R25-M.Tech(Thermal Power Engineering)-PG Course Structure and Syllabus

I-SEMESTER

S.No.	Course code	Course Title	Contact hours/week			Credits	Scheme of Valuation		
			L	T	P		CIE	SEE	Total
Theory Courses									
1	25TE01	Advanced Thermodynamics	3	1	0	4	40	60	100
2	25TE02	Advanced Fluid Mechanics	3	1	0	4	40	60	100
3	25TE03	Advanced Heat Transfer	3	1	0	4	40	60	100
4	**PROGRAMELECTIVE–I**		3	0	0	3	40	60	100
5	**PROGRAMELECTIVE–II**		3	0	0	3	40	60	100
Laboratory Courses									
6	25TE51	Thermal Systems Lab	0	1	2	2	40	60	100
7	25TE52	Simulation – Lab	0	1	2	2	40	60	100
8	25PI01	Seminar-I	0	0	2	1	100	-	100
Total			**15**	**5**	**6**	**23**	380	420	800

List of Professional Elective Courses in I Semester (Electives – I & II)

Course Code	Course Title
25TE04	Power Plant Management
25TE05	Analysis and Design of Turbo Machines
25TE06	AI/ML for Mechanical Engineering
25TE07	Cryogenic Engineering
25TE08	Advanced IC Engines and Emission control Systems
25TE09	Introduction to Quantum Technologies
25TE10	Fuel Cells and Hydrogen Technology
25TE11	Design of Experiments

@ Minimum 2/3 themes per elective

II-SEMESTER

S.No.	Course code	Course Title	Contact hours/week			Credits	Scheme of Valuation		
			L	T	P		CIE	SEE	Total
Theory Courses									
1	25TE12	Computational fluid dynamics	3	1	0	4	40	60	100
2	25TE13	Renewable energy technology	3	1	0	4	40	60	100
3	25TE14	Experimental analysis and Instrumentation	3	1	0	4	40	60	100
4	**Program Elective – III**		3	0	0	3	40	60	100
5	**Program Elective – IV**		3	0	0	3	40	60	100
Laboratory Courses									
6	25TE53	Renewable energy technology Lab	0	1	2	2	40	60	100
7	25TE54	Computational Fluid Dynamics Lab	0	1	2	2	40	60	100
8	25PI02	Seminar-II	0	0	2	1	100	-	100
Total			**15**	**5**	**6**	**23**	**380**	**420**	**800**

List of Professional Elective Courses in II Semester (Electives III & IV)

S.No.	Course Title
25TE15	Equipment design for thermal systems
25TE16	Finite element methods in thermal engineering
25TE17	Energy conservation and management
25TE18	Industrial food preservation
25TE19	Micro and nano scale heat transfer
25TE20	HVAC systems
25TE21	Energy storage technologies
25TE22	Thermal management of EV battery and Fuel cell systems

@ Minimum 2/3 themes per elective

III-SEMESTER

S.No	Course code	Course Title	Contact hours/week			Credits	Scheme of Valuation		
			L	T	P		CIE	SEE	Total
Theory Courses									
1	25RM01	Research Methodology and IPR / *Swayam 12 week MOOC course – RM&IPR*	3	0	0	3	40	60	100
2	25PI03	Summer Internship/ Industrial Training (8-10 weeks)*	-	-	-	3	100	-	100
3	25PI04	Comprehensive Viva#	-	-	-	2	100		100
4	25PI05	Dissertation Part – A$	-	-	20	10	100		100
Total			**3**	**0**	**20**	**18**	340	60	400

*Student attended during summer/ year break and assessment will be done in 3rd Sem. # Comprehensive viva can be conducted courses completed up to second semester.
$Dissertation–Part A , internal assessment

IV-SEMESTER

S.No	Course code	Course Title	Contact hours/week			Credits	Scheme of Valuation		
			L	T	P		CIE	SEE	Total
1	25PI06	Dissertation Part – B%	-	-	32	16	-	100	100
Total			0	0	32	16	0	100	100

% External Assessment

Total Credits: 23+23+18+16= 80

Programme Outcomes for P.G Programme

R25-M.Tech (Thermal Power Engineering)

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

R25-Regulations(w.e.f A.Y.2025-26)

M.Tech-Thermal Power Engineering

Detailed Syllabus

(First Semester)

M.Tech (I Sem)			25TE01-ADVANCED THERMODYNAMICS	L	T	P	Cr
			Program Core	3	1	-	4

Pre-requisites: Thermodynamics

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

COURSE OUTCOMES (COs):

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

CO1: Distinguish the laws of thermodynamics applied to thermal systems (Understanding Level – L2).

