Fundamentals of Gas Dynamics by V. Babu, John Wiley & Sons.
5. Modern Compressible Flow by John D. Anderson,Jr./McGraw Hill.

20METEPE1 Advanced Automobile Engineering

Course Outcomes:

At the end of the course, students will be able to

SNO	DESCRIPTION
CO.1	Describe the Various Components of Automobile Vehicles,Chassis, Engines and it Construction,
CO.2	Students will be able to analyse the transmission systems like Clutches,gearboxes,propellershafts, universal joints and differential gear boxes.
CO.3	They can explain the steering system, it;s Geometry and Steering mechanisms.
CO.4	They Identify Automobile based on Engine specifications and Demonstrate various safety systems related to automobiles...
CO.5	They can Illustrate the Exhaust Emission Control Techniques and Servicing of various parts of Engine.

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO.1	3	2	2					-	1	1	-		1	1
CO.2	3	2	2					-	1	1	-		1	1
CO.3	3	2	2					-	2	1	-		1	1
CO.4	3	2	2					-	2	1	-		1	1
CO.5	3	2	2					-	2	1	-		1	1

UNIT-I **10HOURS**

INTRODUCTION: Overview of the course, Examination and Evaluation patterns, History of Automobiles, Classification of Automobiles.

POWER PLANT: Classification, Engine Terminology, Types of Cycles, working principle of and IC engine, advanced classification of Engines, Multi cylinder engines, Engine balance, firing order.

UNIT-II **10HOURS**

FUEL SYSTEM, IGNITION SYSTEM AND ELECTRICAL SYSTEM: spark Ignition engines, Fuel tank, fuel filter, fuel pump, air cleaner/filter, carburetor, direct injection of petrol engines. Compression Ignition engines, Fuel Injection System, air & solid injection system, Pressure charging of engines, super charging and turbo charging, Components of Ignition systems, battery ignition system, magneto ignition system, electronic ignition and ignition timing. Main electrical circuits, generating & stating circuit, lighting system, indicating devices, warning lights, speedometer.

UNIT-III **10HOURS**

LUBRICATING SYSTEMS AND COOLING SYSTEMS: Functions & properties of lubricants, methods of lubrication, splash type, pressure type, dry sump, and wet sump & mist lubrication. Oil filters, oil pumps, oil coolers. Characteristics of an effective cooling system, types of cooling system, radiator, thermostat, air cooling & water cooling.

TRANSMISSION, AXLES, CLUTCHES, PROPELLER SHAFTS AND DIFFERENTIAL: Types of gear boxes, functions and types of front and rear axles, types and functions, components of the clutches, fluid couplings, design considerations of Hotchkiss drive torque tube drive, function and parts of differential and traction control.

UNIT-IV **10HOURS**

STEERING SYSTEM: Functions of steering mechanism, steering gear box types, wheel geometry. Braking and suspension system: Functions and types of brakes, operation and principle of brakes, constructional and operational classification and parking brake. Types of springs shock observers, objectives and types of suspension system, rear axles suspension, electronic control and proactive suspension system.
WHEELS AND TYRES : Wheel quality, assembly, types of wheels, wheel rims,construction of tyres and tyre specifications.

UNIT-V **10HOURS**

AUTOMATION IN AUTOMOBILES: Sensors and actuators, electronic fuel injection system, electronic management system, automatic transmission, electronic transmission control, Antilock Braking System (ABS).

TEXT BOOKS:

1. Joseph Heitner, Automotive Mechanics, CBS publications,2017.

2. Srinivasan. S, Automotive Mechanics, 2nd Edition, Tata McGraw,Hill, 2003

REFERENCES:

1. Crouse and Anglin, Automotive Mechanism, 9th Edition. Tata McGraw,Hill, 2003.

2.Jack Erjavec, A Systems Approach to Automotive Technology, Cengage Learning Pub.2009.

20METEPE2 Gas Turbines

3 0 0 3

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

SNO	DESCRIPTION
CO.1	Describe The Knowledge of Gas turbine Cycles
CO.2	Know about the rotating machines and compressors
CO.3	Get the knowledge of axial flow compressors
CO.4	Impart the knowledge of Gas Turbine Combustion Systems
CO.5	Explain about Axial And Radial Flow Turbines

Mapping of Course Outcome with Program Outcomes and Program Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO.1	3	3	2	2	-	-	-	-	2	2	-	-	2	2
CO.2	3	3	2	2	-	-	-	-	2	2	-	-	2	2
CO.3	3	3	2	2	-	-	-	-	2	2	-	-	2	2
CO.4	3	3	2	2	-	-	-	-	2	2	-	-	2	2
CO.5	3	3	2	2	-	-	-	-	2	2	-	-	2	2

UNIT-I **10 HOURS**

INTRODUCTION: Review of the fundamentals, Classification of turbo machines, Applications of gas turbines.

GAS TURBINE CYCLES FOR SHAFT POWER: Ideal shaft power cycles and their analysis, Practical shaft power cycles and their analysis.

UNIT-II **10 HOURS**

FUNDAMENTALS OF ROTATING MACHINES: Euler's energy equation, Components of energy transfer, Impulse and reaction machines, Degree of reaction, Flow over an airfoil, Lift and drag.
CENTRIFUGAL COMPRESSORS: Construction and principle of operation, Factors affecting stage pressure ratio, Compressibility effects, Surging and choking, Performance characteristics.

UNIT-III **10 HOURS**

AXIAL FLOW COMPRESSORS: Construction and principle of operation, Factors affecting stage pressure ratio, Degree of reaction, Three dimensional flow, Design process, Blade design, Stage performance, Compressibility effects, Off, design performance.

UNIT-I V **10 HOURS**

GAS TURBINE COMBUSTION SYSTEMS: Operational requirements, Factors affecting combustion chamber design, Combustion process, Flame stabilization, Combustion chamber performance, Practical problems, Gas turbine emissions.

UNIT- V **10 HOURS**

AXIAL AND RADIAL FLOW TURBINES: Construction and operation of axial flow turbines, Vortex theory, Estimation of stage performance, Overall turbine performance, Turbine blade cooling, Radial flow turbines.

TEXT BOOKS:

1. Sarvanamuttoo, H.I.H., Rogers, G. F. C. and Cohen, H., Gas Turbine Theory, 7th Edition, Pearson Prentice Hall, 2017.
2. Ganesan, V., Gas Turbines, 3rd Edition, Tata McGraw Hill, 2017.

REFERENCES:

1. Dixon, S.L., Fluid Mechanics and Thermodynamics of Turbomachinery, 7th Edition, Elsevier, 2014.
2. Flack, R.D., Fundamentals of Jet Propulsion with Applications, Cambridge University Press, 2011.
3. Yahya, S. M., Turbines, Compressors and Fans, 4th Edition, Tata McGraw Hill, 2017.
Lefebvre, A.H. and Ballal D. R., Gas Turbine Combustion – Alternative Fuels and Emissions, CRC Press, 2010

20METEPE2 Alternative Fuel Technologies

3 0 0 3

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

SNO	DESCRIPTION
CO.1	Explain the need of alternative fuels
CO.2	Classify different types of liquid alternative fuels
CO.3	Estimate the engine performance & emission characteristics by using liquid alternative fuels
CO.4	Determine the working of SI/CI engine with various gaseous fuels
CO.5	Identify several methods of alternative fuels for improving the performance of fuel cells

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO.1	3	2	1	1	3	3	-	3	-	-	3	1	2	2
CO.2	2	1	-	-	2	2	2	2	2	2	2	2	2	2
CO.3	-	-	1	1	-	3	-	-	-	-	-	-	-	-
CO.4	3	2	1	1	3	3	-	3	-	-	3	1	-	-
CO.5	3	2	1	1	3	3	-	3	-	-	3	2	3	3

UNIT-I **10 HOURS**

Fossil fuels and their limitations Engine requirements; Potential alternative liquid and gaseous fuels.

UNIT-II **10 HOURS**

Methods of production; Properties, safety aspects, handling and distribution of various liquid alternative fuels like alcohols, vegetable oils, Di,methyl and Di,ethyl ether etc.

UNIT-III **10 HOURS**

Different ways of using alternative liquid fuels in engines, performance and emission characteristics; Conversion of vegetable oils to their esters and effect on engine performance.

UNIT-IV **10 HOURS**

Use of gaseous fuels like biogas, LPG, hydrogen, natural gas, producer gas etc. in SI/CI engines; Production, storage, distribution and safety aspects of gaseous fuels.

UNIT-V **10 HOURS**

Different approaches like duel fuel combustion and surface ignition to use alternative fuels in engines; Use of additives to improve the performance with alternative fuels; Hybrid power plants and fuel cell.

TEXT BOOK:

1. Alternative Fuels: The Future of Hydrogen, Second Edition**,** Michael Frank Hordeski, CRC Press

REFERENCES:

1. Alternative Fuels for Transportation, A S Ramadhas, CRC Press

2. Alternative Fuels & Advanced Technology Vehicles: Incentives & Considerations, Thomas

Huber, Jack Spera, Nova Science Publishers

20METEPE 2 Energy Conservation and Management

3003

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

SNO	DESCRIPTION
CO.1	The students can able to analyze the energy data of industries.
CO.2	The students can carry out energy accounting and balancing
CO.3	The students can suggest methodologies for energy savings
CO.4	The students can suggest optimal sources to energy management.
CO.5	The students can have good amount of knowledge on economics in Indian environment to energy conservation.

Mapping of Course Outcome with Program Outcomes and Program Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO.1	3	3	2	2	-	-	-	-	2	2	-	-	2	2
CO.2	3	3	2	2	-	-	-	-	2	2	-	-	2	2
CO.3	3	3	2	2	-	-	-	-	2	2	-	-	2	2
CO.4	3	3	2	2	-	-	-	-	2	2	-	-	2	2
CO.5	3	3	2	2	-	-	-	-	2	2	-	-	2	2

UNIT-I **10 HOURS**

The energy market, energy scenario, planning, utilization pattern and future strategy, Importance of energy management.

