M.Tech (Thermal Engineering)-PG Course Structure-R20

I SEMESTER

S.No	Course code	Course Title	Contact hours/week				Credits	Scheme of Valuation		
			L	T	P	Total		CIE	SEE	Total
1	20TE01	Advanced Thermodynamics	3	-	-	3	3	40	60	100
2	20TE02	Advanced Heat and Mass Transfer	3	-	-	3	3	40	60	100
3	20TE03	**Program Elective-1** 1.Advanced Fluid Mechanics 2. Bio Energy and Conversion Technologies 3. Turbo machinery	3	-	-	3	3	40	60	100
4	20TE06	**Program Elective-2** 1. Advanced IC Engines and Alternate Fuels 2. Energy Storage Systems 3. Energy Conservation and Management	3	-	-	3	3	40	60	100
5	20RM01	Research Methodology and IPR	2	-	-	2	2	40	60	100
6	20AC02	Disaster Management	2	-	-	2	0	100	-	100
7	20TE61	Thermal systems Lab	-	-	4	4	2	40	60	100
8	20TE62	Simulation – Lab	-	-	4	4	2	40	60	100
		Total	16	0	8	24	18	380	420	800

II SEMESTER

S.No	Course code	Course Title	Contact hours/week				Credits	Scheme of Valuation		
			L	T	P	Total		CIE	SEE	Total
1	20TE09	Computational Fluid Dynamics	3	-	-	3	3	40	60	100
2	20TE10	Renewable Energy Technology	3	-	-	3	3	40	60	100
3	20TE11	**Program Elective-3** 1. Thermal Measurement and Process Control 2. Environmental Pollution & Control 3. Refrigeration and Cryogenics	3	-	-	3	3	40	60	100
4	20TE14	**Program Elective-4** 1. Hybrid Electric Vehicles 2. Design of Thermal Systems 3.Waste Heat Recovery Systems	3	-	-	3	3	40	60	100
5	20AC01	English for Research Paper Writing	2	-	-	2	0	100	-	100
6	20TE63	Computational Fluid Dynamics Lab	-	-	4	4	2	40	60	100
7	20TE64	Renewable Energy Technology Lab	-	-	4	4	2	40	60	100
8	20TE51	Mini Project	-	-	4	4	2	100	-	100
		Total	14	0	12	26	18	440	360	800

III SEMESTER

S.No	Course code	Course Title	Contact hours/week				Credits	Scheme of Valuation		
			L	T	P	Total		CIE	SEE	Total
1	20TE17	**Program Elective-5/** MOOCs 1. Design of experiments 2. Power Plant Engineering 3.High Performance Computing for Scientists and Engineers	3	-	-	3	3	40	60	100
2	OE	Open Elective/ MOOCs	3	-	-	3	3	40	60	100
3	20TE52	Internship	-	-	4	4	2	100	-	100
4	20TE53	Dissertation (Phase-I)	-	-	16	16	8	40	60	100
		Total	6	0	20	26	16	220	180	400

IV SEMESTER

S.No	Course code	Course Title	Contact hours/week				Credits	Scheme of Valuation		
			L	T	P	Total		CIE	SEE	Total
1	20TE54	Dissertation (Phase-II)	-	-	32	32	16	40	60	100
		Total	0	0	32	32	16	40	60	100

Total Credits: 18 + 18 + 16 + 16 = 68

List of Courses offered under Audit Course

AUDIT COURSES		
S.No	**Code**	**Name of the Course**
1	20AC01	English for research paper writing
2	20AC02	Disaster Management
3	20AC03	Sanskrit for Technical Knowledge
4	20AC04	Value education
5	20AC05	Constitution of India
6	20AC06	Pedagogy Methods
7	20AC07	Stress Management by Yoga
8	20AC08	Personality Development through Life Enlightenment Skills.

List of Open Elective Courses offered to other Departments

S.No	Code	Open Elective Name
1	20TE81	Industrial Safety
2	20TE82	Green Energy Technologies
3	20TE83	Waste to Energy

List of Courses in Program Elective-I

S.No	Code	Program Elective Name
1	20TE03	Advanced Fluid Mechanics
2	20TE04	Bio Energy and Conversion Technologies
3	20TE05	Turbo machinery

List of Courses in Program Elective-II

S.No	Code	Program Elective Name
1	20TE06	Advanced IC Engines and Alternate Fuels
2	20TE07	Energy Storage Systems
3	20TE08	Energy Conservation and Management

List of Courses in Program Elective-III

S.No	Code	Program Elective Name
1	20TE11	Thermal Measurement and Process Control
2	20TE12	Environmental Pollution & Control
3	20TE13	Refrigeration and Cryogenics

List of Courses in Program Elective-IV

S.No	Code	Program Elective Name
1	20TE14	Hybrid Electric Vehicles
2	20TE15	Design of Thermal Systems
3	20TE16	Waste Heat Recovery Systems

List of Courses in Program Elective-V(MOOCS)

S.No	Code	Program Elective Name
1	20TE17	Design of experiments
2	20TE18	Power Plant Engineering
3	20TE19	High Performance Computing for Scientists and Engineers

R20-Regulations(w.e.f.2020-21)

M.Tech(Thermal Engineering)-I Semester

Detailed Syllabus

M.Tech. (I Sem.) **20TE01 - ADVANCED THERMODYNAMICS**

L	P	T	Cr
3	-	-	3

Pre-requisites: Thermodynamics

Course Objective: To provide the insights on the laws of thermodynamics and its relations, Kinetic theory of ideal gases, non-reactive gas and liquid reactive mixtures, exergy and irreversibility of thermal systems and advanced power cycles

Course Outcomes: After the completion of the course, students should be able to

- CO1 Apply the laws of thermodynamics and thermodynamic relations of gas mixtures.
- CO2 Describe the concepts of kinetic theory applicable for ideal gases.
- CO3 Analyse non-reactive gas and liquid mixtures using thermodynamic relations.
- CO4 Apply energy balances to reacting systems for both closed and open system.
- CO5 Analyse vapour and gas power cycles. .

UNIT - I

BASIC CONCEPTS: Thermodynamics - Temperature and Zeroth law of thermodynamics - First law of thermodynamics-Applications - Limitations of first law - Concept of internal energy - Second law of thermodynamics-Applications - concept of entropy-Third law of Thermodynamics.

THERMODYNAMIC RELATIONS: Introduction – Reciprocity and cyclic relations – The Maxwell's relations – The Gibbs and Helmholtz relations - The Clapeyron Equation –Applications, General relations for du, dh, ds - Fugacity Coefficient and Residual Gibbs Function, Thomson Coefficient and Inversion Curve, Thermodynamic similarity.

UNIT- II

KINETIC THEORY OF AN IDEAL GAS: Kinetic theory of gases- introduction, basic assumption, molecular flux, equation of state for an ideal gas, collisions with a moving wall, principle of equipartition of energy, classical theory of specific heat capacity. Transport phenomena-intermolecular forces, The Van der Waals equation of state, collision cross section, mean free path.

UNIT- III

NON-REACTIVE GAS AND LIQUID MIXTURES: Introduction - Basic definitions for gas mixtures - PVT relationship for mixtures of ideal gases - Properties of 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, Relations for Activity and Activity Coefficient in Real Liquid Mixtures/Solutions.

UNIT – IV

EXERGY: Introduction - Quality of Energy - Available and Unavailable energy - Availability, Surroundings work- Reversible work -Availability function of the closed & open system - availability in a SSSF process in an open system - Applications.

IRREVERSIBILITY: Introduction - Irreversibility for closed and open system - Steady flow process – Effectiveness-Applications

UNIT – V

ADVANCED POWER CYCLES:

Vapor power cycles: - Second law analysis of vapor power cycles, Cogeneration, Binary vapor cycles, combined gas vapor power cycles-Applications.