CO2:Apply the thermodynamics laws to solve various thermal system problems (Applying Level - L3).

CO3: Analyse the thermodynamic properties of various thermal systems (Analysing Level - L4).

CO4: Compare the exergy and irreversibility of closed and open thermal systems (Analysing Level - L4).

CO5: Classifies the working of advanced power cycles (Understanding Level – L2).

UNIT - I

THERMODYNAMICS – Introduction, Review of Zeroth, First, Second and Third law of thermodynamics. THERMODYNAMIC RELATIONS: Introduction – Reciprocity and cyclic relations – The Maxwell's relations – The Gibbs and Helmholtz relations - Relations involving enthalpy, internal energy, and entropy; Mayer relation, Clausius-Clapeyron equation, Joule-Thompson experiment.

UNIT- II

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

UNIT- III

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

UNIT – IV

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

UNIT – V

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

REFERENCES

1.Sonntag, Borgnakke, Van Wyllan, Fundamentals of Thermodynamics: 5th Edition John Wiley and Sons, 2010.

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

L	T	P	Cr.
3	1	-	4

M.Tech.(I Sem.) **25TE02-ADVANCED FLUID MECHANICS**

Program Core

**Pre-requisites : ** Mathematics, Fluid mechanics

COURSE EDUCATIONAL OBJECTIVES(CEOs): To make the students exposed to the study of compressibleandincompressibleflowsofviscousandnon-viscousfluids,boundarylayerconcepts,turbulent flows and gas dynamics.

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

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

- CO1 Classify the fluid kinematics and dynamics principles and calculates the velocity, stream and vorticity functions in fluid mechanics.(Understanding - L2)
- CO2 Distinguishes an importance of Navier Stokes equation, Hagen–Poiseuille flow and Couette-flow in laminar flows and apply to solve the fluid flow problems.(Understanding - L2)
- CO3 Apply the concepts of boundary layer thickness, displacement thickness, momentum thickness and energy thickness for various velocity profiles.(Apply - L3)
- CO4 Identify the flow patterns in compressible flows and apply the area velocity relations to solve the problems related to compressible flows(Understanding - L2)
- CO5 Describes the working principles of micro fluidic devices(Understanding-L2)

UNIT-I

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

UNIT-II

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

UNIT-III

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

UNIT-IV

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

UNIT-V

MICROFLUIDICS: Miniaturization, Scaling Laws,Physics of Fluids --Basic Principles Fluid Dynamics – Flow,BoundaryEffects,ChargeDrivenFluids:Electrokinetics,ElectrowettingMicrofabricationTechnology, 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 –Easterneconomyedition,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 MechanicsYoung, Munsen and Okiisyi,2ndEdition, JohnWiley,2000.
6. Fluid Mechanics,Frank.M.White5thEdition–McGrawHill,2005.

M.Tech(I Sem)			25TE03-ADVANCED HEAT TRANSFER	L	T	P	Cr
Program Core				3	1	-	4

Pre-requisites: Heat Transfer

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

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

- CO1 Apply the governing equations and boundary conditions for conduction, convection, radiation, boiling, condensation, and mass transfer problems.(Apply - L3)
- CO2 Solve problems related to1-D and 2-D steady and unsteady state heat transfer.(Apply-L3)
- CO3 Formulate the heat transfer equations to solve problems of conduction ,convection ,and radiation. (Apply - L3)
- CO4 Apply conduction convection and radiation heat transfer phenomenon for various geometries.(Apply -L3)
- CO5 Evaluate the heat transfer aspects for various thermal systems.(Apply-L3)

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

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

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

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

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

REFERENCES:
1. R.C.Sachdeva, Fundamentals of engineering heat and mass transfer,5thedition, NewAge Pub 2017
2. Yunus Cengel, Heat Transfer a basic approach–TMH,2007
3 J.P.Holman, Heat Transfer–TMH,2010
4. P.KNag, Heat & Mass Transfer,TMH
5. Incropera,F.P.and DeWitt,D.P., Fundamentals of Heat and MassTransfer,5th Edition, John Wiley & Sons, New York, 2006.