UNIT-II **10 HOURS**

ENERGY CONSERVATION: Methods of energy conservation and energy efficiency for buildings, air conditioning, heat recovery and thermal energy storage systems Energy conservation in industries, Cogeneration, Combined heating and power systems.

UNIT-III **10 HOURS**

Energy Management: Principles of Energy Management, Energy demand estimation, Organising and Managing Energy Management Programs, Energy pricing

Energy Audit: Purpose, Methodology with respect to process Industries, Characteristic method employed in Certain Energy Intensive Industries

UNIT-IV **10 HOURS**

Economic Analysis: Scope, Characterization of an Investment Project

UNIT-V **10 HOURS**

Relevant international standards and laws.

TEXT BOOK:

1. L.C. Witte, P.S. Schmidt, D.R.Brown, "Industrial Energy Management and Utilization", Hemispherical Publication, 1988.
2. Callaghan "Energy Conservation".

REFERENCES:

1. 1.D.A. Reeg, "Industrial Energy Conservation", Pergamon Press, 1980.
2. T.L. Boyen, "Thermal Energy Recovery" Wiley, 1980
3. L.J. Nagrath, "Systems Modeling and Analysis", Tata McGraw Hill, 1982.
4. W.C. Turner, "Energy Management Handbook ", Wiley, New York, 1982.
5. I.G.C. Dryden, "The Efficient Use of Energy ", Butterworth, London, 1982.
6. R. Loftnen, Van Nostrarid Reinhold C. "Energy Handbook", 1978.
7. TERI Publications.
8. WR Murphy, G McKay "Energy Management"

20METEPE2 Thermal And Nuclear Power Plants

3 0 0 3

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

SNO	DESCRIPTION
CO.1	Calculate volumetric, gravimetric and flue gas analysis on combustion of coal
CO.2	Explain the working of a steam power plant with subsystems.
CO.3	Summarize the gas turbine power plant and waste heat recovery
CO.4	Analyze various activities and safety of nuclear power plant.
CO.5	Describe instruments used for the pollution analysis.

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO.1	3	3	-	-	-	-	3	-	-	-	-	-	2	1
CO.2	3	2	1	-	-	-	-	3	-	3	-	-	2	1
CO.3	3	2	1	-	-	-	-	3	-	-	-	-	2	1
CO.4	3	3	-	-	-	-	3	-	3	-	-	-	2	1
CO.5	3	3	-	-	-	-	2	-	-	3	-	-	2	1

UNIT-I **10 HOURS**

Introduction to the sources of energy – resources and development of power in India.

STEAM POWER PLANT: Plant layout, working of different circuits, fuel handling equipments, types of coals, coal handling, choice of handling equipment, coal storage, ash handling systems. Combustion: properties of coal – overfeed and underfeed fuel beds, traveling grate stokers, spreader stokers, retort stokers, pulverized fuel burning system and its components, combustion needs and draught system, cyclone furnace, design and construction, dust collectors, cooling towers and heat rejection. corrosion and feed water treatment.

UNIT- II **10 HOURS**

GAS TURBINE PLANT: Introduction – classification , construction – layout with auxiliaries, combined cycle power plants and comparison. Cogeneration of Power and Process heat. Waste heat recovery systems.

HYDRO PROJECTS AND PLANT: Classification – typical layouts – plant auxiliaries – plant operation pumped storage plants.

UNIT-III **10 HOURS**

NUCLEAR POWER STATION: Nuclear fuel – breeding and fertile materials – nuclear reactor – reactor operation.

TYPES OF REACTORS: Pressurized water reactor, boiling water reactor, sodium,graphite reactor, fast breeder reactor, homogeneous reactor, gas cooled reactor, radiation hazards and shielding – radioactive waste disposal.

UNIT-I V **10 HOURS**

COMBINED OPERATIONS OF DIFFERENT POWER PLANTS: Introduction, advantages of combined working, load division between power stations, storage type hydro,electric plant in combination with steam plant, run,of,river plant in combination with steam plant, pump storage plant in combination with steam or nuclear power plant, co,ordination of hydro,electric and gas turbine stations, co,ordination of hydro,electric and nuclear power stations, co,ordination of different types of power plants.

POWER PLANT INSTRUMENTATION AND CONTROL: Importance of measurement and instrumentation in power plant, measurement of water purity, gas analysis, O2 and CO2 measurements, measurement of smoke and dust, measurement of moisture in carbon dioxide circuit, nuclear measurements.

UNIT-V **10 HOURS**

POWER PLANT ECONOMICS AND ENVIRONMENTAL CONSIDERATIONS: Capital cost, investment of fixed charges, operating costs, general arrangement of power distribution, load curves, load duration curve, definitions of connected load, maximum demand, demand factor, average load, load factor, diversity factor – related exercises. effluents from power plants and Impact on environment – pollutants and pollution standards – methods of pollution control.

TEXT BOOKS:

1. A course in Power Plant Engineering /Arora and Domkundwar/Dhanpatrai & Co.
2. Power Plant Engineering /P.C.Sharma / S.K.Kataria Pub

REFERENCES:

1. Power Plant Engineering: P.K.Nag/ II Edition /TMH.
2. Power station Engineering – ElWakil / McGrawHill.
3. An Introduction to Power Plant Technology / G.D. Rai/Khanna Publishers

20METE3 Research Methodology and IPR

3 0 0 3

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

SNO	DESCRIPTION
CO.1	Illustrate research problem formulation.
CO.2	Analyse research related information and research ethics
CO.3	Summarise the present day scenario controlled and monitored by Computer and Information Technology, where the future world will be ruled by dynamic ideas, concept, creativity and innovation.
CO.4	Explain how IPR would take such important place in growth of individuals & nation, to summarise the need of information about Intellectual Property Right to be promoted among student community in general & engineering in particular.
CO.5	Relate 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. .

Mapping of Course Outcome with Program Outcomes and Program Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO.1	3	3	2	2	-	-	-	-	2	2	-	-	2	2
CO.2	3	3	2	2	-	-	-	-	2	2	-	-	2	2
CO.3	3	3	2	2	-	-	-	-	2	2	-	-	2	2
CO.4	3	3	2	2	-	-	-	-	2	2	-	-	2	2
CO.5	3	3	2	2	-	-	-	-	2	2	-	-	2	2

10 Hours

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

10 Hours

UNIT-II

Effective literature studies approaches, analysis Plagiarism, Research ethics, 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 -III **10 Hours**

Nature of Intellectual Property: Patents, Designs, Trade and Copyright. 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-IV **10 Hours**

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

Unit -V **10 Hours**

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.

REFERENCES:

(1) Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students'"

(2) Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"

(3) Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide for beginners"

(4) Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007. (5) Mayall, "Industrial Design", McGraw Hill, 1992.

(6) Niebel, "Product Design", McGraw Hill, 1974.

(7) Asimov, "Introduction to Design", Prentice Hall, 1962.

(8) (8) Robert P. Merges, Peter S. Menell, Mark A. Lemley, " Intellectual Property in New Technological Age", 2016.

(9) T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008

20METE4 Computational Fluid Dynamics Lab - I

3003

Course Outcomes:

At the end of the course, students will be able to

SNO	DESCRIPTION
CO.1	To design models using CAD software and practice of Ansy's software for real time problems of fluid mechanics and heat transfer
CO.2	Able to Design optimized thermal equipment for different fields
CO.3	Design and build a geometry, mesh that geometry, Perform CFD method on the mesh for further simulation
CO.4	Understand the validation of the numerical result by comparison with known analytical results of real time problems in thermal industry
CO.5	Simulate and analysis carried out on all heat transfer and fluid mechanics related problems

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO.1	3	3	-	-	-	-	-	-	-	-	-	-	2	1
CO.2	3	2	1	-	-	-	-	-	-	3	-	-	2	1
CO.3	3	2	1	-	-	-	-	-	-	-	-	-	2	1
CO.4	3	3	-	-	-	-	-	-	3	-	-	-	2	1
CO.5	3	3	-	-	-	-	-	-	-	3	-	-	2	1

LIST OF EXPERIMENTS:

1. Analysis Of Transient State Compressible Flow Through Pipes
2. Performance Analysis Of Heat Exchanger Device
3. Calibration Performance Characteristics Of Combustion
4. Estimation Of C.O.P For Refrigeration Cycle
5. Analysis Of Gas Cooled Air-Cooler
6. Performance Of Air-Conditioner
7. Thermal Stresses In Long Cylinder

8. Determination Of Insulated Wall Temperature
9. Temperature Gradient Across Solid Cylinder
10. Radiation Heat Transfer Between Concentric Cylinders
11. Solid Liquid Phase Change
12. Thermal Loading On Support Structure

TEXT BOOKS:

1.Numerical heat transfer and fluid flow / Suhas V. Patankar/Butter-worth Publishers
2. Computational fluid dynamics - Basics with applications /John. D. Anderson / Mc Graw Hill.

REFERENCES:

1. Computational Fluid Flow and Heat Transfer/ Niyogi/Pearson Publications
2. .Finite Element Methods with Programming and Ansys, Mar 7, 2013, by Meung Kim

20METE5 Thermal Engineering Lab - I

3003

Course Outcomes:

At the end of the course, students will be able to

SNO	DESCRIPTION
CO.1	Estimate the convective heat transfer coefficient in various conditions.
CO.2	Calculate the heat transfer through a pin-fin
CO.3	Evaluate the performance of heat exchanger in various arrangements
CO.4	Compute the emissivity of different bodies.