Gas power cycles: - Second law analysis of gas power cycles-Applications, Atkinson cycle, Lenoir cycle

REFERENCES:

1. Basic and Applied Thermodynamics, P.K.Nag, TMH, 2019.

2. Thermodynamics, J.P Holman, McGraw Hill, 2017.

3. Thermodynamics, CP Arora, McGraw Hill education (India pvt limited), 2016.

4. Engineering Thermodynamics, PL.Dhar, Elsevier, 2008.

5. Thermodynamics, Sonnatag& Van Wylen, John Wiley & Sons, 2004.

6. Thermodynamics for Engineers, Doolittle-Messe, John Wiley & Sons, 2018.

7. Irreversible thermodynamics, HR De Groff, .

8. Thermal Engineering, Soman, PHI, 2011.

9. Thermal Engineering, Rathore, TMH, 2010.

10. Engineering Thermodynamics, Chattopadyaya, 2010.

M.Tech. (I Sem.) **20TE02 - ADVANCED HEAT AND MASS TRANSFER**

L	P	T	Cr
3	-	-	3

Pre-requisites: Thermodynamics, Heat transfer

Course Objective: To provide students an insight of heat and mass transfer laws, theories to solve the problems of conduction, convection, radiation, two phase flows and mass transfer.

Course Outcomes: After the completion of the course, the student will be able to

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

UNIT - I

INTRODUCTION: Modes of Heat transfer- Governing equations–1-D steady state conduction-Fins of Uniform and Non Uniform cross sections, Rectangular Fin of minimum weight-1-D Heat transfer with internal heat generation.

UNIT- II

TRANSIENT HEAT CONDUCTION: General Lumped capacitance analysis, Transient heat flow in finite and semi-infinite solid, Multidimensional systems, use of Heisler chart, Schmidt's method.

2-D STEADY STATE CONDUCTION: Method of separation of variables, FDM.

UNIT- III

FORCED-CONVECTION: General review, Laminar Flow: a similarity solution, Turbulent flow, mixed boundary layer conditions, flow across cylinders and spheres, tube banks – inline and staggered arrangement.

FREE-CONVECTION: Inclined and horizontal plates – the flow pattern and heat transfer, tubes, enclosures, simplified free convection relations for air, combined free and forced convection, External flows, Internal flows.

UNIT – IV

HEAT TRANSFER WITH PHASE CHANGE: Boiling modes, Pool boiling, flow boiling, condensation: Nusselt's theory, Film condensation, drop-wise condensation.

RADIATION: Review of radiation principles - laws of thermal radiation - Surface properties - radiative heat exchange among diffuse, gray and non-gray surfaces separated by nonparticipating media.

GAS RADIATION: Radiation transfer in enclosures containing absorbing and emitting media - interaction of radiation with conduction and convection.

UNIT – V

MASS TRANSFER: Introduction- Analogy between heat and mass transfer-Mass diffusion- Fick's law of diffusion-Boundary conditions-Steady mass diffusion through a wall-Mass convection-Analogy between friction, Transient Mass diffusion in semi-finite stationary medium, Heat transfer and Mass transfer coefficients-Significance of Non – dimensional numbers.

REFERENCES:

1. R.C.Sachdeva, Fundamentals of engineering heat and mass transfer, 5th edition, New age publishers,2017
2. NecatiOzisik, Heat Transfer –TMH, 1985
3. YunusCengel, Heat Transfer a basic approach –TMH, 2007
4. J.P.Holman,Heat Transfer – TMH, 2010
5. P.S. Ghoshdastidar, Heat Transfer, Oxford Press
6. P.K Nag, Heat & Mass Transfer, TMH
7. Frank Kreith& Mark. Bohn Principle of Heat & Mass Transfer
8. SadikKakac and YamanYener, Heat Conduction, 2nd Edition, Hemisphere, 2001.
9. Kays, W. M. and Crawford, M. E., Convective Heat and Mass Transfer, 4th Edition, Tata McGraw Hill, 2012.
10. Siegel, R. and Howell, J. R., Thermal Radiation Heat Transfer, 4th Edition, Taylor & Francis, 2002.
11. Incropera, F. P. and De Witt, D. P., Fundamentals of Heat and Mass Transfer, 5th Edition, John Wiley &Sons, New York, 2006.

Programme Elective-I

M.Tech. (I Sem.) **20TE03–ADVANCED FLUID MECHANICS**

L	P	T	Cr
3	-	-	3

Course Objective: To make the students exposed to the study of compressible and incompressible flows of viscous and non-viscous fluids, boundary layer concepts, turbulent flows and gas dynamics.

Course Outcomes: After the completion of the course, the student will be able to

- CO1 Apply the fluid kinematics and dynamics principles and compute the velocity, stream and vorticity functions of fluid flow problems.
- CO2 Distinguishes the significance of Navier Stokes equation, Hagen – Poiseuille, and Couette-flow equations and solve viscous fluid flow problems.
- CO3 Apply the concepts of boundary layer thickness, displacement thickness, momentum thickness and energy thickness for various velocity profiles.
- CO4 Solve the problems related to compressible flows with the flow patterns based on the area velocity relations
- CO5 Describes the working principles and salient features of microfluidic devices

UNIT-I

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

UNIT-II

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

UNIT-II

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

UNIT-IV

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

UNIT-V

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

REFERENCES:

1. Fluid Mechanics, Fox, R. W., McDonald, A. T., & Pritchard, P. J.,(Eighth Edition), John Wiley & Sons.
2. Foundations of Fluid Mechanics, Yuan S.W. Prentice Hall – Eastern economy edition, 1983.
3. Gas Dynamics, Zucrwo M.J. and Hoffman J.D.Vol-I &Vol-II, John Wiley and Sons Inc. 1977.
4. Fundamentals of Compressible Flow, - Yahya S.M. Wiley Eastern.
5. A Brief Introduction to Fluid Mechanics Young, Munsen and Okiisyi, 2nd Edition, John Wiley, 2000.
6. Fluid Mechanics, Frank.M.White 5th Edition – McGraw Hill, 2005.

Programme Elective-I

M.Tech. (I Sem.) **20TE04–BIO ENERGY AND COVERSION TECHNOLOGIES**

L	P	T	Cr
3	-	-	3

Course Objective: To make the students exposed to the study different bio energy conversion technologies used in the industries.

Course Outcomes: After the completion of the course, the student will be able to

CO1: Differentiate the bio energy conversion technologies and their significance in process industries.
CO2: Describe the parameters affecting the performance of the Bio gas digester
CO3: Identify the power generation methods used in different bio energy conversion technologies.
CO4: Compare and contrast the proximate and ultimate analysis used in bio mass fuels.
CO5: Solve the bio energy conversion power generation problems.

UNIT-I
THERMO CHEMICAL CONVERSION

Different processes: Direct combustion, incineration, pyrolysis, gasification and liquefaction; Economics of thermochemical conversion.

UNIT-II
BIOLOGICAL CONVERSION
Biochemistry and process parameters of bio-methanation; Biogas digester types; Digester design and biogas utilization; Economics of biogas plant with their environmental and social impacts; Bioconversion of substrates into alcohol: Methanol & ethanol Production

UNIT-III
GASIFICATION CONVERTERS
Gasification: Fuels for gasification, Properties of biomass - size, size distribution, bulk density, volatile matter, ash and ultimate analysis., Types of gasifiers, Design of a Down draft gasifier, Performance evaluation of a Down draft gasifier. Use of producer gas in SI & CI engines, Reasons for derating, Gasifier engine system Problems associated with gasifer engine system

UNIT-IV
BIOMASS FORMATION
Biomass resources: Classification and characteristics; Techniques for biomass assessment; Biomass estimation, Water-to-biomass resources, Advantages associated with biomass resources, Availability of biomass for energy generation. Energy plantation: Concept, Objectives and advantages. Waste land development: Extent of water lands in India, Nature of waste lands.