M.Tech(I Sem)			25TE04–POWER PLANT MANAGEMENT	L	T	P	Cr
			Program Elective-I	3	-	-	3

Pre-requisites: Thermodynamics, IC Engines

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

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

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

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

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

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

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

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

REFERENCES:

1. Robert Henderson Emerick, Power plant Management, Mc Graw Hill, NewYork,1965.
2. Production Handbook, Carson-etal.–John wiley & Sons, NewYork, 1974.
3. Tara Chand, Engineering Economics, Nem Chand & Bros., Roorkee, 1988.
4. Murthy,P.S.R.,Powersystemoperation&control,TataMcGrawHill,NewDelhi,1989.

M.Tech(I Sem)			23TE05–ANALYSIS AND DESIGN OF TURBO MACHINES	L	T	P	Cr
			Program Elective-I	3	-	-	3

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

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

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

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

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

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

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

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

UNIT–V

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

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

REFERENCES:

1. William W Perg, Fundamentals of Turbo machinery: JohnWiley & 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 Hilland Carl Peterson Mechanics and thermodynamics of Propulsion-,Prentice Hall
5. Dixon, Fluid Mechanics, Thermodynamics of Turbomachinery, Pergamon Press
6. Ganesan,V, GasTurbines, Tata McGraw-Hill, New Delhi.
7. Mattingly JD, Elements of Gas turbine Propulsion,McGrawHill,1st Edition.1997.
8. Ganesan,V.,GasTurbines3/e, Tata McGraw Hill Book Company, NewDelhi,2010

M.Tech(I Sem)			25TE06– AI/ML FOR MECHANICAL ENGINEERING	L	T	P	Cr
Program Elective-I				3	-	-	3

Pre-requisites: Nil

COURSE EDUCATIONAL OBJECTIVES(CEOs): To make the students familiar with the fundamentals of artificial intelligence and machine learning techniques and to apply the concepts for optimizing and enhancing the performance and smart working of mechanical engineering systems

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

CO1	Explain the basic concepts of artificial intelligence.(Understanding- L2)
CO2	Learn about the principles of supervised learning methods (Understanding- L2)
CO3	Gain knowledge in unsupervised learning method and Bayesian algorithms (Understanding- L2)
CO4	Get knowledge about neural networks and genetic algorithms.(Understanding-L2)
CO5	Understand the machine learning analytics and apply deep learning techniques to mechanical engineering applications. (Understanding-L2)

UNIT I

INTRODUCTION: Definition of Artificial Intelligence, Evolution, Need, and applications in real world. Intelligent Agents, Agents and Environments; Good Behaviour - concept of rationality, the nature of environments, structure of agents.

INTRODUCTION TO MACHINE LEARNING (ML): Definition, Evolution, Need, applications of ML in industry and real-world, regression and classification problems, performance metrics, differences between supervised and unsupervised learning paradigms, bias, variance, over fitting and under fitting.

SUPERVISED LEARNING: Linear regression, logistic regression, Distance-based methods, NearestNeighbours, Decision Trees, Support Vector Machines, Nonlinearity and Kernel Method

UNIT II

UNSUPERVISED LEARNING: Clustering, K-means, Dimensionality Reduction, PCA and Kernel.

BAYESIAN AND COMPUTATIONAL LEARNING: Bayes theorem, concept learning, maximum likelihood of normal, binomial, exponential, and Poisson distributions, minimum description length principle, Naïve Bayes Classifier, Instance-based Learning- K-Nearest neighbour learning.

UNIT III

NEURAL NETWORKS AND GENETIC ALGORITHMS: Neural network representation, problems, perceptron, multilayer networks and backpropagation, steepest descent method, Convolutional neural networks and their applications Recurrent Neural Networks and their applications, LSTM, Transformers, Local vs Global optima, Genetic algorithms- binary coded GA, operators, convergence criteria.

UNIT IV

DEEP LEARNING: Deep generative models, Deep Boltzmann Machines, Deep auto-encoders, Applications of Deep Networks. Machine Learning Algorithm Analytics: Evaluating Machine Learning algorithms, Model, Selection, Ensemble Methods - Boosting, Bagging, and Random Forests.

UNITV

APPLICATIONS TO MECHANICAL ENGINEERING: Modal analysis and damping prediction in mechanical structures, Crack detection and fatigue life estimation, Defect detection in casting and welding, Tool wear and Surface roughness prediction in CNC machining, Heat exchanger design optimization, fault diagnosis and energy optimization in refrigeration and air conditioning systems.