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO.1	3	3	-	-	-	-	-	-	-	-	-	-	2	1
CO.2	3	2	1	-	-	-	-	-	-	3	-	-	2	1
CO.3	3	2	1	-	-	-	-	-	-	-	-	-	2	1
CO.4	3	3	-	-	-	-	-	-	3	-	-	-	2	1
CO.5	3	3	-	-	-	-	-	-	-	3	-	-	2	1

LIST OF EXPERIMENTS:

1. Forced Convection Apparatus: Determination of theoretical, experimental and empirical values of convection heat transfer coefficient for internal forced convection through a circular GI pipe
2. Emissivity Apparatus: Determination of surface emissivity of a given aluminium test plate at a given absolute temperature
3. Heat Pipe Demonstrator: Demonstration of near isothermal characteristic exhibited by a heat pipe in comparison to stainless steel and copper pipes
4. Abel's apparatus: Determination of flash and fire points of a given oil sample
5. Redwood Viscometer No. 1: Determination of kinematic and absolute viscosities of an oil sample given
6. Distillation apparatus: Determination of distillation characteristic of a given sample of gasoline
7. Two-Stage Reciprocating Air-Compressor: Determination of volumetric efficiency of the compressor as a function of receiver pressure
8. Pin-Fin Apparatus: Determination of temperature distribution, efficiency and effectiveness of the fin working in forced convection environment
9. Natural Convection Apparatus: Determination of experimental and empirical values of convection heat transfer coefficient from a Vertical Heated Cylinder losing heat to quiescent air

10. Composite Slab Apparatus: Determination of theoretical end experimental values of equivalent thermal resistance of a composite slab

Text Books	1. https://www.iare.ac.in/sites/default/files/lab2/TE%2Blab.pdf 2.www.bitswgl.ac.in/.../TE%20LAB%20MANUAL%20BITS% 20NEW%20UPDATED 3.mech.gecgudlavalleru.ac.in/pdf/manuals/THERMAL%20ENG INEERING%20L AB.pd
Web sources	1.https://www.youtube.com/watch?v=jz7nBi76cPU 2.https://www.youtube.com/watch?v=O5zWJ-GCslc 3.https://www.youtube.com/watch?v=-Wj_MO4BqtA 4.https://www.youtube.com/watch?v=2vk5B6Gga10

20METEA1 ENGLISH FOR RESEARCH PAPER WRITING

3003

Course Outcomes:

At the end of the course, students will be able to

SNO	DESCRIPTION
CO.1	Demonstrate writing meaningful sentences and coherent paragraphs
CO.2	Show conciseness, clarity and avoid redundancy in writing
CO.3	Summarize, evaluate literature, and write methodology, results and conclusion
CO.4	Describe how to develop title, write abstract and introduction
CO.5	Apply correct style of referencing and use punctuation appropriately

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO.1	3	3	-	-	-	-	-	-	-	-	-	-	2	1
CO.2	3	2	1	-	-	-	-	-	-	3	-	-	2	1
CO.3	3	2	1	-	-	-	-	-	-	-	-	-	2	1
CO.4	3	3	-	-	-	-	-	-	3	-	-	-	2	1
CO.5	3	3	-	-	-	-	-	-	-	3	-	-	2	1

UNIT-I

Planning and preparation, word order & breaking up long sentences, structuring sentences and paragraphs.

UNIT-II

Being concise, avoiding redundancy, ambiguity and vagueness, literature survey - highlighting your findings, hedging, paraphrasing and plagiarism

UNIT-III

Sections of a paper – abstract, introduction, etc. review of the literature, writing - methods, results, discussion, conclusions and final check

UNIT-IV

Writing – Title, Abstract and Introduction, Review of Literature and Methods

UNIT-V

Useful phrases and punctuation, in-text citation and bibliography – MLA/APA styles

REFERNCES:

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

20METE6 Advanced Heat Transfer

3003

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

SNO	DESCRIPTION
CO.1	Develop heat conduction equation for various conditions and able to solve 1D and 2D problems
CO.2	Apply the conservation equations on forced convection
CO.3	Analyze the effect of various parameters on the convective heat transfer.
CO.4	Estimate the effect of various geometries on free convection and Explain the phenomenon of boiling and condensation
CO.5	Compute the heat transfer rate through radiation and Discuss the phenomenon of convective mass transfer.

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO.1	3	2	-	1	-	-					-	-	2	1
CO.2	3	2	-	1	-	-					-	-	2	1
CO.3	3	2	-	1	-	-					-	-	2	1
CO.4	3	3	-	2	-	-					-	-	2	1
CO.5	3	3	-	2	-	-					-	-	2	1

UNIT-I **10 HOURS**

Brief Introduction To Different Modes Of Heat Transfer: Conduction: General heat Conduction equation, initial and boundary conditions.

Transient Heat Conduction: Lumped system analysis, Heisler charts, semi infinite solid,use of shape factors in conduction,2D transient heat conduction, product solutions.

UNIT-II **10 HOURS**

Finite Difference Methods For Conduction: ID & 2D steady state and simple transient heat conduction problems, implicit and explicit methods.

Forced Convection: Equations of fluid flow, concepts of continuity, momentum equations, derivation of energy equation, methods to determine heat transfer coefficient: Analytical methods, dimensional analysis and concept of exact solution. Approximate method, integral analysis.

UNIT-III **10 HOURs**

External Flows: Flow over a flat plate: Integral method for laminar heat transfer coefficient for different velocity and temperature profiles. Application of empirical relations to variation geometries for laminar and turbulent flows.

Internal Flows: Fully developed flow: Integral analysis for laminar heat transfer coefficient,types of flow, constant wall temperature and constant heat flux boundary conditions, hydrodynamic &thermal entry lengths; use of empirical correlations.

UNIT-IV **10 HOURS**

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, Nusselts theory of film condensation on a vertical plate, assumptions & correlations of film condensation for different geometries.

Heat Exchangers Types of Heat Exchangers, LMTD and NTU methods

UNIT-V **10 HOURS**

Radiation Heat Transfer: Radiant heat exchange in grey, non, grey bodies, with transmitting, Reflecting and absorbing media, specular surfaces, gas radiation, from flames.

Mass Transfer: Concepts of mass transfer, diffusion & convective mass transfer analogies, significance of non-dimensional numbers.

TEXT BOOKS:

1. Principles of Heat Transfer / Frank Kreith / Cengage Learning
2. Heat Transfer / Necati Ozisik / TMH

REFERENCES:

1. Fundamentals of Heat and Mass Tra
2. nsfer,5th Ed. / Frank P. Incropera/John Wiley
2. Elements of Heat Transfer/E. Radha Krishna/CRC Press/2012
3. Introduction to Heat Transfer/SK Som/PHI
4. Heat Transfer / Nellis& Klein / Cambridge University Press / 2012.
5. Heat Transfer/ P.S. Ghoshdastidar/ Oxford Press
6. Engg. Heat & Mass Transfer/ Sarat K. Das/DhanpatRai
7. Heat Transfer/ P.K.Nag /TMH
8. Heat Transfer / J.P Holman/MGH

20METE7 Thermal Measurements and Process Controls

3 0 0 3

Course Outcomes:

At the end of the course, students will be able to

SNO	DESCRIPTION
CO.1	To discuss the types and parameters used in measuring devices.
CO.2	Describe the working principle of flow measuring devices.
CO.3	Explain the types of temperature measuring devices.
CO.4	Classify the types of measuring devices
CO.5	Analyze the performance of process control principles and examples.

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO.1	2	1	-	-	-	2	-	-	-	-	-	3	3	3
CO.2	2	1	-	-	-	2	-	-	-	-	-	2	2	2
CO.3	-	-	2	2	-	3	-	-	-	-	-	-	-	-
CO.4	3	-	2	2	-	3	-	-	-	-	-	3	3	3
CO.5	-	-	2	2	-	3	-	-	-	-	-	3	3	3

UNIT-I **10 HOURS**

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

UNIT-II **10 HOURS**

Measurement Of Flow: Obstruction meters, variable area meters, Pressure probes, compressible fluid flow measurement, Thermal anemometers, calibration of flow measuring instruments. Introduction to design of flow measuring instruments.

UNIT-III **10 HOURS**

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

Measurment Of : Velocity, moisture content , humidity and thermal conductivity .

UNIT-IV **10 HOURS**

Voltage Indicating, Recording And Data Acquisition Systems: Standards and calibration, analog volt meters and potentiometers. Electrical instruments. Digital voltmeters and multimeters. Signal generation. Electro mechanical servo type XT and XY recorders. Thermal array recorders and data acquisition systems. Analog and digital CROs. Displays and liquid crystals flat panel displays. Displays. Virtual instruments. Magnetic tape and disk recorders/reproducers. Fiber optic sensors.

UNIT-V **10 HOURS**

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

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

TEXT BOOK:

1. Measurement System, Application & Design – E.O. Doeblin, MGH

REFERENCES:

1. Mechanical and Industrial Measurements – R.K. Jain – Khanna Publishers.
2. Mechanical Measurements – Buck & Beckwith – Pearson.
3. Control Systems, Principles & Design, 2nd Edition – M. Gopal – TMH.
4. Mechanical Measurements – J.P Holman

20METEPE3 Equipment Design for Thermal Systems

3003

Course Outcomes:

At the end of the course, students will be able to

SNO	DESCRIPTION
CO.1	Explain the different types of heat exchangers
CO.2	Make use of the different design methods for heat exchangers
CO.3	Analyze the double pipe heat exchanger
CO.4	Calculate the condensation of single vapours.
CO.5	Estimate the heat transfer performance in direct contact heat exchangers, vaporizers, evaporator

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO.1	-	3	2	-	-	-	-	-	-	-	-	-	1	1
CO.2	3	2	1	-	3	3	-	-	-	-	-	-	2	2
CO.3	-	3	2	-	-	-	-	-	-	-	-	-	2	2
CO.4	-	3	2	-	-	-	-	-	-	-	-	-	2	2
CO.5	-	3	2	-	-	-	-	-	-	-	-	-	2	2

UNIT-I **10 HOURS**

Classification Of Heat Exchangers: Introduction, Recuperation & regeneration, Tabular heat exchangers, Double pipe, shell & tube heat exchanger, Plate heat Exchangers, Gasketedplate heat exchanger. Spiral plate heat exchanger, Lamella heat exchanger, Extended surface heat exchanger, Plate fin and Tabular fin.