UNIT-V
WASTE TO ENERGY CONVERSION
Energy production through gasification of wastes, Energy production through pyrolysis and gasification of wastes, syngas utilization Energy production from wastes through fermentation and transesterificaton energy production from algae

REFERENCES:

1. S.Rao Pauleka, Energy technology, Khanna publishers Delhi, 1999
2. Noyes daa corporation, Biomass gasification principles and technology, Energy technology view no.67, USA, 1981
3. O.P Vimal and M.S Bhatt, Wood energy systems , K.L publications, New Delhi
4. A.Kaupp and J.R Goss ,Frieder, State of art for small scale gas producer engine systems, Viewgans Sohnverlags, 1984
5. R. C. Maheswari (Bio Energy for Rural Energisation) , Concepts Publication, 1997
6. Elsevier Applied SC, Biogas Technology : Transfer & Diffusion, London

Programme Elective-I

M.Tech. (I Sem.) **20TE05–TURBO MACHINERY**

L	P	T	Cr
3	-	-	3

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

Course Objective: To learn about the Dimensional Analysis for Turbo machines, Performance levels of various pumps, Characteristics of fans, blowers, axial compressors, gas and wind turbines performance.

Course Outcomes: After the completion of the course, students should be able to

CO1 Describe the dimensional analysis and energy transfer in turbo machines.
CO2 Solve problems of centrifugal pumps and steam turbines.

CO3 Solve the problems related to fans, blowers and compressors

CO4 Identify different technologies used in gas turbine and aviation industries.
CO5 Develop the ability to solve the wind turbine problems.

UNIT – I

INTRODUCTION: Types of Turbo machines, Applications of Turbo machines, Performance Characteristics, Methods of Analysis

DIMENSIONAL ANALYSIS: Dimensions and Dimensional Homogeneity, Buckingham Pi Theorem, Other Non-dimensional Parameters for Turbo machines, Similarity Laws

ENERGY TRANSFER IN TURBO MACHINES: Review on Fluid Mechanics Related to Turbo machinery, Energy in Flowing Fluids, Euler Equations, Equations for Axial Flow Machines, Equations for Mixed and Radial Flow Machines. Degree of Reaction

UNIT - II

CENTRIFUGAL PUMPS: Basic Construction and Classification, Basic Working Principles, Performance Characteristics, Cavitation, Performance Modifications, Preliminary Design Procedure, Pump Performance Tests Axial.

STEAM TURBINES:. Flow through impulse and reaction steam turbine stage. Optimum blade speed ratio and two stage impulse wheel. Blade and stage efficiencies for multi stage steam turbines. Vortex flow and mixed flow turbines. Thermal stress in steam turbine rotors and blades. Material for rotor and blades. Blade attachment techniques.

UNIT – III

CENTRIFUGAL FANS BLOWERS AND COMPRESSORS: Classification Performance Parameters and Characteristics, Change of Performance, Polytropic Efficiency, Preliminary Design of Centrifugal Compressors

AXIAL FLOW COMPRESSORS: Introduction. Basic Theory, Preliminary Design of Compressor Stage, Determination of Stage Efficiency, Axial Flow Compressor Performance, Surge and Stall in Compressor and the Remedies

UNIT – IV

GAS TURBINES: Introduction, Thermodynamics of Axial Flow Turbine, Degree of Reaction, Preliminary Design Procedure for Turbine Stage, Determination of Turbine Stage Efficiency, Axial Flow Turbine Performance, Compressor, Turbine Matching, Radial Inflow Gas Turbine, Thermodynamic Processes in Radial Inflow Gas Turbine.

COMBUSTION CHAMBERS: Gas turbine combustion systems - Introduction, Geometry, Factors affecting Design & Performance, Requirements of the Combustion Chamber.

UNIT – V

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

REFERENCES:

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

M.Tech. (I Sem.) **Programme Elective-II**

20TE06- ADVANCED IC ENGINES AND ALTERNATE FUELS

L	P	T	Cr
3	-	-	3

Pre-requisites: Internal-Combustion engines, Thermodynamics

Course Objective:

The main objective of this course is to provide the knowledge on internal combustion engines with emphasis on pollutants and their control strategies, heat release rate and cylinder pressure analysis. The focus is on explaining the possible utilization of alternate fuels and their performance. On the other hand, economic and environmental aspects of alternative fuels usage will be illustrated.

Course Outcomes: After the completion of the course, students should be able to

CO1: Analyse the performance of the engine using various combustion parameters.

CO2: Describe the modern developments in IC Engines.

CO3: Evaluate the performance of different engines using exhaust emission data and suggest control measures to reduce emissions.

CO4: Analyse the fuel challenges in the world and relationship between property-performance-economics of alternate fuels.

CO5: Evaluate the socio-economical nature, performance of different alternative fuels and suggest the alternate fuel for SI and CI engines.

UNIT-I: COMBUSTION IN SPARK-IGNITION ENGINES:

Stages of combustion in SI Engine- Flame Front propagation-FGactors influencing flame speed-Rate of pressure rise-Analysis of Cylinder Pressure data- Heat release analysis-Abnormal combustion- Effects of Knocking- Effect of various parameters on Knocking- SI Engine Combustion chambers.

COMBUSTION IN COMPRESSION-IGNITION ENGINES:

Stages of combustion in CI Engine-Factors effecting Ignition delay- Detonation in CI Engine-Types of injection systems in Diesel engines- Combustion chambers in CI Engines- Analysis of Cylinder Pressure data- Heat release analysis.

UNIT-II: MODERN DEVELOPMENTS IN IC ENGINES:

Lean burn engines, Ceramic and adiabatic engines, Working principle of dual fuel engines, Multi-fuel engines, Stratified charged engines, Wankel engine, Features of Rotary engine, Variable compression-ratio engines, Methods of obtaining variable compression-ratio, Surface-ignition engines, Free Piston engines, Homogeneous charge compression-ignition engines.

UNIT-III: ENGINE POLLUTION ENGINE AND CONTROL:

Types of Pollutants- Oxides of Nitrogen, Unburnt hydrocarbon, Carbon monoxide emissions, Particulate Emissions, Health and environmental effects of pollution, Measurement of emissions- Oxides of Nitrogen, Unburnt hydrocarbon, Carbon monoxide emissions, Particulate Emissions, Exhaust Gas recirculation, Thermal reactors, Catalytic Convertors, Selective catalytic reduction, NOx traps, Diesel Particulate filters, Continuously Regenerating Trap (CRT), Oxidation Catalysts .

UNIT-IV: VEGETABLE OILS AS ALTERNATE FUELS:

Need of alternative fuels, Transesterification process, Biodiesel properties and their importance, Performance and emission characteristics of vegetable fuels, Advantages and drawbacks with usage of vegetable oils, Effect of injection timing, injection pressure, compression ratio on the performance of biodiesel fuelled engine, Usage of additives and split injection strategy in Biodiesel fuelled engines.

UNIT-V: ALTERNATE FUELS FROM WASTE RESOURCES:

Introduction, Overview of Waste resources around the world, Biomass conversion technologies, Biomass as solar energy, Biomass as an automobile fuel, Primary Biomass energy sources, Secondary Biomass sources, Physical processing of biomass, Thermochemical and Biochemical processing of Biomass, Environmental considerations of biomass, Economics and future aspects of biomass.

REFERENCES:

1) John B. Heywood, Internal Combustion Engine Fundamentals, 3rd edition, McGraw-Hill series, 2008.
2) V.Ganesan, Internal Combustion Engines, 4th edition, Tata McGraw Hill Education Private Limited, 2013.
3) S.S. Thipse, Alternative Fuels- Concepts, Technologies and Developments, 2nd edition, Jaico Publishing House, 2010.
4) Godfrey Boyle, Renewable Energy- Power for a sustainable future, 2nd edition, Oxford University press, 2012.