REFERENCES:

1) Stuart Russell and Peter Norvig, Artificial Intelligence: A Modern Approach, 2/e, Pearson Education, 2010.
2) Tom M. Mitchell, Machine Learning, McGraw Hill, 2013.
3) Ethem Alpaydin, Introduction to Machine Learning (Adaptive Computation and Machine Learning), The MIT Press, 2004.
4) Elaine Rich, Kevin Knight and Shivashankar B. Nair, Artificial Intelligence, 3/e, McGraw Hill Education, 2008.
5) Dan W. Patterson, Introduction to Artificial Intelligence and Expert Systems, PHI Learning, 2012.

ONLINERESOURCES: https://www.tpointtech.com/artificial-intelligence-ai https://www.geeksforgeeks.org

M.Tech(I Sem)			25TE07–CRYOGENIC ENGINEERING	L	T	P	Cr
			Program Elective-I	3	-	-	3

Pre-requisites: Thermodynamics, Heat Transfer and Fluid Mechanics

COURSE EDUCATIONAL OBJECTIVES(CEOs): To impart the knowledge on the fundamentals and applications of cryogenic engineering in diverse fields of applications.

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

CO1	Understand the different fluid and material properties at low temperatures (Understanding -L2)
CO2	Impart knowledge of the working principles of various cryo-refrigerators, thermodynamic cycles for attaining low temperature, and gas separation and purification principles (Understanding -L2)
CO3	Understand the fundamental principles of thermal design of storage vessels and insulation, transfer systems (Understanding -L2)
CO4	Understand the cool-down process and heat transfer in cryogenic fluids, occurrence of two-phase flow and stratification in cryogenic systems(Understanding -L2)
CO5	Understand the importance of vacuum requirements in cryogenics, superconductivity, and special phenomena at very low-temperature engineering applications(Understanding -L2)

UNIT–I

FLUID AND MATERIAL PROPERTIES AT LOW TEMPERATURE & APPLICATIONS OF CRYOGENICS: Introduction to cryogenics: Cryogenic temperature scale, Properties of cryogenic fluids, super fluidity of He3 & He 4, properties of engineering materials at cryogenic temperatures, mechanical properties, thermal properties, electric & magnetic properties, super conducting materials. Applications of cryogenic systems: Super conductive devices, space technology, space simulation, cryogenics in biology and medicine, food preservation and industrial applications, nuclear propulsions, chemical propulsions

UNIT-II

CRYOGENIC GAS LIQUIFICATION:

Gas liquefaction systems: Introduction, thermodynamically ideal systems, Joule Thomson effect, liquefaction systems such as Linde Hampton, precooled Linde Hampson, Linde dual pressure, cascade system, Claude system, Kapitza system, Heyland systems using expanders, comparison of liquefaction systems and its performance evaluations.

UNIT–III

CRYOGENICAIR-SEPARATION:

Basics of Gas Separation, Ideal Gas Separation System, Gibbs Phase Rule, Phase Equilibrium Curves, Temperature Composition Diagrams, Raoult's Law, Gibbs – Dalton's Law, Distribution Coefficient, Enthalpy composition diagrams, Rectification Column Murphree efficiency, Theoretical Plate Calculations

UNIT–IV

CRYOGENICREFRIGERATORANDCRYOCOOLERS:

Cryogenic Refrigeration System: Ideal isothermal and reversible isobaric source refrigeration cycles, Joule

Thomson system, cascade or pre-cooled joule–Thomson refrigeration systems, expansion engine and cold gas refrigeration systems, Sterling refrigerators, Importance of regenerator effectiveness for the Sterling refrigerators, Gifford single volume refrigerator, Gifford double volume refrigerators analysis, Refrigerators using solids as working media: Magnetic cooling, magnetic refrigeration systems, thermal; valves, nuclear demagnetization, dilution refrigerator

UNIT–V

CRYOGENIC FLUID STORAGE INSTRUMENTATION AND INSULATION:

Dewar vessel for cryogenic fluid storage, Construction, Inner vessel design, outer vessel design, temperature measurements, pressure measurements, flow measurements, liquid level measurements, fluid quality measurements, Cryogenic insulation – expanded foams, gas filled & fibrous insulation, vacuum insulation, evacuated powder & fibrous insulation, Opacified powder insulation, multilayer insulation, comparison of performance of various insulations.