Basic Design Methods Of Heat Exchanger: Introduction, Basic equations in design, Overall heat transfer coefficient, LMTD method for heat exchanger analysis, Parallel flow, Counter flow. Multipass, cross flow heat exchanger design calculations:

UNIT-II **10 HOURS**

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 **10 HOURS**

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 **10 HOURS**

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 **10 HOURS**

Direct Contact Heat Exchanger: Cooling towers, relation between wet bulb & dew point temperatures, The Lewis number and Classification of cooling towers, Cooling tower internals and the roll of fill, Heat Balance. Heat Transfer by simultaneous diffusion and convection, Analysis of cooling tower requirements, Deign of cooling towers, Determination of the number of diffusion units, Calculation of cooling tower performance.

TEXT BOOK:

1. Process Heat Transfer/D.Q.Kern/ TMH
2. Design of Thermal Systems / Wilbert F. Stoecker / McGrawHill

REFERENCES:

1. Heat Exchanger Design/ A.P.Fraas and M.N.Ozisicj/ John Wiely& sons, New York.
2. Cooling Towers / J.D.Gurney and I.A. Cotter/ Maclaren
3. Design & Optimization of Thermal Systems / Yogesh Jaluria / CRC Press

20METEPE3 Solar Energy Technologies

3003

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

SNO	DESCRIPTION
CO.1	The students can able to explain the technical and physical principles of solar cells and solar collectors
CO.2	The students can carry out measure and evaluate different solar energy technologies through knowledge of the physical function of the devices
CO.3	The students can calculate the required size of solar cell systems and solar collectors from a given power need by using appropriate software.
CO.4	The students can make critical comparisons of different solar energy systems.
CO.5	The students can communicate technological, environmental and socio-economic issues around solar energy in a concise and an accessible way to a target group with basic technical skills.

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO.1	-	3	2	-	-	-	-	-	-	-	-	-	1	1
CO.2	3	2	1	-	3	3	-	-	-	-	-	-	2	2
CO.3	-	3	2	-	-	-	-	-	-	-	-	-	2	2
CO.4	-	3	2	-	-	-	-	-	-	-	-	-	2	2
CO.5	-	3	2	-	-	-	-	-	-	-	-	-	2	2

UNIT-I **10 HOURS**

Introduction: Solar energy option, specialty and potential – Sun – Earth – Solar radiation, beam and diffuse – measurement – estimation of average solar radiation on horizontal and tilted surfaces – problems – applications.
Capturing solar radiation – physical principles of collection – types – liquid flat plate collectors – construction details – performance analysis – concentrating collection – flat plate collectors with plane reflectors– cylindrical parabolic collectors – Orientation and tracking – Performance Analysis.

UNIT-II **10 HOURS**

Design Of Solar Water Heating System And Layout: Power generation – solar central receiver system – Heliostats and Receiver – Heat transport system – solar distributed receiver system – Power cycles, working fluids and prime movers, concentration ratio.

UNIT-III **10 HOURS**

Thermal Energy Storage: Introduction – Need for – Methods of sensible heat storage using solids and liquids – Packed bed storage – Latent heat storage – working principle – construction – application and limitations. Other solar devices – stills, air heaters, dryers, Solar Ponds & Solar Refrigeration, active and passive heating systems.

UNIT- IV **10 HOURS**

Direct Energy Conversion: Solid, State Principles – Semiconductors – Solar Cells – Performance – Modular Construction – Applications. Conversion Efficiencies Calculations.

UNIT- V **10 HOURS**

Economics: Principles of Economic Analysis – Discounted cash flow – Solar system – life cycle costs – cost benefit analysis and optimization – cost based analysis of water heating and photo voltaic applications.

TEXT BOOK:

1. Principles of solar engineering/ Kreith and Kerider/Taylor and Franscis/2nd edition

REFERENCES:

1. Solar energy thermal processes/Duffie and Beckman/John Wiley & Sons
2. Solar energy: Principles of Thermal Collection and Storage/Sukhatme/TMH/2nd edition
3. Solar energy/Garg/TMH
4. Solar energy/Magal/McGraw Hill
5. Solar Thermal Engineering Systems /Tiwari and Suneja/Narosa
6. Power plant Technology/ El Wakil/TMH

20METEPE3 Fuels, Combustion ,Emissions and Environment

3003

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

SNO	DESCRIPTION
CO.1	Explain the basics of combustion reactions of any type of fuels
CO.2	Explain the combustion and emission formation in the spark ignited engine
CO.3	Explain the combustion and emission formation in the diesel engine
CO.4	Identify the most common exhaust emissions from internal combustion engines and their impact on health and environment
CO.5	Communicate different methods to reduce exhaust emissions from engines during combustion and after treatment process

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO.1	-	3	2	-	-	-	-	-	-	-	-	-	1	1
CO.2	3	2	1	-	3	3	-	-	-	-	-	-	2	2
CO.3	-	3	2	-	-	-	-	-	-	-	-	-	2	2
CO.4	-	3	2	-	-	-	-	-	-	-	-	-	2	2
CO.5	-	3	2	-	-	-	-	-	-	-	-	-	2	2

UNIT- I **10 HOURS**

Fuels :- Detailed Classification – Conventional and Unconventional Solid, Liquid, gaseous fuels and nuclear fuels – Origin Of Coal – Analysis Of Coal.

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 HCs.

UNIT- II **10 HOURS**

Thermodynamics Of Combustion: Enthalpy of formation, Heating value of fuel, Adiabatic flame Temperature, Equilibrium composition of gaseous mixtures.

UNIT- III **10 HOURS**

Laminar And Turbulent Flames Propagation And Structure: Flame stability, burning velocity of fuels, Measurement of burning velocity, factors affecting the Burning velocity. Combustion of fuel droplets and sprays, Combustion systems, Pulverized fuel furnaces- fixed, entrained and fluidized bed systems.

UNIT- IV **10 HOURS**

Pollution Formation Measurement And Control: Causes for Formation of NOx, SOx, COx, Smoke and UBHC. Different methods of measurement of pollutants. methods of controlling the formation of pollutants, BHARAT and EURO standards of emissions.

UNIT- V **10 HOURS**

Environmental Considerations: Air Pollution, Effects On Environment, Human Health Etc. Principal Pollutants, Legislative Measures, Methods Of Emission Control.

TEXT BOOK:

1. Fuels And Combustion, Sharma And Chandra Mohan, Tata Mcgraw Hill, 1984..

REFERENCES:

1. Combustion Fundamentals , Roger A Strehlow , Mcgraw Hill.
2. Combustion Engineering And Fuel Technology , Shaha A.K., Oxford And IBH.
3. Principles Of Combustion , Kannethk.Kuo, Wiley And Sons.
4. Combustion , Samir Sarkar , Mc. Graw Hill, 2009.
5. An Introduction To Combustion , Stephen R. Turns, Mc. Graw Hill International Edition.
6. Combustion Engineering , Gary L. Berman & Kenneth W. Ragland, Mc. Graw Hill International Edition 2009.

20METEPE4 Renewable Energy Technologies

3003

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

SNO	DESCRIPTION
CO.1	Explain the concepts involved in solar energy
CO.2	Discuss about geothermal energy with its limitations
CO.3	Analyze the performance of direct energy systems
CO.4	Distinguish the wind energy systems
CO.5	Evaluate the performance of tidal energy plants

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO.1	3	1	-	-	-	-	-	-	-	-	-	-	3	-
CO.2	3	1	-	-	-	-	-	-	-	-	-	-	3	-
CO.3	1	3	-	-	-	-	-	-	-	-	-	-	2	-
CO.4	1	1	-	-	-	-	-	-	-	-	-	-	1	-
CO.5	2	3	2	-	-	-	-	-	-	-	-	-	2	-

UNIT- I **10 HOURS**

Introduction: Energy Scenario, Survey of energy resources. Classification and need for conventional energy resources.

Solar Energy: 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 generation.

UNIT- II **10 HOURS**

Geothermal Energy: Structure of earth, Geothermal Regions, Hot springs. Hot Rocks, Hot Aquifers. Analytical

methods to estimate thermal potential. Harnessing techniques, Electricity generating systems.

UNIT- III **10 HOURS**

Direct Energy Conversion: Nuclear Fusion,Fusion, Fusion reaction, P,P cycle, Carbon cycle, Deuterium cycle, Condition for controlled fusion, Fuel cells and photovoltaic. Thermionic & thermoelectric generation, MHD generator.
Hydrogen Gas As Fuel: Production methods, Properties, I.C. Engine applications, Utilization strategy, Performance.

UNIT-IV **10 HOURS**

Bio,Energy: Biomass energy sources. Plant productivity, Biomass wastes, aerobic and Anaerobic bioconversion processes, Raw material and properties of bio,gas, Bio,gas plant technology and status, the energetic and economics of biomass systems, Biomass gasification

UNIT- V **10 HOURS**

WIND ENERGY: Wind, Beaufort number, Characteristics, Wind energy conversion systems, Types, Betz model. Interference factor. Power coefficient, Torque coefficient and Thrust coefficient, Lift machines and Drag machines. Matching, Electricity generation.