Programme Elective-II

M.Tech. (I Sem.) **20TE07–ENERGY STORAGE SYSTEMS**

L	P	T	Cr
3	-	-	3

Pre-requisites: Thermodynamics

Course Objective: To know the design procedure of heat exchangers related to different thermal applications like condensers, evaporators, cooling towers etc. and cooling of electronic components.

Course Outcomes: After the completion of the course, students should be able to

CO1 Distinguish the methods of energy storage systems.

CO2 Comprehend the preservation of food, green house heating, drying and heating process in industries.

CO3 Identify the latent heat thermal storage systems

CO4 Describe chemical storage systems

CO5 Identify the essential applications of thermal storage systems

UNIT – I

ENERGY STORAGE: Introduction, Need of Energy Storage, Different modes of Energy Storage Potential Energy: Pumped Hydro Storage, KE and Compressed gas system: Flywheel Storage, Compressed air energy Storage, Electrical and magnetic energy storage: Capacitors, Electromagnets and battery storage systems, Chemical Energy Storage: Thermo-Chemical, Bio-Chemical, Electro-Chemical, Fossil fuels and synthetic fuels and Hydrogen storage.

UNIT - II

SENSIBLE HEAT STORAGE: Sensible Heat Storage mediums, Stratified storage systems, Rock-bed storage systems, Thermal storage in buildings, Earth storage, Energy storage in aquifers, Heat storage in SHS systems, Aquifers storage

UNIT – III

LATENT HEAT THERMAL ENERGY STORAGE; Phase Change Materials (PCMs), Selection Criteria of PCMs, Stefan Problem, Solar Thermal LHTES Systems, Energy Conservation through LHTES Systems, LHTES Systems in Refrigeration and Air Conditioning Systems, Enthalpy formulation, Numerical heat transfer in melting and freezing process.

UNIT – IV

CHEMICAL ENERGY STORAGE SYSTEMS: Types of Battery, Working of Battery, Types of Fuel Cells, Working of Fuel Cells, Energy storage in battery and fuel cells

UNIT – V

APPLICATION OF ENERGY STORAGE: Food Preservation, Waste Heat Recovery, Solar Energy Storage, Green House Heating, Power Plant Applications, Drying and Heating for Process Industries.

REFERENCES:

1. H.P.Garg et al, D Reidel (1985)"Solar Thermal Energy Storage", Publishing Company.
2. V Alexiades&A.D.Solomon(1993) "Mathematical Modeling of Melting and Freezing Process" , Hemisphere Publishing Corporation,
3. Washington Narayan R, Viswanath B(1998), Chemical and Electro Chemical Energy System, Universities Press
4. A. Ter-Gazarian (1994), "Energy Storage for Power Systems", Peter Peregrinus Ltd. London
5. B.Kilkis and S.Kakac (1989),"Energy Storage Systems",(Ed),KAP,London,1989

Programme Elective-II

M.Tech. (I Sem.)

20TE08 - ENERGY CONSERVATION AND MANAGEMENT

L	P	T	Cr
3	-	-	3

**Pre-requisites : **Industrial management, Thermal engineering

Course Objective: To provide students an insight of principles and opportunities of energy conservation in thermal, electrical domains through energy audit and its effective management on the grounds of economy and waste heat recovery.

Course Outcomes: After the completion of the course, the student will be able to

- CO1 Apply the fundamental principles, objectives and rules of energy conservation in buildings.
- CO2 Evaluate the energy efficiency in thermal and electric utilities.
- CO3 Comprehend the energy audit procedures for energy conservation and management.
- CO4 Analyze the economic feasibility of energy conservation programmes.
- CO5 Identify significance of the climate policy and associated developments around the globe.

UNIT - I

ENERGY CONSERVATION: Principles of energy conservation, Energy Conservation Act 2001 and its features, Electricity Act-2003 & its features, Energy consumption pattern, Resource availability, Energy pricing, Energy Security, Estimation of energy use in a building. Heat gain and thermal performance of building envelope - Steady and non-steady heat transfer through the glazed window and the wall - Standards for thermal performance of building envelope, Evaluation of the overall thermal transfer

UNIT - II

ENERGY EFFICIENCY IN THERMAL UTILITIES: Energy efficiency in boilers, furnaces, steam systems, cogeneration utilities, waste heat recovery, compressed air systems, HVAC&R systems, fans and blowers, pumps, cooling tower

ENERGY EFFICIENCY IN ELECTRICAL UTILITIES: Energy efficiency for electric motors, lighting systems, Characteristics of Light, Types of Lighting, Incandescent Lighting, Fluorescent Lighting, Vapor Lighting, Street Lighting, LED Lighting, Lighting Design, Light Dimming, Tips for Energy Conservation, Products for Energy Conservation in lighting system

UNIT - III

ENERGY AUDIT: Definition, objective and principles of Energy Management, Need of Energy Audit and Management, types of energy audit, audit process, Guidelines for writing energy audit report, data presentation in report, findings recommendations, impact of renewable energy on energy audit recommendations and energy audit report, energy audit of building system, lighting system, HVAC system, Water heating system, heat recovery opportunities during energy audit, Industrial audit opportunities, Instruments for Audit and Monitoring Energy and Energy Savings

UNIT - IV

ENERGY ECONOMICS: Simple Payback Period, Time Value of Money, Internal Rate of Return, Net Present Value, Life Cycle Costing, Equivalent uniform annual cost (EUAC), Life cycle cost, Discounting factor, Capital recovery, Depreciation, taxes.

UNIT - V

CLIMATE POLICY: Government initiative towards energy conservation and management-the national and world perspective-local Govt policies- clean and green cities-smart cities-Kyoto protocol, Clean development mechanism (CDM), Geopolitics of GHG control; Carbon Market

REFERENCES:

1. Energy Conservation Guidebook, Dale R Patrick, Stephen W Fardo, 2nd Edition, CRC Press
2. Handbook of Energy Audits, Albert Thumann, 6th Edition, The Fairmont Press
3. Bureau of Energy Efficiency Reference book: No.1, 2, 3 4
4. Energy Management Handbook, W.C. Turner, John Wiley and Sons, A Wiley Inter science publication
5. Carbon Capture and Sequestration: Integrating Technology, Monitoring, and Regulation edited by E J Wilson and D Gerard, Blackwell Publishing
6. Heating and Cooling of Buildings - Design for Efficiency, J. Krieder and A. Rabl, McGraw Hill Publication, 1994

M.Tech. (I Sem.) **20RM01–RESEARCH METHODOLOGYU&IPR**

L	P	T	Cr
2	-	-	2

Pre-requisites: Knowledge in Engineering, English

Course Objective: To understand the research problem, to know the literature studies, plagiarism and ethics ,to get the knowledge about technical writing ,to analyse the nature of intellectual property rights and new developments and research related information and to know the patent rights

Course Outcomes: After the completion of the course, students should be able to

- CO1 Analyze the research problem and its formulation.
- CO2 Analyze the significance of research ethics
- CO3 Apply the information technology for better tomorrow and to develop creativity.
- CO4 Identify the importance of intellectual property rights to be promoted among students in general & engineering in particular
- CO5 Describe the IPR protection for new and better products, and in turn brings about, economic growth and social benefits.

UNIT I- RESEARCH PROBLEM AND SCOPE FOR SOLUTION

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

UNIT II- FORMAT

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- PROCESS AND DEVELOPMENT

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- PATENT RIGHTS

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

UNIT V- NEW DEVELOPMENTS IN IPR

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. 74. Asimov, "Introduction to Design", Prentice Hall, 1962.
7. Robert P. Merges, Peter S. Menell, Mark A. Lemley, " Intellectual Property in New Technological Age", 2016.
8. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008

Audit Course

M.Tech. (I Sem.) **20AC02–DISASTER MANAGEMENT**

L	P	T	Cr
2	-	-	0

Pre-requisites: Environmental science

Course Objective:

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

Course Outcomes: After the completion of the course, students should be able to

CO1: Differentiate the types of disasters, causes and their impact on environment and society.