REFERENCES

1. Barron,R.,1985,Cryogenic Systems, SI version, Oxford university press
2. Scott,R.B.,1962,Cryogenic Engineering, D.Van Nostrand Company.
3.Timmerhaus,K.D.and Flynn,T.M.,1989,Cryogenic Process Engineering, Plenum Press.
4.Vance,R.W.,and Duke,W.M.,1962,Applied Cryogenic Engineering, John Wiley.
5.Sittig,M.,1963,Cryogenics Research and Applications, D.Van Nostrand Company.
6.Hands,B.A.,1986,Cryogenic engineering, Academic press.
7.Flynn,T.M.,2005,Cryogenic Engineering, Marcel Dekker Inc.,NewYork.

M.Tech(I Sem)			25TE08- ADVANCED INTERNAL COMBUSTION ENGINES AND EMISSION CONTROL SYSTEMS	L	T	P	Cr
Program Elective-II				3	-	-	3

Pre-requisites: Thermodynamics, IC Engines

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

COURSE OUTCOMES(COs): Afterthecompletionofthecourse,studentsshouldbeableto

- CO1 Discuss the engine design parameters along with the engine cycle analysis.(UnderstandingL2)
- CO2 Analyze the combustion phenomenon in S.I and C.I engines(Apply-L3)
- CO3 Describe the engine energy transfer and modern trends used in I.C. engines(UnderstandingL2)
- CO4 Comprehend the EV concepts, EV configurations and various HEV parameters for better understanding of the EV technology.(Understanding-L2)
- CO5 Analyze the various pollutants from engine and apply different pollution control techniques to reduce the emissions.(Understanding-L2)

UNIT–I

INTRODUCTION – Historical Review – Engine Types – Design and operating Parameters. CYCLE ANALYSIS: Thermo-chemistry of Fuel – Air mixtures, properties – Ideal Models of Engine cycles– Real Engine cycles - differences and Factors responsible for – Computer Modeling.

UNIT-II

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

UNIT–III

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

UNIT–IV

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

UNIT–V

POLLUTANT FORMATION AND CONTROL: Nature and extent of problems – Nitrogen Oxides, Carbon monoxide, unburnt Hydrocarbon and particulate – Emissions – Measurement – Exhaust Gas Treatment, Catalytic converter, Selective catalytic reduction, Particulate Traps, Lean, NOX, Oxidation

Catalysts, Diesel Particulate filters. Engine modifications to reduce emissions, Health and environmental effects of pollution,.

REFERENCES:

1. John B. Heywood, Internal Combustion Engine Fundamentals, 3rd edition, McGraw-Hill series, 2008.

2. V.Ganesan, Internal Combustion Engines, 4th edition, Tata McGraw Hill Education Private Limited, 2013. 3. Paul Degobert, Automobiles and Pollution, SAE International, 1991.

4. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.

5. C.C Chan, K.T Chau: Modern Electric Vehicle Technology, Oxford University Press Inc., New York,

2001. 6. Ferguson C. R, Internal Combustion Engines, John Wiley ,1989.

M.Tech (I Sem)			25TE09-INTRODUCTION TO QUANTUM TECHNOLOGIES	L	T	P	Cr
			Program Elective-II	3	-	-	3

Pre-requisites: Nil

Course Educational Objectives:

To introduce fundamental concepts of quantum mechanics and its mathematical formalism. To explore quantum computing and communication principles and technologies. To understand the physical implementation and limitations of quantum systems. To enable students to relate quantum theory to practical applications in computing, cryptography, and sensing. To familiarize students with the emerging trends in quantum technologies.

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

CO1 Explain core principles of quantum mechanics and their technological implications. (Understanding - L2)

CO2 Analyze quantum phenomena like superposition and entanglement. (Apply - L3)

CO3 Apply mathematical tools to model and solve quantum systems. (Apply - L3)

CO4 Demonstrate understanding of quantum algorithms and quantum circuits. (Understanding - L2)

CO5 Analyze potential applications and challenges in quantum communication and sensing.(Apply - L3)

UNIT – I

FUNDAMENTALS OF QUANTUM MECHANICS: Historical background: Blackbody radiation, photoelectric effect, and Compton scattering; Dual nature of light and matter; De Broglie hypothesis; Schrödinger equation; Free particle, infinite potential well, step potential; Operators and observables: position, momentum, Hamiltonian; Commutation relations and uncertainty principle; Quantum postulates and measurement theory; Eigen values, eigen functions.