ENERGY FROM OCEANS: Tidal energy, Tides , Diurnal and semi,diurnal nature, Power from tides, Wave Energy, Waves, Theoretical energy avaible. Calculation of period and phase velocity of waves, Wave power systems, Submerged devices. Ocean thermal Energy, Principles, Heat exchangers, Pumping requirements, Practical considerations.

TEXT BOOK:

1. Renewable Energy Resources/ John Twidell& Tony Weir/Taylor & Francis/2nd edition

REFERENCES:

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

20METEPE4 Cryogenic Engineering

3003

Course Outcomes:

At the end of the course, students will be able to

SNO	DESCRIPTION
CO.1	To know different Cooling Cycle And Working of Vapour Compression Refrigeration System
CO.2	Explore their knowledge about working of Multiple Stage Refrigeration System
CO.3	To know and apply different processes of Liquefaction of the light weight gases like helium and hydrogen
CO.4	Explore their knowledge about Application Of Lower Temperatures fluids at different fields
CO.5	Explore their knowledge about different lower temperature equipment and systems used in plants

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO.1	3	2	2	1	2	2	2	-			-	1	1	1
CO.2	3	2	2	1	2	2	2	-			-	1	1	1
CO.3	3	2	2	2	3	3	2	-			-	1	1	1
CO.4	3	2	2	2	3	3	2	-			-	1	1	1
CO.5	3	2	2	2	3	3	2	-			-	1	1	1

UNIT- I **10 HOURS**

Vapour Compression Refrigeration Systems:
Analysis of vapor compression refrigeration cycle, Second law of Thermodynamics, Carnot refrigerator, Vapor Compression Refrigeration Cycle, components, Properties of Refrigerants.

UNIT- II **10 HOURS**

Multiple Stage Refrigeration System :
Introduction, Methods of improving COP of Multi Stage Compression with Intercooling , Multistage evaporator System, Cascade Refrigeration System, Dry ice Manufacturing, Auto Cascade System, Joule-Thomson Coefficient.

UNIT- III **10 HOURS**
CRYOGENICS :
Liquefaction of air, Linde system, Analysis, Liquefaction of Neon, Hydrogen and Helium.

UNIT- IV **10 HOURS**
Application Of Lower Temperatures:
Effects on the properties of metal strength, Thermal properties, super conductivity, super fluidity. Applications, such as expansion fitting, cryobiology, cryosurgery, space research, computers , underground power lines.

UNIT-V **10 HOURS**

Low Temperature Insulation:

Reflective insulation, Evacuated powders, Rigid foams, Super insulation. Cooling by adiabatic de-magnetization , Gas separation and cryogenic systems , separation of gases, Rectifying columns, Air separating, single and double columns Air separation plant.

Storage and handling of cryogenic liquids , Dewars and other types of containers.

TEXT BOOKS:

1. Refrigeration & Air, Conditioning by C.P. Arora, TMH, 2017

2. Cryogenic Systems by R.F Barron ,Oxford University Press, 1985 .

REFERENCE BOOKS:

1. Refrigeration& Air, Conditioning, StoeckerW.F. Jones, J.W., McGraw Hill, 2014.

2. Refrigeration & Air,Conditioning , Manohar Prasad New Age, 2018 .

3. Refrigeration & Air,Conditioning Domkunduwar, and Arora ,Dhanpatrai & Sons, 2015.

20METEPE4 MODELLING OF IC ENGINES

3 0 0 3

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

SNO	DESCRIPTION
CO.1	By undergoing the course, one will be able to design various Internal Combustion Engine and its components for the required output at the given conditions
CO.2	Recognize and understand reasons for differences among operating characteristics of different engine types and designs
CO.3	Given an engine design specification, predict performance and fuel economy trends with good accuracy
CO.4	Learn to compare and contrast experimental results with theoretical trends, and to attribute observed discrepancies to either measurement error or modeling limitations
CO.5	Through the use of both theoretical techniques and experimentation, develop an appreciation for theoretical and practical limits to engine performance and fuel economy

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO.1	3	2						-			-		1	1
CO.2	3	2	2					-			-		1	1
CO.3	3	2						-			-		1	1
CO.4	3	2						-			-		1	1
CO.5	3	2	2					-			-		1	1

UNIT-I **10 HOURS**

Fundamentals: Governing equations, Equilibrium charts of combustion chemistry, chemical reaction rates, and approaches of modeling, model building and integration methods, gas exchange through valves, engine and porting geometry, exhaust gas recirculation, valve lift curves.

UNIT-II **10 HOURS**

Thermodynamic Combustion Models Of Ci Engines: Single zone models, premixed and diffusive combustion models, combustion heat release using wiebe function, wall heat transfer correlations, ignition delay, internal energy estimations, two zone model, application of heat release analysis.

UNIT-III **10 HOURS**

Fuel Spray Behavior: Fuel injection, spray structure, fuel atomization, droplet turbulence interactions, droplet impingement on walls.

UNIT-IV **10 HOURS**

Modeling Of Charging System: Constant pressure and pulse turbo charging, compressor and turbine maps, charge air cooler.

UNIT-V **10 HOURS**

Mathematical Models Of Si Engines: Simulation of Otto cycle at full throttle, part throttle and supercharged conditions. Progressive combustion, Autoignition modeling, single zone models, mass burning rate estimation, SI Engine with stratified charge. Friction in pumping, piston assembly, bearings and valve train etc. friction estimation for warm and warm up engines

REFERENCES:

1. Haywood, "I.C. Engines", Mc Graw Hill.
2. Ramos **J** (1989**)** Internal Combustion Engine Modeling**.** Hemisphere Publishing Company
3. C. D. Rakopoulos and E. G. Giakoumis, "Diesel Engine Transient
4. V. Ganeshan, "Internal Combustion Engines", Tata McGraw Hill, New Delhi, 1996.
5. P.A. Lakshminarayanan and Y. V. Aghav, " Modelling Diesel Combustion" Springer, 2010
6. Bernard Challen and Rodica Baranescu, "Diesel Engine Reference Book" Butterworth Heinemann, 1999.

20METEPE4 JET PROPULSION AND ROCKETRY

3 0 0 3

Course Outcomes:

At the end of the course, students will be able to

SNO	DESCRIPTION
CO.1	Explain the working of jet engines and rocket propulsion systems.
CO.2	Describe liquid propellant rocket engines.
CO.3	Discuss solid propellant rocket engines and explain rocket motor
CO.4	Classify solid propellants and discuss the characteristics.
CO.5	Explain the working of hybrid propellant rockets and select the Process for rocket propulsion systems.

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO.1	3	3	2	2	-	-	-	-	2	2	-	-	2	2
CO.2	3	3	2	2	-	-	-	-	2	2	-	-	2	2
CO.3	3	3	2	2	-	-	-	-	2	2	-	-	2	2
CO.4	3	3	2	2	-	-	-	-	2	2	-	-	2	2
CO.5	3	3	2	2	-	-	-	-	2	2	-	-	2	2

UNIT-I **10 HOURS**

Turbo Jet Propulsion Systems : Gas turbine cycle analysis,layout of turbo jet engine. Turbo machinery, compressors and turbines, combustor, blade aerodynamics, engine off design performance analysis.

Flight Performance: Forces acting on vehicle,Basic relations of motion,multi stage vehicles.

Unit-II **10 Hours**

Principles Of Jet Propulsion And Rocketry: Fundamentals Of Jet Propulsion, Rockets And Air Breathing Jet Engines,Classification,Turbo Jet , Turbo Fan, Turbo Prop, Rocket (Solid And Liquid Propellant Rockets) And Ramjet Engines.

Nozzle Theory and Characteristics Parameters: Theory of one dimensional convergent, divergent nozzles, aerodynamic choking of nozzles and mass flow through a nozzle,nozzle exhaust velocity, thrust, thrust coefficient,

Ac / At of a nozzle, Supersonic nozzle shape, non, adapted nozzles, Summerfield criteria, departure from simple analysis,characteristic parameters,1) characteristic velocity, 2) specific impulse 3) total impulse 4) relationship between the characteristic parameters 5) nozzle efficiency, combustion efficiency and overall efficiency.

UNIT-III **10 HOURS**

Aero Thermo Chemistry Of The Combustion Products: Review of properties of mixture of gases,Gibbs,Dalton laws,Equivalent ratio, enthalpy changes in reactions, heat of reaction and heat of formation,calculation of adiabatic flame temperature and specific impulse,frozen and equilibrium flows.

Solid Propulsion System: Solid propellants, classification, homogeneous and heterogeneous propellants, double base propellant compositions and manufacturing methods. Composite propellant oxidizers and binders. Effect of binder on propellant properties. Burning rate and burning rate laws, factors influencing the burning rate, methods of determining burning rates.

UNIT-IV **10 HOURS**

Solid Propellant Rocket Engine: Internal ballistics, equilibrium motor operation and equilibrium pressure to various parameters. Transient and pseudo equilibrium operation, end burning and burning grains, grain design. Rocket motor hard ware design. Heat transfer considerations in solid rocket motor design. Ignition system, simple pyro devices.

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

UNIT-V **10 HOURS**

Ramjet And Integral Rocket Ramjet Propulsion System: Fuel rich solid propellants, gross thrust, gross thrust coefficient, combustion efficiency of ramjet engine, air intakes and their classification, critical, super critical and sub,critical operation of air intakes, engine intake matching, classification and comparison of Integral Rocket Ramjet (IRR) propulsion systems.