CO2: Assess vulnerability and various methods of risk reduction measures as well as mitigation.

CO3: Identify inter-relationship between disasters and development.

CO4: Comprehend disaster risk management in India.

CO5: Describe disaster management applications, case studies and field works

UNIT I

INTRODUCTION TO DISASTERS

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

UNIT II

APPROACHES TO DISASTER RISK REDUCTION (DRR)

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

UNIT III

INTER-RELATIONSHIP BETWEEN DISASTERS AND DEVELOPMENT

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

UNIT IV

DISASTER RISK MANAGEMENT IN INDIA

Hazard and Vulnerability profile of India, Components of Disaster Relief: Water, Food, Sanitation, Shelter, Health, and Waste Management, Institutional arrangements (Mitigation, Response and

Preparedness, Disaster Management Act and Policy – Other related policies, plans, programmes and legislation – Role of GIS and Information Technology Components in Preparedness, Risk Assessment, Response and Recovery Phases of Disaster – Disaster Damage Assessment

UNIT V

DISASTER MANAGEMENT: APPLICATIONS, CASE STUDIES AND FIELD WORKS

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

REFERENCES:

1. Singhal J.P. Disaster Management, Laxmi Publications, 2010. ISBN-10: 9380386427 ISBN-13: 978-9380386423
2. Tushar Bhattacharya, Disaster Science and Management, McGraw Hill India Education Pvt. Ltd., 2012. ISBN-10**:** 1259007367, ISBN-13**:** 978-1259007361
3. Gupta Anil K, Sreeja S. Nair. Environmental Knowledge for Disaster Risk Management, NIDM, New Delhi, 2011
4. Kapur Anu Vulnerable India: A Geographical Study of Disasters, IIAS and Sage Publishers, New Delhi, 2010.
5. Govt. of India: Disaster Management Act , Government of India, New Delhi, 2005.
6. Government of India, National Disaster Management Policy,2009.

M.Tech. (I Sem.) **20TE61–THERMAL SYSTEMS LAB**

L	T	P	Cr
-	-	4	2

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

Course Objective: The main objective of this laboratory is to enrich the graduates are empowered with principles of working and its performance analysis on Refrigerator, Air Conditioner, Air compressor, solar concentrator and fuel testing apparatus. It also focuses on to measure the amount of exhaust emissions coming from the engines and creating awareness among the graduates about its impact on the global environment.

Course Outcomes: After the completion of the course, students should be able to

- CO1 Acquire the knowledge on analysis of heat pipe
- CO2 Analyze the performance characteristics of an internal combustion engines
- CO3 Evaluate the performance parameters of refrigeration system
- CO4 Evaluate the performance parameters of Air-conditioning system
- CO5 Evaluate the performance parameters of counter flow heat exchanger

List of Experiments

At least 10 Experiments are required to be conducted.

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

M.Tech. (I Sem.) **20TE62 - SIMULATION LAB**

L	T	P	Cr.
-	-	4	2

Pre requisites: Theory courses in Heat Transfer and Numerical Methods

Course Objective: The objective of this lab is to get the hands on experience with problems solving on heat transfer and thermodynamics in MATLAB code.

Course Outcomes: After the completion of the course, students should be able to

CO1 write program source codes to some heat transfer problems and solve them using MAT lab

CO2 Compute heat transfer problems using FEM software

CO3 Simulate problems involving flow and heat transfer using ANSYS

LIST OF NUMERICAL PROBLEMS:

The following problems are solved using MATLAB, FEM and FVM software

Any TEN numerical problems.

1. Study of simulation software Like ARENA , MATLAB. FEM and FVM software
2. Simulation of translational and rotational mechanical systems
3. Simulation of Queuing systems
4. Two dimensional steady state heat conduction in a slab.
5. One dimensional unsteady state heat conduction in a slab.
6. Heat transfer from a rectangular fin.
7. Heat transfer from a triangular fin.
8. Laminar flow through a rectangular duct.
9. Laminar natural convection from a vertical plate.
10. Parallel flow double pipe heat exchanger.
11. Counter flow heat exchanger.
12. Solution of a Tridiagonal matrix (TDM) using Thomas algorithm.
13. Solution of a second order ordinary differential equation by fourth-order Runge-Kutta Method.
14. Solution of simultaneous first order ordinary differential equations by fourth-order Runge-Kutta Method.

R20-Regulations(w.e.f.2020-21)

M.Tech(Thermal Engineering)-II Semester

Detailed Syllabus

M.Tech. (II Sem.)

20TE09-COMPUTATIONAL FLUID DYNAMICS

L	T	P	Cr.
3	-	-	3

Pre-requisites: Advanced Fluid Mechanics

Course Objective: To describe the governing equations, approaches, methodologies and applications used in CFD, distinguishes the importance of parabolic, elliptic and hyperbolic equations used in CFD and grid formations, consistency of CFD problems and numerical algorithms.

Course Outcomes: After the completion of the course, students should be able to

CO1: Classify the mathematical models for FEM, FDM, FVM techniques.

CO2: Apply the mathematical and computational methods for fluid flow simulations.

CO3: Analyse the computational problems of fluid flow and heat transfer.

CO4: Distinguishes the grid sensitivity methods and analyze the accuracy of a numerical solution.

CO5: Identify the correct numerical algorithm to solve 1D and 2DProblems in steady and transient heat transfer conditions.

UNIT-I

INTRODUCTION AND GOVERNING EQUATIONS OF CFD: – Physical Boundary Conditions – Methods of solutions of Physical Problems – Need for Computational Fluid Dynamics – Different numerical/CFD techniques – FDM, FEM, FVM etc., - Main working principle - CFD as a research and design tool – Applications in various branches of Engineering Mathematical behaviour of Partial Differential Equations (Governing Equations):Classification of linear/ quasi linear PDE – Examples - Physical Processes: Wave Equations and Equations of Heat Transfer and Fluid Flow – Mathematical Behaviour – General characteristics

UNIT-II

FLUID FLOW EQUATIONS: – Finite Difference Solutions of 2D Viscous Incompressible flow problems – Vorticity and Stream Function Formulation.

MATHEMATICAL BEHAVIOUR OF PARTIAL DIFFERENTIAL EQUATIONS: Classification of quasi-linear partial differential equations, Methods of determining the classification, General aspects of Discretization using Taylor series expansion, Uniform and unequally spaced grid points.

UNIT-III

PARABOLIC EQUATIONS: Finite difference formulations, Explicit methods – FTCS, Richardson and DuFort-Frankel methods, Crank-Nicolson and Beta formulation methods, Fractional step methods, Consistency analysis,.

ELLIPTIC EQUATIONS: Finite difference formulation, solution algorithms: Jacobi-iteration method, Gauss-Siedel iteration method, point- and line-successive over-relaxation methods-Alternative direction implicit methods.

UNIT-IV

GRIDS WITH APPROPRIATE TRANSFORMATION: General transformation of the equations, Metrics and Jacobians, The transformed governing equations of the CFD, Boundary fitted coordinate systems, Algebraic and elliptic grid generation techniques, Adaptive grids.

GRID GENERATION: Algebraic Grid Generation, Elliptic Grid Generation, Hyperbolic Grid Generation, Parabolic Grid Generation, Finite Volume Method For Unstructured Grids: Advantages, Cell Centered and Nodal point Approaches.

UNIT-V

NUMERICAL ALGORITHMS: FTCS explicit, FTBCS explicit, Maccormack explicit and implicit, BTCS and BTBCS implicit algorithms, applications.