UNIT – II

QUANTUM INFORMATION THEORY: Classical vs. quantum information; Qubit representation using Bloch sphere; Quantum superposition and quantum entanglement; Dirac notation (bra-ket), tensor products, and composite systems; Bell states and EPR paradox; Quantum gates: Pauli-X, Y, Z; Hadamard; Phase; T; CNOT; Quantum circuit models and notation; Measurement in computational basis; Quantum teleportation and no-cloning theorem; Quantum state tomography (introductory)

UNIT – III

QUANTUM COMPUTING: Classical computing review and limitations; Quantum parallelism and interference; Deutsch and Deutsch-Jozsa algorithms; Grover's search algorithm, Oracle and amplitude amplification; Shor's factoring algorithm (overview and significance); Quantum Fourier Transform (QFT); Quantum error correction: Bit-flip, phase-flip, and Shor's 9-qubit code; Introduction to quantum programming: Qiskit, Cirq, IBM Quantum Experience (overview)

UNIT – IV

QUANTUM COMMUNICATION: Introduction to quantum cryptography; Quantum key distribution (QKD): BB84 protocol; Entanglement-based QKD: Ekert protocol (E91); Eavesdropping and security of QKD; Quantum teleportation (circuit and protocol); Quantum dense coding; Quantum networks and entanglement swapping; Role of quantum repeaters; Single-photon sources and detectors; Implementation challenges (loss, decoherence, noise)

UNIT – V

QUANTUM TECHNOLOGIES AND APPLICATIONS: QUANTUM SENSORS: magnetometry, gravimetry; Quantum metrology: standard time, atomic clocks; Quantum imaging and lithography; Quantum materials: topological insulators, graphene, quantum dots; NV centers in diamonds for sensing; Hardware platforms: Superconducting qubits, Trapped ions, Photonic quantum processors; Quantum supremacy and NISQ era; Global initiatives: IBM, Google, D-Wave, IonQ, India's NQM; Ethical concerns and future prospects

REFERENCES

1. "Quantum Computation and Quantum Information" by Michael A. Nielsen and Isaac L. Chuang

2. "Quantum Mechanics: Concepts and Applications" by Nouredine Zettili

M.Tech(I Sem)			25TE10-FUEL CELLS AND HYDROZEN TECHNOLOGIES	L	T	P	Cr
			Program Elective-II	3	-	-	3

Pre-requisites: Thermodynamics

Course Educational Objectives:
To impart the knowledge on the characteristics, construction, operation, production, storage, transportation and performance of fuel cells and hydrozen energy technologies and applications

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

CO1 Understand fuel cell fundamentals (Understanding - L2)
CO2 Demonstrate the operation of different fuel cells (Understanding - L2)
CO3 Analyse the performance of PEM fuel cell system (Apply - L3)
CO4 Understand the Production, Storage and Transportation systems of Hydrogen (Understanding - L2)
CO5 Analyze the dynamic behavoiur of thermal systems using different techniques (Apply - L3)

UNIT-I:
INTRODUCTION TO FUEL CELLS – Fuel cell concept - key components - physical and chemical phenomena in fuel cells - advantages and disadvantages of fuel cells – different types of fuel cells and their characteristics – fuel cells for stationary applications – fuel cell vehicles.

UNIT-II
THERMODYNAMIC ANALYSIS – systematic enthalpy change of a reacting system – systematic Gibbs free energy – change of a reacting system – ideal efficiency of the energy conversion – energy balance in fuel cells.

UNIT-III:
ELECTROCHEMISTRY – Nernst equation, relation of the fuel consumption versus output – stoichiometric coefficients and utilization percentages of fuels and oxygen – mass flow rate calculation for fuel and oxygen in single cell and fuel cell stack – total voltage and current for fuel cells in parallel and series connection – over-potential and polarizations.

UNIT-IV:
DMFC OPERATION SCHEME – general issues-water flooding and water management - polarization in PEMFC - optimization design of PEMFC – case studies. Hydrogen economy – Introduction to hydrogen economy - production, storage and transportation systems – hydrogen from fossil fuels – electrolysis of water – thermochemical cycles – baseline and alternative thermochemical cycles.