TEXT BOOKS:

1. Mechanics and Dynamics of Propulsion/ Hill and Peterson/John Wiley & Sons
2. Rocket propulsion elements/Sutton/John Wiley & Sons/8th Edition

REFERENCES:

1. Gas Turbines/Ganesan /TMH
2. Gas Turbines & Propulsive Systems / Khajuria & Dubey / Dhanpat Rai& Sons
3. Rocket propulsion/Bevere/
4. Jet propulsion /Nicholas Cumpsty/University of Cambridge

20METE8 Computational Fluid Dynamics Lab - II

3003

Course Outcomes:

At the end of the course, students will be able to

SNO	DESCRIPTION
CO.1	Design models using CAD software and practice of Ansy's software for real time problems of fluid mechanics and heat transfer
CO.2	Design optimized thermal equipment for different fields
CO.3	Design and build a geometry, mesh that geometry, Perform CFD method on the mesh for further simulation
CO.4	Understand the validation of the numerical result by comparison with known analytical results of real time problems in thermal industry
CO.5	Simulate and analysis carried out on all heat transfer and fluid mechanics related problems

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO.1	3	3		2	2	-	-	-	2	2	-	-	1	1
CO.2	3	3		2	2	-	-	-	2	2	-	-	1	1
CO.3	3	3		2	2	-	-	-	2	2	-	-	1	1
CO.4	3	3		2	2	-	-	-	2	2	-	-	1	1
CO.5	3	3		2	2	-	-	-	2	2	-	-	1	1

List of the Experiments:

1. Static Structural Analysis of a Rectangular Plate with Circular hole
2. Steady State Analysis of a Composite Slab
3. Analysis of Laminar flow in a 3D Circular Pipe
4. Analysis of Pressure and Velocity in a Convergent Divergent Nozzle
5. Study of Variation of various losses in a Sudden contraction in pipes

6. External flow analysis of a Cylinder
7. 3 D analysis of a Rectangular Duct
8. Internal Flow 3D analysis
9. Study of Variation of various parameters in a Rotor
10. Study of Variation of various parameters in a Rotary Compressor
11. Transient State Analysis of a Sphere
12. Analysis of Orifice in a Cylinder

Text Books	1. Numerical heat transfer and fluid flow / Suhas V. Patankar/Butter-worth Publishers
	2.Computational fluid dynamics - Basics with applications /John. D. Anderson / Mc Graw Hill.
References	1. Computational Fluid Flow and Heat Transfer/ Niyogi/Pearson Publications
	2. Fundamentals of Computational Fluid Dynamics /Tapan K. Sengupta / Universities Press.
	3.Finite Element Methods with Programming and Ansys, Mar 7, 2013, by Meung Kim

20METE9 THERMAL ENGINEERING LAB – II

3003

Course Outcomes:

At the end of the course, students will be able to

SNO	DESCRIPTION
CO.1	Estimate the convective heat transfer coefficient in various conditions.
CO.2	Calculate the heat transfer through a pin-fin
CO.3	Evaluate the performance of heat exchanger in various arrangements.
CO.4	Determination of Calorific Value of fuel.

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO.1	3	2				-	-	-	2	2	-	-	1	1
CO.2	3	2		1		-	-	-	2	2	-	-	1	1
CO.3	3	2		1		-	-	-	2	2	-	-	1	1
CO.4	3	2				-	-	-	2	2	-	-	1	1

List of the Experiments:

1. Natural convection through Pin-Fin.
2. Forced convection.
3. Natural convection through vertical Cylinder.
4. Flame propagation analysis of gaseous fuels.
5. Measurement of Viscosity by Sayboltz's Viscometer.
6. Determination of Calorific Value of fuel.
7. Performance evaluation of Shell and Tube heat exchanger.

8. Performance test on Rotary Air Compressor.
9. Performance test on Reciprocating Air Compressor.
10. Measurement of Dryness Fraction by using Throttling Calorimeter.
11. Performance evaluation of Solar Flat Plate Collector.

Text Books	1. https://www.iare.ac.in/sites/default/files/lab2/TE%2Blab.pdf 2.www.bitswgl.ac.in/.../TE%20LAB%20MANUAL%20BITS%20NEW%20UPDATED 3.mech.gecgudlavalleru.ac.in/pdf/manuals/THERMAL%20ENGINEERING%20L AB.pd
Web sources	1.https://www.youtube.com/watch?v=jz7nBi76cPU 2.https://www.youtube.com/watch?v=O5zWJ-GCslc 3.https://www.youtube.com/watch?v=-Wj_MO4BqtA 4.https://www.youtube.com/watch?v=2vk5B6Gga10

20METE10 MINI PROJECT WITH SEMINAR

3 0 0 3

Note:
It is recommended that a Supervisor/advisor should be allotted to each student at the end of the semester-I or allot at the start of the semester-II

Syllabus content:
A Student has to select one paper published in any of the IEEE Transactions and simulate the same. The student has to present the progress of the work at the middle of the semester. At the end of the semester, the student has to present the results by explaining the idea of the topic, methodology, finding of the simulations. A Student should also submit a report of the entire work carried out under this course. The end semester presentation must be video recorded and preserved.

For Ist & IInd semesters Seminar 100 marks are allotted for each, which shall be awarded based on the performance of the student on the selected advanced topic which is subdivided as follows.

- Marks for assignment - 20
- Marks for Power Point Presentation - 60
- Marks for viva voce (Orals) - 20

Total marks - 100

20METEA2 VALUE EDUCATION

3 0 0 3

Course Outcomes:

At the end of the course, students will be able to

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

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO.1	1													
CO.2	1													
CO.3	1													

UNIT-I **10 HOURS**

Values and self-development –Social values and individual attitudes, Work ethics, Indian vision of humanism, Moral and non- moral valuation. Standards and principles, Value judgements

UNIT-II **10 HOURS**

Importance of cultivation of values, Sense of duty. Devotion, Self-reliance. Confidence, Concentration. Truthfulness, Cleanliness, Honesty, Humanity. Power of faith, National Unity, Patriotism.Love for nature ,Discipline

UNIT-III **10 HOURS**

Personality and Behavior Development - Soul and Scientific attitude, Positive Thinking. Integrity and discipline, Punctuality, Love and Kindness, Avoid fault Thinking, Free from anger, Dignity of labour, Universal brotherhood and religious tolerance, True friendship.

UNIT-IV **10 HOURS**

Happiness Vs suffering, love for truth, Aware of self-destructive habits, Association and Cooperation. Doing best

UNIT-V **10 HOURS**

Character and Competence –Holy books vs Blind faith, Self-management and Good health, Science of reincarnation, Equality, Nonviolence ,Humility, Role of Women, All religions and same message, Mind your Mind, Self-control, Honesty, Studying effectively.

TEXT BOOK:

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

20METEPE5 ADVANCED OPTMIZATION TECHNIQUES

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

SNO	DESCRIPTION
CO.1	Solve optimization problems using classical optimization techniques
CO.2	Solve simple non-linear multivariable optimization problems
CO.3	Solve optimization problems using geometric programming
CO.4	Explain the working of different operators used in genetic algorithms for optimization.
CO.5	Explain concepts of stochastic programming and solve problems using integer programming.

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO.1	3	3	2	2	-	-	-	-	2	2	-	-	2	2
CO.2	3	3	2	2	-	-	-	-	2	2	-	-	2	2
CO.3	3	3	2	2	-	-	-	-	2	2	-	-	2	2
CO.4	3	3	2	2	-	-	-	-	2	2	-	-	2	2
CO.5	3	3	2	2	-	-	-	-	2	2	-	-	2	2

UNIT-1 **10 HOURS**

Single Variable Non,Linear Unconstrained Optimization: One dimensional Optimization methods:, Uni,modal function, elimination methods, Fibonacci method, golden section method, interpolation methods,quadratic & cubic interpolation methods.

UNIT-II **10 HOURS**

Multi Variable Non,Linear Unconstrained Optimization: Direct search method,Univariant method , pattern search methods,Powell's, Hook ,Jeeves, Rosenbrock search methods, gradient methods, gradient of function, steepest decent method, Fletcher Reeves method, variable metric method.

UNIT-III **10 HOURS**

Linear Programming: Formulation,Sensitivity analysis. Change in the constraints, cost coefficients, coefficients of the constraints, addition and deletion of variable, constraints. Duality,importance of duality, solution of primal from dual.

UNIT-IV **10 HOURS**

Non Traditional Optimization Algorithms: Genetics Algorithm,Working Principles, Similarities and Differences between Genetic Algorithm & Traditional Methods. Simulated Annealing, Working Principle,Simple Problems.

UNIT-V **10 HOURS**

Applications To Thermal Systems: Optimal design of heat exchangers, condensers, evaporator and IC Engines.

TEXT BOOKS:

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

REFERENCE BOOKS:

1. S.D.Sharma / Operations Research
2. Optimization Techniques /Benugundu & Chandraputla / Pearson Asia.
3. Design of Thermal Systems / W.F Stoecker/Mc Graw Hill Education

20METEPE5 DESIGN AND ANALYSIS OF EXPERIMENTS

Course Outcomes:

At the end of the course, students will be able to

SNO	DESCRIPTION
CO.1	Appreciate the advantages and disadvantages of a design for a particular experiment
CO.2	Construct optimal or good designs for a range of practical experiments
CO.3	Understand the potential practical problems in its implementation
CO.4	Describe how the analysis of the data from the experiment should be carried out
CO.5	Interpret the results of an inferential test and understand the limitations of each procedure.

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO.1	3	3			-	-	-	-			-	-	1	1
CO.2	3	3	2		-	-	-	-			-	-	1	1
CO.3	3	3			-	-	-	-			-	-	1	1
CO.4	3	3			-	-	-	-			-	-	1	1
CO.5	3	3	2		-	-	-	-			-	-	1	1

UNIT-I **10 HOURS**

STRATEGY OF EXPERIMENTATION: Guidelines for designing experiments, sampling and sampling distributions, hypothesis testing, choice of sample size. Experiments with single factor: Analysis of variance, analysis of the fixed effects model, model adequacy checking, sample computer output, regression approach to the analysis of variance.