HEAT TRANSFER: Finite Difference Applications in Heat conduction and Convention – Heat conduction, steady heat conduction, in a rectangular geometry, transient heat conduction, and Finite difference application in convective heat transfer

REFERENCES:

1. Anderson, J.D.(Jr), *Computational Fluid Dynamics*, McGraw-Hill Book Company, 1995.
2. Hoffman, K.A., and Chiang, S.T., *Computational Fluid Dynamics,* Vol. I, II and III, Engineering Education System, Kansas, USA, 2000.
3. Chung, T.J., *Computational Fluid Dynamics*, Cambridge University Press, 2003.
4. Anderson, D.A., Tannehill, J.C., and Pletcher, R.H., *Computational Fluid Mechanics and Heat Transfer*, McGraw Hill Book Company, 2002.

M.Tech. (II Sem.)

20TE10-RENEWABLE ENERGY TECHNOLOGY

L	T	P	Cr.
3	-	-	3

Pre-requisites: Non-conventional energy sources

Course Objective:

To make the student familiar in need of alternative energy resources, sensitize about solar energy radiation and measurement devices and also to recognize the source and potential of wind energy and understand the classifications of wind mills and different ways of energy generation and different fuel cells.

Course Outcomes: After the completion of the course, students should be able to

CO1: Identify the solar energy utilization and measurement devices
CO2: Analyse the performance of non-concentrating and concentrating collectors.
CO3: Estimate the power output of photovoltaic power plants based on the given parameters of solar photovoltaic power plants,
CO4: Analyse the efficiency and performance of wind power extraction from different turbines.
CO5: Compare the energy and exergy efficiency of different energy systems

Unit I

INTRODUCTION Based on the given parameters of Solar Photovoltaic Power Plants, Estimate the power output of Photovoltaic Power Plants.Conventional and Non-conventional sources of energy, Alternative energy sources, The Sun and the Earth, Solar Radiation- Global, Beam and Diffuse Solar Radiation estimation, prediction and Instruments to Measure Solar Radiation, Solar energy utilization. Solar Radiation incident on the tilted surface of A Solar Collector, Solar Collectors, Collector Optical Properties and Selective Coatings,

Unit II

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

Unit III
SOLAR PHOTOVOLTAIC POWER PLANTS
Introduction, Solar Cells- Design of Solar Photovoltaic Power Plants, Design and Sizing of Off-Grid Standalone Photovoltaic Power Plants, Required Storage Battery Capacity, Grid-Connected Solar Photovoltaic Power Plants, Concentrated Photovoltaic Power Generation, Performance of Concentrated Photovoltaic Modules, Annual Energy Output of a Photovoltaic Power Plant, Utility-

Scale Photovoltaic Power Plants, Hybrid Solar–Wind–Diesel Plants For Remote Area Power Generation.

Unit IV

WIND ENERGY SYSTEMS

Rise of Wind Powered Electricity – Modern Era, Origin of Wind, Wind Types, Fundamental equation of wind power, Efficiency in extracting wind power, Power curve of a wind turbine, Lift and Drag forces of wind turbines, Wind Turbine types , Wind Power Control Systems and Electronics.

Unit V

ENERGY ANALYSIS

Embodied-Energy Analysis, Energy Density (Intensity), Overall Thermal Energy Energy-Payback Time (EPBT), Embodied Energy and Payback Time of Solar Systems- Hybrid Flat-Plate Collector, Hybrid Air Collector.

EXERGY ANALYSIS

Energy-Payback Time (EPBT), Energy-Production Factor (EPF). Life Cycle Conversion Efficiency (LCCE), Energy Matrices of Solar Systems- PVT Greenhouse Dryer, PVT Solar Concentrators, CO_2 Emissions, Carbon Credit Formulation, A Case Study with the BIPVT System.

REFERENCES:

1. D.Y. Goswami, F. Kreith and J.F. Kreider, “Principle of Solar Engineering”, Taylor and Francis, 2000.
2. G.N. Tiwari, Arvind Tiwari, Shyam, Handbook of Solar Energy Theory, Analysis and Applications
3. J.F. Kreider, F. Kreith, “Solar Energy Handbook”, McGraw Hill, 1981
4. J.A. Duffie and W.A. Beckman, “Solar Engineering of Thermal Processes”, John Wiley, 1991.

Programme Elective-III

M.Tech. (II Sem.)

20TE11–THERMAL MEASUREMENT AND PROCESS CONTROL

L	T	P	Cr
3	-	-	3

Pre-requisites **:** Instrumentation and control systems

Course Objective: To familiarize the various methods of measuring temperature, pressure and velocity using advanced techniques.

Course Outcomes: After the completion of the course, students should be able to

CO1 Apply the principles of temperature measurements with different methods
CO2 Comprehend the various techniques of pressure measurement.
CO3 Distinguish various principles for velocity measurement.
CO4 Identify the significance of analog methods used in Electro-Mechanical Systems.
CO5 Describe the digital techniques in Mechanical Measurements.

UNIT – I

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

UNIT - II

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

UNIT – III

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

UNIT – IV

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

UNIT – V

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

REFERENCES

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

Programme Elective-III

M.Tech. (II Sem.) **20TE12-ENVIRONMENTAL POLLUTION & CONTROL**

L	T	P	Cr
3	-	-	3

Pre-requisites: Environmental studies

Course Objective: To understand the atmospheric pollutants, different emissions, air pollution control equipment.

Course Outcomes: After the completion of the course, students should be able to

CO1 Identify the sources of air pollution and its effects

CO2 Analyze the composition and structure of the atmosphere

CO3 Describe the stack emissions and its monitoring

CO4 Analyze air pollution and its control techniques

CO5 Comprehend the legal aspects of noise and control measures

UNIT I

INTRODUCTION: Sources, effects on – ecosystems, characterization of atmospheric pollutants, air pollution episodes of environmental importance. Indoor Air Pollution– sources, effects.

UNIT II

METEOROLOGY: Composition and structure of the atmosphere, wind circulation, solar radiation, lapse rates, atmospheric stability conditions, wind velocity profile, Maximum Mixing Depth (MMD), Temperature Inversions, Windrose diagram.

UNIT III

GENERAL CHARACTERISTICS: Stack emissions, plume behaviour, heat island effect. Pollutants dispersion models – description and application of point, line and areal sources. Monitoring of particulate matter and gaseous pollutants –respirable, non-respirable and nano - particulate matter. CO, CO2, Hydrocarbons (HC), SOX and NOX, photochemical oxidants.

UNIT IV

AIR POLLUTION CONTRO: Equipment for particulate matter & gaseous pollutants– gravity settling chambers, centrifugal collectors, wet collectors, fabric filters, electrostatic precipitator (ESP). – Adsorption, Absorption, Scrubbers, Condensation and Combustion.

UNIT V

NOISE - SOURCES, MEASUREMENTS: Effects and occupational hazards. Standards, Noise mapping, Noise attenuation equations and methods, prediction equations, control measures, Legal aspects of noise.

REFERENCES:

1. Wark ., Warner C.F., and Davis W.T., "Air Pollution - Its Origin and Control", Harper & Row Publishers, New York.
2. Lee C.C., and Lin S.D., "Handbook of Environmental Engineering Calculations", McGraw Hill, New York.
3. Perkins H.C., "Air Pollution", McGraw Hill.
4. Crawford M., "Air Pollution Control Theory", TATA McGraw Hill.
5. Stern A.C., "Air Pollution", Vol I, II, III.
6. Seinfeld N.J.,, "Air Pollution", McGraw Hill.
7. Stern A.C. Vol. V, "Air Quality Management". 8. M N Rao and HVN Rao, Air Pollution" Tata McGraw Hill publication

Programme Elective-III

M.Tech. (I Sem.) **20TE13 – REFRIGERATION AND CRYOGENICS**

L	T	P	Cr.
3	-	-	3

Pre-requisites: Thermodynamics

Course Objective: This course provides simple understandings of refrigeration and cryogenics fundamentals. It covers the different refrigeration cycles and its analysis. It also covers the basic principles of cryogenics and its related systems.