UNIT-V:
HYDROGEN UTILIZATION – Hydrogen for stationary and automotive applications – transmission and infrastructure requirements – safety and environmental impacts - economics of transition to hydrogen systems – case studies

REFERENCES:
1. Vishwanathan B. and AuliceScibioh, “Fuel cells: Principles and Applications”, University Press, 2006.
2. Ram B. Gupta, “Hydrogen Fuel: Production, Transport and Storage”, CRC Press.
3. Peter Hoffman, “Tomorrow’s Energy – Hydrogen Fuel cells and the Prospects for Cleaner Planet”, MIT, 2002. 4. Prashukumar G.P., “Hydrogen – A Fuel for Automatic Engines”“ ISTE, 1999.
5. Hart A.B. and Womack G.J., “Fuel Cells – Theory and Applications”, Chapman and Hall, 1967. 4. Young G.J., “Fuel Cells”, Rein hold publishing Corp., 1960.
6. Veziroglu T., “Hydrogen Energy”, Springer publishing, 1975.

M.Tech(I Sem)			25TE11-DESIGN OF EXPERIMENTS	L	T	P	Cr
Program Elective-II				3	-	-	3

Pre-requisites : Probability and Statistics, Mathematics

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

COURSE OUTCOMES(COs): After the completion of this course, the student will be able to:
CO1 Identify the need for the strategies of design of experiments and probability. (Understanding - L2)
CO2 Acquire the knowledge of random variables used in the experimental strategies (Understanding - L2)
CO3 Analyze the vast experimental data using the sampling criteria. (Apply - L3)
CO4 Design the experiments with single factor and several factors. (Apply - L3)
CO5 Apply the regression analysis and response surface methods to optimize the parametric data. (Apply - L3)

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

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

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

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

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

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

Optimization Using Designed Experiments, John Wiley

M.Tech. (I Sem.) **25TE51 - THERMAL SYSTEMS LAB**

L	T	P	Cr.
-	1	2	2

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

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

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

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

List of Experiments

At least 10 Experiments are required to be conducted.

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

M.Tech. (I Sem.) **25TE52 - SIMULATION LAB**

L	T	P	Cr.
-	1	2	2

Pre requisites: Theory courses in Heat Transfer and Numerical Methods

Course Educational Objectives: To make the student understand

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

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

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

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

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

LIST OF NUMERICAL PROBLEMS:

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

Any TEN numerical problems.

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

M.Tech. (I Sem.) **25PI01–SEMINAR-I**

L	T	P	Cr.
-	-	2	1

**Pre-requisites : ** Nil

COURSE EDUCATIONAL OBJECTIVE(CEO): To improve the presentation skills of the students

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

CO1 Identify a topic of his choice in the area of thermal engineering

CO2 Prepare the slides minimum 10-15 slides on the selected topic

CO3 Present the PPT in front of the panel members with confidence

CO4 Make corrections in the PPT or presentation style, time management and confidence levels

R25-Regulations (w.e.f A.Y.2025-26)

M.Tech-Thermal Power Engineering

Detailed Syllabus
(Second Semester)

M.Tech. (II Sem.) 25TE12-COMPUTATIONAL FLUID DYNAMICS

L	T	P	Cr.
3	1	-	4

Pre-requisites: Fluid Mechanics, Fluid Dynamic

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

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

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

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

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

UNIT – IV
FINITE DIFFERENCE APPLICATIONS IN FLUID FLOW, HEAT CONDUCTION AND CONNECTION: A Finite Volume Method to solve NS Equations in 3D Complex Geometry (Part-3); Turbulent Flow and Heat Transfer, Fundamentals of fluid flow modelling, elementary finite difference quotients, implementation aspects of finite difference equations, Discretization, consistency, stability, explicit and implicit methods, Conduction, steady heat conduction in a rectangular geometry, transient heat conduction finite difference application in convective heat transfer, Discretization, consistency, stability.