UNIT-II **10 HOURS**

Factorial Designs: Principles, advantage of factorials, two-factor factorial design, general factorial design, fitting response curves and surfaces.2^k factorial design: 2^2 design, 2^3 design, General 2^kdesign, single replicate of 2^k design.

UNIT-III **10 HOURS**

Two-Level Fractional Factorial Designs: one-half fraction of 2^K design, one- quarter fraction of 2^K design, blocking replicated 2^K factorial design, confounding in 2^K factorial design. Three-level and mixed-level factorial design: 3^K factorial design, confounding in 3^K factorial design, fractional replication of 3^K factorial design, factorials with mixed levels.

UNIT-IV **10 HOURS**

REGRESSION MODELS: Linear regression models, estimation of the parameters, hypothesis testing in multiple regression, confidence intervals in multiple regression, prediction of new response observations, regression model diagnostics.

UNIT-V **10 HOURS**

Response Surface Methods: Introduction, method of steepest ascent, analysis of second-order response surface, experimental designs for fitting response surfaces.

TEXT BOOK:

1. D.C. Montgomery, "Design and Analysis of Experiments", 5th edition, John Wiley and sons,
.

REFERENCES:

1. D.C. Montgomery," Introduction to Statistical Quality Control", 4th edition, John Wiley and sons, 2001.
2. Angela Dean and Daniel Voss, "Design and Analysis of Experiments", Springer, 1999

20METEPE5 Convective Heat Transfer

Course Outcomes:

At the end of the course, students will be able to

SNO	DESCRIPTION
CO.1	Explain principles of forced and free convection heat transfer processes.
CO.2	Distinguish the laminar and turbulent flow convection.
CO.3	Analyze natural convection and solve problems.
CO.4	Solve the combined convection problems.
CO.5	Apply the concept of convection to porous media..

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO.1	2	1			2	-	-	-			-	-	2	1
CO.2		3	2		-	-	-	-			-	-	2	1
CO.3		3	2		-	-	-	-			-	-	2	1
CO.4	3	2	1		3	-	-	-			-	-	2	1
CO.5	3	2	1		3	-	-	-			-	-	2	1

UNIT-I **10 HOURS**

Introduction to free, forced combined convection,convective heat transfer coefficient,Application of dimensional analysis to convection,Physical interpretation of dimensionless numbers.

Equations of Convective Heat Transfer: Continuity, Navier,Strokes equation & energy equation for steady state flows,similarity,Equations for turbulent convective heat transfer,Boundary layer equations for laminar, turbulent flows,Boundary layer integral equations.

UNIT-II **10 HOURS**

External Laminar Forced Convection: Similarity solution for flow over an isothermal plate,integral equation solutions,Numerical solutions,Viscous dissipation effects on flow over a flat plate.

External Turbulent Flows: Analogy solutions for boundary layer flows,Integral equation solutions,Effects of dissipation on flow over a flat plate.

Internal Laminar Flows: Fully developed laminar flow in pipe, plane duct & ducts with other cross,sectional shapes,Pipe flow & plane duct flow with developing temperature field,Pipe flow& plane duct flow with developing velocity & temperature fields.

Internal Turbulent Flows: Analogy solutions for fully developed pipe flow – Thermally developing pipe & plane duct flow.

UNIT-III **10 HOURS**

Naturalconvection: Boussineqapproximation,Governingequations,Similarity,Boundary layer equations for free convective laminar flows, Numerical solution of boundary layer equations. Free Convective flows through a vertical channel across a rectangular enclosure,Horizontal enclosure,Turbulent natural convection.

UNIT-IV **10 HOURS**

Combined Convection: Governing parameters & equations,laminar boundary layer flow over an isothermal vertical plate,combined convection over a horizontal plate,correlations for mixed convection,effect of boundary forces on turbulent flows,internal flows , internal mixed convective flows,Fully developed mixed convective flow in a vertical plane channel & in a horizontal duct.

UNIT-V **10 Hours**

Convective Heat Transfer Through Porous Media: Area Weighted Velocity,Darcy Flow Model,Energy Equation,Boundary Layer Solutions For 2,D Forced Convection,Fully Developed Duct Flow,Natural Convection In Porous Media,Filled Enclosures,Stability Of Horizontal Porous Layers.

TEXT BOOK:

1. Convective Heat & Mass Transfer /Kays& Crawford/TMH

REFERENCES:

1. Introduction to Convective Heat Transfer Analysis/ Patrick H. Oosthuigen& David Naylor, MGH.
2. Convection Heat Transfer / Adrian Bejan / Wlley
3. Principles of Convective Heat Transfer / Kaviany, Massoud /Springer

20METEPE5 ADVANCED FINITE ELEMENTS METHODS

Course Outcomes:

At the end of the course, students will be able to

SNO	DESCRIPTION
CO.1	Illustrate the Variational methods-potential energy method, Raleigh Ritz method, strong and weak forms, Galerkin and weighted residual methods
CO.2	Identify the application and characteristics of FEA elements such as Bar, trusses, beams and frames.
CO.3	Solve the 2-D Stress Analysis with CST element and Axi-Symmetric Formulation
CO.4	Make use of 2-D Isoparametric elements and Numerical Integration for solving problems.
CO.5	Apply Steady state Heat Transfer Analysis and Static and dynamic analysis to solve problems

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO.1	3	3	2	2	-	-	-	-	2	2	-	-	2	2
CO.2	3	3	2	2	-	-	-	-	2	2	-	-	2	2
CO.3	3	3	2	2	-	-	-	-	2	2	-	-	2	2
CO.4	3	3	2	2	-	-	-	-	2	2	-	-	2	2
CO.5	3	3	2	2	-	-	-	-	2	2	-	-	2	2

UNIT – I **10HOURS**

Formulation Techniques: Methodology, Engineering problems and governing differential equations, finite elements., Variational methods-potential energy method, Raleigh Ritz method, strong and weak forms, Galerkin and weighted residual methods, calculus of variations, Essential and natural boundary conditions.

UNIT – II **10HOURS**

One-Dimensional Elements: Bar, trusses, beams and frames, displacements, stresses and temperature effects.

UNIT – III **10HOURS**

Two Dimensional Problems: CST, LST, four nodded and eight nodded rectangular

elements, Lagrange basis for triangles and rectangles, serendipity interpolation functions. Axisymmetric Problems: Axisymmetric formulations, Element matrices, boundary conditions. Heat Transfer problems: Conduction and convection, examples: - two- dimensional fin.

UNIT – IV **10HOURS**

Isoparametric Formulation: Concepts, sub parametric, super parametric elements, numerical integration, Requirements for convergence, h-refinement and p-refinement, complete and incomplete interpolation functions, Pascal's triangle, Patch test.

UNIT – V **10HOURS**

Finite Elements In Structural Analysis: Static and dynamic analysis, eighen value problems,
and their solution methods, case studies using commercial finite element packages.

TEXT BOOK:

1. Finite element methods by Chandrubatla & Belagondu.

REFERENCES:

1. J.N. Reddy, Finite element method in Heat transfer and fluid dynamics, CRC press, 1994
2. Zienckiwicz O.C. & R. L. Taylor, Finite Element Method, McGraw-Hill,1983.
3. K. J. Bathe, Finite element procedures, Prentice-Hall, 1996

20METEOE1 WASTE AS A SOURCE OF ENERGY

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

SNO	DESCRIPTION
CO.1	Understand technologies for generation of energy from solid waste.
CO.2	Compare methods of solid waste disposal.
CO.3	Identify various energy generation methods.
CO.4	Identify sources of energy from bio-chemical conversion.
CO.5	Survey techniques for management of e-waste.

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO.1	3	3	2	2	-	-	-	-	2	2	-	-	2	2
CO.2	3	3	2	2	-	-	-	-	2	2	-	-	2	2
CO.3	3	3	2	2	-	-	-	-	2	2	-	-	2	2
CO.4	3	3	2	2	-	-	-	-	2	2	-	-	2	2
CO.5	3	3	2	2	-	-	-	-	2	2	-	-	2	2

UNIT-I **10 HOURS**

Introduction To Energy From Waste: Classification of waste as fuel,Agro based, Forest residue, Industrial waste , MSW, Conversion devices, Incinerators, gasifiers, digestors

UNIT-II **10 HOURS**

Biomass Pyrolysis: Pyrolysis, Types, slow fast, Manufacture of charcoal, Methods ,Yields and application, Manufacture of pyrolytic oils and gases, yields and applications

.

UNIT-III **10 HOURS**

Biomass Gasification: Gasifiers, Fixed bed system, Downdraft and updraft gasifier– Fluidized bed gasifiers, Design, construction and operation, Gasifier burner arrangement for thermal heating, gasifier engine arrangement and electrical power Equilibrium and kinetic consideration in gasifier operation.

UNIT-IV **10 HOURS**

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-V **10 HOURS**

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 Processes , Thermo Chemical Conversion , Direct Combustion ,Biomass Gasification , Pyrolysis And Liquefaction , Biochemical Conversion , Anaerobic Digestion ,Types Of Biogas Plants, Applications , Alcohol Production From Biomass, Bio Diesel Production Urban Waste To Energy Conversion , Biomass Energy Programmed In India.

Text Books

1. Biogas Technology , A Practical Hand Book , Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
2. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley &Sons,
1996.

References:

1. Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd.,
1990.
2. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd.,
1991.