Course Outcomes (COs): After the completion of the course, the student should be able to

- CO1 Describe various concepts of refrigeration and its applications
- CO2 Analyse the various aircraft refrigeration systems
- CO3 Evaluate the performance parameters of refrigeration systems
- CO4 Comprehend the VAR and non-conventional refrigeration methods
- CO5 Describe the significant characteristics and applications of cryogenics

UNIT -I

REFRIGERATION: Introduction-Necessity and applications, unit of refrigeration, Heat Engine, Refrigerator and Heat Pump-C.O.P and Types of Refrigeration.

REFRIGERANTS*:* A survey of Refrigerants-Nomenclature, Desirable properties- Classification of Refrigerants – Alternate refrigerants – Ozone depletion potential and Global Warming Potential.

UNIT – II

AIRCRAFT REFRIGERATION SYSTEM: Necessity of Aircraft Refrigeration – Advantages of Air cycle for Aircraft Refrigeration – Classification of Aircraft Refrigeration Systems –Simple air craft Bootstrap– Regenerative air refrigeration systems, Reduced ambient and Regenerative systems, Problem analysis.

UNIT - III

VAPOUR COMPRESSION REFRIGERATION: Simple Vapour Compression refrigeration cycle, P-h charts, Factors affecting performance of VCR cycle, Actual VCR cycle

MULTISTAGE VAPOUR COMPRESSION SYSTEMS: Introduction-Multi stage or Compound Compression-Multi Evaporator system-Cascade System.

UNIT - IV

VAPOUR ABSORPTION REFRIGERATION SYSTEM: Description and working of simple and actual Aqua-Ammonia system-Maximum COP-Li-Br Water system-Three fluid Vapour absorption refrigeration system-Applications, Solar VAR systems.

NON-CONVENTIONAL REFRIGERATION METHODS: Principle and operation of (i) Thermoelectric refrigeration (ii) Vortex tube or Hilsch tube (iii) Adiabatic demagnetization (iv) Steam jet refrigeration system.

UNIT - V

CRYOGENICS : Introduction , Joules Thomson effect, production of dry ice, liquefaction of Hydrogen, Liquefaction of helium, Linde system, Claude system & its analysis, application of cryogenics**.**

REFERENCES:

1. C. P. Arora. Refrigeration and air conditioning - TMH, 2nd Edition,2000.
2. R. Dossat, Principles of Refrigeration - - Pearson ,4th Edition 2001
3. Randal Barron " Cryogenics systems", McGraw Hill,2000.
4. C.P.Arora, "Refrigeration and air conditioning" –, Tata McGraw-Hill, 2001.
5. Arora & Domkundwar " Refrigeration& Air Conditioning" – Dhanpat Rai & Co.
6. Manohar Prasad, "Refrigeration and Air Conditioning"-, New Age International, 2003.
7. Roy J. Dossat ,"Principles of refrigeration"-. Prentice Hall, 1996.
8. Wilbert F. Stoecker, "Refrigeration and air conditioning"- r, Jerold W. Jones, MGH, 1986.
9. Anantha Narayana ,"Refrigeration & Air Conditioning" Tata McGraw-Hill, 2001.

Programme Elective-IV

M.Tech. (II Sem.)

20TE14 - HYBRID ELECTRIC VEHICLES

L	T	P	Cr
3	-	-	3

Pre-requisites: Internal-Combustion engines, Automobile Engineering.

Course Objective: The main objective of this course is to provide the knowledge on architecture of Hybrid Electric Vehicles, Fuel cells and their sub-systems. The focus is as well on explaining the requirements of hybrid electric vehicles and Fuel-cells for automobile applications. At the same time, various design considerations in fuel cell vehicles and electric vehicles will be explained.

Course Outcomes: After the completion of the course, students should be able to

CO1 Illustrate the working of Hybrid Electric Vehicles and its systems.

CO2 Analyse the use of propulsion systems and storage systems in Hybrid Electric Vehicles.

CO3 Design and develop the propulsion and storage systems for Hybrid Electric Vehicles.

CO4 Describe the working principle of fuel cell and various types of fuel-cells.

CO5 Perform a case study on Hybrid electric vehicles and Fuel-cells.

UNIT-I

INTRODUCTION TO HYBRID ELECTRIC VEHICLES:

Vehicle basics- Constituents of a conventional vehicle-Drive cycles and Drive Terrain, A Brief history of Hybrid Electric vehicles (HEVs), Basics of Electric Vehicles (EV), Basics of Hybrid Electric Vehicles (HEVs), Architecture of HEVs- Series HEVs, Parallel HEVs, Series-Parallel HEVs, Parallel Hybrid Drive trains with Torque coupling, Parallel Hybrid Drive trains with both Speed coupling, Parallel Hybrid Drive trains with both speed Torque coupling.

UNIT-II

ELECTRIC PROPULSION SYSTEMS:

DC Motors- Operating principle and control of DC motors, Induction Motor Drives: Operating principle and Control Mechanisms, Brushless Motor Drives-Principle and Construction, Switched Reluctance Motor (SRM) Drives- Basic structure, Drive Convertor, Modes of Operation.

UNIT-III

DESIGN OF HYBRID ELECTRIC VEHICLE DRIVES:

Design of Series Hybrid Electric Vehicle Drive- Control Strategies, Sizing of Major Components and Case Study for designing for various parameters.

Design of Parallel Hybrid Electric Vehicle Drive- Control Strategies of Drive Train and Design of Drive Train Parameters.

UNIT-IV

ENERGY STORAGE SYSTEMS:

Electrochemical Batteries, Lead-Acid Batteries, Nickel Based Batteries, Lithium Based Batteries, Ultra Capacitors- Basic Principles and Performance, Ultrahigh-speed flywheels- Basic Principle and Power Capacity, Fly Wheel technologies.

UNIT-V

FUEL CELLS:

Operating principles of fuel cells, Fuel and oxidant consumption, Fuel cell system characteristics, Fuel cell technologies- Proton Exchange membrane fuel cells, Alkaline Fuel cells, Phosphoric acid fuel cells, Molten carbonate fuel cells, Solid oxide fuel cells, Fuel supply- Hydrogen storage-Hydrogen production, Ammonia as hydrogen carrier, Non-Hydrogen fuel cells, Fuel Cell Hybrid Vehicle Drive Train.

REFERENCES:

1. Mehrdad Ehsani, Yimin Gao, Ali Emadi, 2nd edition, Modern Electric, Hybrid Electric and Fuel cell vehicles, CRC Press, Taylor and Francis Group, 2010.
2. Chris Mi, M.Abul Masrur and David Wenzhong Gao, 1st Edition, Hybrid Electric Vehicles, John Wiley & Sons, Ltd, 2011.

Programme Elective-IV

M.Tech. (II Sem.) **20TE15 - DESIGN OF THERMAL SYSTEMS**

L	T	P	Cr
3	-	-	3

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

Course Objective: To know the design procedure of heat exchangers related to different thermal applications like condensers, evaporators, cooling towers etc. and cooling of electronic components.

Course Outcomes: After the completion of the course, students should be able to

CO1	Classify the different heat exchanger and apply LMTD and NTU approaches to solve problems on parallel, counter and cross flow heat exchangers.
CO2	Analyse the design procedures in shell and tube heat exchangers.
CO3	Describe the working procedures and calculate the heat transfer aspects in condenser and evaporators.
CO4	Distinguishes the performance parameters in cooling tower performance and heat pipe applications.
CO5	Identify various techniques for cooling of electronic equipment's.

UNIT – I

CLASSIFICATION OF HEAT EXCHANGERS: INTRODUCTION- Recuperation & Regeneration-Tubular heat exchangers-Double pipe, Shell and Tube heat exchangers, Plate heat exchanger Exchangers-Plate fin and Tubular fin heat exchangers

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

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

UNIT - II

DOUBLE PIPE HEAT EXCHANGER:

Film coefficient for fluids in annulus, fouling factors, calorific temperature, Average fluid temperature, Calculation of double pipe exchanger, double pipe exchangers in series parallel arrangements.

SHELL & TUBE HEAT EXCHANGERS: Tube layouts for exchangers, Baffle heat exchangers, Calculation of shell and tube heat exchangers, Shell side film coefficients, Shell side equivalent diameter, The true temperature difference in a 1-2 heat exchanger. Influence of approach temperature on correction factor. Shell side pressure drop, Tube side pressure drop, Analysis of performance of 1-2 heat exchanger and design of shell & tube heat exchangers, Flow arrangements for increased heat recovery, the calculation of 2-4 exchangers.

UNIT – III

CONDENSERS & EVAPORATORS:

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

UNIT – IV

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

UNIT – V

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

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

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

REFERENCES:

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

Programme Elective-IV

M.Tech. (II Sem.) **20TE16–WASTE HEAT RECOVERY SYSTEMS**

L	T	P	Cr
3	-	-	3

Pre-requisites : ** Thermodynamics,** Thermal engineering

Course Objective: To provide students' knowledge of waste heat potential, its effective recovery based on economic analysis, energy storage using various waste heat recovery methods and devices.

Course Outcomes: After the completion of the course, students should be able to

CO1	Comprehend the Rankine cycle, coupled cycles for combined plants for energy conservation.
CO2	Analyze the waste heat recovery technologies developed for various thermal systems.
CO3	Acquire knowledge on waste heat recovery in heat pump, thermoelectric and HVAC systems.
CO4	Apply the economic analysis concepts for the effective implementation of waste heat recovery.
CO5	Identify the need for various energy storage systems in waste heat recovery applications.

UNIT-I

INTRODUCTION: Rankine cycle, coupled cycles and combined plants, energy resources and use, potential for energy conservation, optimal utilization of fossil fuels, total energy approach.

UNIT-II

WASTE HEAT RECOVERY SYSTEMS: Selection criteria for waste heat recovery technologies-recuperators-regenerators-economizers-plate heat exchangers-thermic fluid heaters-Waste heat boilers-classification, location, service conditions, design considerations-fluidized bed heat exchangers-heat pipe exchangers-heat pumps –sorption systems.

UNIT-III

PRIME MOVER EXHAUSTS: Incineration plants; heat pump systems; thermoelectric devices. Utilization of low grade reject heat from power plants, Utilization of waste heat in refrigeration, heating, ventilation and air conditioning systems. Thermoelectric system to recover waste heat.

UNIT-IV

ENERGY STORAGE SYSTEMS: Need for energy storage, Thermal, electrical, magnetic and chemical storage systems. Energy storage using phase change materials, micro encapsulation, Nano-PCMs, sensible and latent heat thermal energy storage systems, active and passive types.

UNIT-V

ECONOMIC ANALYSIS: Investment cost –economic concepts–measures of economic performance –procedure for economic analysis–examples–procedure for optimized system selection and design–load curves -sensitivity analysis –regulatory and financial frame work for cogeneration and waste heat recovery system.

REFERENCES:

1. Parker, Colin & Roberts, Energy from Waste1985 An Evaluation of Conversion Technologies Elsevier Applied Science
2. Shah, Kanti L.,(2000) Basics of Solid & Hazardous Waste Management Technology, Prentice Hall of India.
3. Manoj Datta,(1997)Waste Disposal in Engineered Landfills , Narosa Publishing House.
4. Rich, Gerald et.al.,(1987) Hazardous Waste Management Technology, Podvan Publishers.
5. Bhide AD., Sundaresan BB,(1983) Solid Waste Management in Developing Countries, INSDOC New Delhi.

AUDIT COURSE

M.Tech. (II Sem.) **20AC01 – ENGLISH FOR RESEARCH PAPER WRITING**

L	T	P	Cr
2	-	-	0

Pre-requisites : English

Course Objective: To develop technical writing skills necessary to communicate information gained through a process of technical or experimental work.

Course Outcomes: After the completion of the course, students should be able to

CO1 Identify appropriate research topics for college classes.

CO2 Draft detailed outlines for research papers and find source material for research papers.

CO3 Develop and organize good practices for research.

CO4 Apply appropriate academic tone and language.

CO5 Identify plagiarism status of resources.

UNIT – I

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

UNIT – II

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

UNIT – III

METHODS OF COLLECTING & ANALYSING EMPIRICAL MATERIALS: Observations, interviewing, Interpretation of documents & material culture, Images & visual methods, Auto ethnography, personal narrative & reflexivity.

UNIT – IV

ANALYZING TALK & TEXT, DATA MANAGEMENT & ANALYSIS METHODS: Software & qualitative research, Interpretation, evaluation & presentation, The problem of criteria, Interpretation, Writing, Evaluation and social programs, Qualitative research and social policy, What, why and how of technical and research writing.

UNIT – V

LITERATURE REVIEW: Writing about methods, results, and discussion of results. Referencing, academic integrity, and writing for different types of readers (Research proposals, Dissertations, Journal articles, Magazine articles).

REFERENCES:

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

2. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press

3. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman'sbook

4. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011

M.Tech. (II Sem.) **20TE63 - COMPUTATIONAL FLUID DYNAMICS LAB**

L	T	P	Cr.
-	-	4	2

Course Objective: To solve the problems of fluid flow and heat transfer and build up the skills in the actual implementation of CFD methods for 1D and 2D heat conduction and convection problems and acquire skills in thermal analysis of the same.

Course Outcomes: After the completion of the course, students should be able to

CO1	Develop codes for numerical methods to tackle simple problems.
CO2	Build up the skills in the actual implementation of CFD methods (1D and 2D heat conduction and convection problems) by attempting to write their own codes.
CO3	Analyze and validate output of written codes with analytical solution.
CO4	Obtain experience in the application of CFD analysis to real engineering designs.

List of Experiments

1) Determination of heat transfer through circular fins
2) Find the steady state heat transfer of a heat sink
3) Steady state thermal analysis of a steel bar
4) Temperature and heat transfer analysis of a cylinder
5) Compute the steady state heat transfer through composite slab
6) Transient thermal analysis of convection of bar in air
7) A turbulent fluid flow and heat transfer problem in a mixing elbow using Ansys fluent
8) Fluid flow analysis of a radiator using ANSYS- FLUENT
9) Fluid flow fluent analysis of a helical coil
10) Fluid flow fluent analysis of two phase flow in a horizontal pipe
11) Analysis of water flow in a converging pipe using ANSYS- FLUENT
12) Analysis of two dimensional laminar flow using ANSYS- FLUENT

M.Tech. (II Sem.) **20TE64 - RENEWABLE ENERGY TECHNOLOGY LAB**

L	T	P	Cr.
-	-	4	2

Pre-requisites : Non-conventional sources of energy

Course Objective: This laboratory is mainly focused to make the students to understand the basic concepts involved in solar thermal systems, i.e., Flat plate collector, concentrator and solar PV systems and its calculation procedures.

Course Outcomes: After the completion of the course, students should be able to

CO1 Understand the principles of renewable energy conversion techniques.
CO2 Estimate the performance characteristics of renewable energy devices.
CO3 Acquire the knowledge to improve the performance of renewable energy devices.
CO4 Comprehend the performance parameters of the renewable energy devices.

List of Experiments

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

M.Tech. (II Sem.) **20TE51 - MINI PROJECT**

L	T	P	Cr.
-	-	4	2

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

Course Objective: To make the students plan and execute a mini project independently using the available resources in the institute.

Course Outcomes: After the completion of the course, students should be able to

CO1 Plan a technical task based on the domain of problem

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

CO3 Develop the ability to execute a mini project independently

CO4 Prepare a well-organized technical report

CO5 Improve presentation skills through seminars

***********THE END*************