20METEOE1 OPERATIONS RESEARCH

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

SNO	DESCRIPTION
CO.1	Formulate a linear programming problem for given problem and solve this problem by using Simplex techniques
CO.2	Evaluate sensitivity analysis to the given input data in order to know sensitive of the output
CO.3	Apply the concept of non-linear programming for solving the problems involving non-linear
CO.4	Solve deterministic and Probabilistic inventory control models for known and unknown demand of the items.
CO.5	Apply the dynamic programming to solve problems of discrete and continuous variables

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO.1	3	3	2	2	-	-	-	-	2	2	-	-	2	2
CO.2	3	3	2	2	-	-	-	-	2	2	-	-	2	2
CO.3	3	3	2	2	-	-	-	-	2	2	-	-	2	2
CO.4	3	3	2	2	-	-	-	-	2	2	-	-	2	2
CO.5	3	3	2	2	-	-	-	-	2	2	-	-	2	2

UNIT-I **10 HOURS**
Optimization techniques, model formulation, models, simplex techniques, inventory control models

UNIT-II **10 HOURS**
Formulation of a LPP - graphical solution for LPP, revised simplex method - duality theory - dual simplex method - sensitivity analysis - parametric programming

UNIT-III **10 HOURS**
Nonlinear programming problem - Kuhn-Tucker conditions, CPM/PERT

UNIT-IV **10 HOURS**
Single server and multiple server models - deterministic inventory models - probabilistic inventory control models - geometric Programming

UNIT-V **10 HOURS**
Single and multi-channel problems , sequencing models, dynamic programming, flow in networks, elementary graph theory, game theory simulation

TEXT BOOKS:
1. Kanthi Swarup, P.K. Gupta and Man Mohan, *Operations Research*, 14 son's, New Delhi, 2008.
2. S. D. Sharma, *Operations Research*, Kedar Nath and Ram Nath, Meerut,2008.
REFERENCE BOOKS:
1. H.A. Taha, *Operations Research, An Introduction*, 7

2. J.C. Pant, *Introduction to Optimisation: Operations Research*,7th
3. Hitler Libermann, *Operations Research*, McGraw Hill Pub., 2009.
Edition, PHI, 2008. Edition, Sultan chand and Edition, Jain Brothers, Delhi, 2008.
4. Pannerselvam, *Operations Research*, Prentice Hall of India, 2010.
5. Harvey M Wagner, *Principles of Operations Research*, Prentice Hall of India, 2010.

20METEOE1 ADVANCED NUMERICAL METHODS

Course Outcomes:

At the end of the course, students will be able to

SNO	DESCRIPTION
CO.1	Solve the algebraic equations like linear equations, Eigenvalue problems
CO.2	Analyze ordinary differential equations
CO.3	Solve the finite difference method for time dependent partial differential equation
CO.4	Analyze finite difference methods for elliptic equations
CO.5	Analyze finite element method

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO.1	3	3	2	-	-	-	-	-	-	-	-	-	1	1
CO.2	3	2	1	-	-	-	-	-	-	-	-	-	2	2
CO.3	3	3	2	-	-	-	-	-	-	-	-	-	2	2
CO.4	3	3	2	-	-	-	-	-	-	-	-	-	2	2
CO.5	3	3	2	-	-	-	-	-	-	-	-	-	2	2

UNIT – I **10HOURS**

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 **10 HOURS**

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 **10 HOURS**

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 **10 HOURS**

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 **10 HOURS**

Finite Element Method : Partial differential equations – Finite element method - orthogonal collocation method, orthogonal collocation with finite element method, Galerkin finite element method

TEXT BOOKS:

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.

20METEOE1 Composite Materials

Course Outcomes:

At the end of the course, students will be able to

SNO	DESCRIPTION
CO.1	Learn composite material history, definition, grouping and its applications.
CO.2	Gain knowledge about macro mechanical properties (stress/strain/elastic module/Hooke's law/strain energy/stress-strain relations) of composite lamina and laminates
CO.3	Gain knowledge about micromechanical properties (volume and mass fractions, density and void content) of composite lamina
CO.4	Design and analyze composite materials to assess failure criteria
CO.5	Understand types, manufacturing processes, and applications of composite materials

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO.1	3	3		-	-	-	-	-	-	-	-	-	1	
CO.2	3	2	3	-	-	-	-	-	-	-	-	-	1	1
CO.3	3	3		-	-	-	-	-	-	-	-	-	1	
CO.4	3	3		-	-	-	-	-	-	-	-	-	1	1
CO.5	3	3		-	-	-	-	-	-	-	-	-	1	1

UNIT – I **10 HOURS**

Introduction: Definitions, Composites, Reinforcements and matrices, Types of reinforcements, Types of matrices, Types of composites, Carbon Fibre composites, Properties of composites in comparison with standard materials, Applications of metal, ceramic and polymer matrix composites.

UNIT – II **10HOURS**

Manufacturing methods : Hand and spray lay - up, injection molding, resin injection, filament winding, pultrusion, centrifugal casting and prepregs. Fibre/Matrix Interface, mechanical. Measurement of interface strength. Characterization of systems; carbon fibre/epoxy, glass fibre/polyester, etc.

UNIT – III **10HOURS**

Mechanical Properties -Stiffness and Strength: Geometrical aspects – volume and weight fraction. Unidirectional continuous fibre, discontinuous fibers, Short fiber systems, woven reinforcements –Mechanical Testing: Determination of stiffness and strengths of unidirectional composites; tension, compression, flexure and shear.

UNIT – IV **10HOURS**

Laminates : Plate Stiffness and Compliance, Assumptions, Strains, Stress Resultants, Plate Stiffness and Compliance, Computation of Stresses, Types of Laminates -, Symmetric Laminates, Antisymmetric Laminate, Balanced Laminate, Quasi-isotropic Laminates, Cross-ply Laminate, Angleply Laminate. Orthotropic Laminate, Laminate Moduli, Hygrothermal Stresses.

UNIT – V **10HOURS**

Joining Methods and Failure Theories : Joining –Advantages and disadvantages of adhesive and mechanically fastened joints. Typical bond strengths and test procedures.

Text Books

1. Introduction to composite materials design / 2nd ed.Ever J. Barbero.
2. Design and Analysis of Composite Structures: With Applications to Aerospace ... By Christos Kassapoglou
3. Mechanics of composite structures / László P. Kollár, George S. Springer.
4. Composite materials : production, properties, testing and applications / K. Srinivasan.

Reference Books

1. Finite element analysis of composite materials using Abaqus / Ever J. Barbero
2. Finite Element Analysis of Composite Materials Using ANSYS®, Second Edition By Ever J. Barbero

M.Tech – III&IV Sem		L	T	P	C
(DISSERTATION) DISSERTATION PHASE – I AND PHASE – II					

Course Outcomes:

At the end of the course, students will be able to

SNO	DESCRIPTION
CO.1	Synthesize knowledge and skills previously gained and applied to an in-depth study and execution of new technical problem..
CO.2	Select from different methodologies, methods and forms of analysis to produce a suitable research design, and justify their design.
CO.3	Present the findings of their technical solution in a written report.
CO.4	Present the work in International/ National conference or reputed journals.

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO.1	3	3		-	-	-	-	-	-	-	-	3	1	
CO.2	3	2	3	-	-	-	-	-	-	-	-	3	1	1
CO.3	3	3		-	-	-	-	-	-	-	-	3	1	
CO.4	3	3		-	-	-	-	-	-	-	-	3	1	1

Syllabus Contents:

The dissertation / project topic should be selected / chosen to ensure the satisfaction of the urgent need to establish a direct link between education, national development and productivity and thus reduce the gap between the world of work and the world of study. The dissertation should have the following

- Relevance to social needs of society
- Relevance to value addition to existing facilities in the institute
- Relevance to industry need
- Problems of national importance
- Research and development in various domain

The student should complete the following:

- Literature survey Problem Definition
- Motivation for study and Objectives
- Preliminary design / feasibility / modular approaches
- Implementation and Verification
- Report and presentation

The dissertation stage II is based on a report prepared by the students on dissertation allotted to them. It may be based on:

- Experimental verification / Proof of concept.
- Design, fabrication, testing of Communication System.
- The viva-voce examination will be based on the above report and work.

Guidelines for Dissertation Phase – I and II at M. Tech.:

- As per the AICTE directives, the dissertation is a yearlong activity, to be carried out and evaluated in two phases i.e. Phase – I: July to December and Phase – II: January to June.
- The dissertation may be carried out preferably in-house i.e. department's laboratories and centers OR in industry allotted through department's T & P coordinator.
- After multiple interactions with guide and based on comprehensive literature survey, the student shall identify the domain and define dissertation objectives. The referred literature should preferably include IEEE/IET/IETE/Springer/Science Direct/ACM journals in the areas of Computing and Processing (Hardware and Software), Circuits- Devices and Systems, Communication-Networking and Security, Robotics and Control Systems, Signal Processing and Analysis and any other related domain. In case of Industry sponsored projects, the relevant application notes, while papers, product catalogues should be referred and reported.
- Student is expected to detail out specifications, methodology, resources required, critical issues involved in design and implementation and phase wise work distribution, and submit the proposal within a month from the date of registration.

• Phase – I deliverables: A document report comprising of summary of literature survey, detailed objectives, project specifications, paper and/or computer aided design, proof of concept/functionality, part results, A record of continuous progress.

- Phase – I evaluation: A committee comprising of guides of respective specialization shall assess the progress/performance of the student based on report, presentation and Q &A. In case of unsatisfactory performance, committee may recommend repeating the Phase-I work.
- During phase – II, student is expected to exert on design, development and testing of the proposed work as per the schedule. Accomplished results/contributions/innovations should be published in terms of research papers in reputed journals and reviewed focused conferences OR IP/Patents.
- Phase – II deliverables: A dissertation report as per the specified format, developed system in the form of hardware and/or software, a record of continuous progress.
- Phase – II evaluation: Guide along with appointed external examiner shall assess the progress/performance of the student based on report, presentation and Q &A. In case of unsatisfactory performance, committee may recommend for extension or repeating the work