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

REFERENCES:
1.John. D. Anderson, Computational fluid dynamics – The basics with Applications - Mc Graw Hill 6th Edition 1995.
2. Dr. Atual Sharma, Introduction to Computational Fluid Dynamics: Developments, Applications and Analysis, Athena Academic and Wiley (UK), 1st Edition 2017.
3. K.A. Hoffman and Steve T Chiang, Computational Fluid Dynamics, Vol.I, 4th Edition, Engineering Education System Publications.
4. Suhas V Patankar, Numerical heat transfer and Fluid flow, Taylor and Francis, 1st Edition, 1980.
5.Tannehill, J.E., Anderson, D.A., and Pletcher, R.H., Computational Fluid Mechanics and Heat Transfer, 2nd ed., Taylor & Francis, 1997

M.Tech. (II Sem.) 25TE13 – RENEWABLE ENERGY TECHNOLOGIES

L	T	P	Cr.
3	1	-	4

Pre-requisites: Non-conventional energy sources

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

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

CO1: Identify the solar energy measurement devices and its applications.(Understanding - L2)

CO2: Analyse performance of non-concentrating and concentrating collectors.(Understanding- L2)

CO3: Estimate the power output of wind turbine and ocean energy conversion plants. (Understanding - L2)

CO4: Comprehend power generation from geothermal energy and bio-energy.(Understanding- L2)

CO5: Demonstrate the power generation from direct energy conversion systems and hydrogen as potential fuel.(Understanding - L2)

UNIT I

INTRODUCTION: Energy Scenario, Survey of energy resources. Classification and need for conventional energy resources. Sun , Earth relationship, Basic matter to waste heat energy circuit, Solar Radiation, Attention, Radiation measuring instruments.

SOLAR ENERGY APPLICATIONS: Solar water heating. Space heating, Active and passive heating. Energy storage. Selective surface. Solar stills and ponds, solar refrigeration, Photovoltaic power generation.

UNIT II

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

UNIT III

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

ENERGY FROM OCEANS: Tidal energy, Tides, Power from tides, Wave Energy, Waves, Theoretical energy available. Wave power systems, Submerged devices. Ocean thermal Energy, Principles.

UNIT IV

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

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

UNIT V

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

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

REFERENCES:

1. Renewable Energy Resources, Basic Principles and Applications/ G.N.Tiwari and M.K.Ghosal/ Narosa Publications,2001.

2. Renewable Energy Resources, Basic Principles and Applications/ G.N.Tiwari and M.K.Ghosal/ Narosa Publications, 2000.

3. Biological Energy Resources/ Malcolm Fleischer & Chris Lawis/ E&FN Spon, 2002.

4. Renewable Energy Sources / G.D Rai /Khanna Publishers. 1998.

M.Tech. (II Sem.)	25TE14–EXPERIMENTAL ANALYSIS AND ISTRUMENTATION	L	T	P	Cr.
		3	1	-	4

Pre-requisites: Advanced Fluid mechanics

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

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

CO1: Post-process the experimental data employing the standard statistical tools.

CO2: Analyze First and Second Order Systems applied different Thermal Systems.

CO3: Estimate uncertainties associated with the measurements.

CO4: Employ the knowledge for carrying out experiments in research labs and industries.

CO5: Design novel techniques for measurements of thermo-physical properties

UNIT-I:

CONCEPTS IN DYNAMICS MEASUREMENTS: system response; error analysis; uncertainty analysis; calibration; statistical analysis; probability distributions; goodness of data; method of least squares and multivariable regression.

UNIT-II:

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 & Secondorder systems with examples of mechanical and thermal systems. Control System Evaluation – Stability, steady-state regulations, and transient regulations. Data acquisition systems: A to D and D to A convertors

UNIT-III:

TEMPERATURE MEASUREMENTS: mechanical effects, electrical effects; thermistors; liquid crystal thermography; thermocouples – types, laws of thermocouple, thermopile, transient response of thermal systems; temperature measurement in cryogenics. Pressure measurements - bourdon-tube gage, diaphragm and bellows gage; inductive, piezoelectric and capacitative transducers; McLeod gage; Knudsen gage; ionization gage.

UNIT-IV:

FLOW MEASUREMENTS: – flow obstruction meters – venturi, orifice, nozzle meters; turbine meters; coriolis flow meters; ultrasonic flow meters; magnetic flow meters. Hot-wire and hot-film anemometry; Laser Doppler Anemometer. Acoustic measurements – microphones and sound lever meters. Flow visualization - schlieren; shadowgraph; interferometer.

UNIT-V:

MEASUREMENT OF THERMAL AND PHYSICAL PROPERTIES: – viscosity; thermal conductivity of solids and fluids – steady and unsteady state measurements; thermal conductivity of low-conducting and metallic solids; measurement of specific heat of solids and fluids; measurement of derived quantities – heat flux; heat transfer coefficient; measurement of calorific values, humidity. Thermal radiation measurements – emissivity; reflectivity and transmissivity; pyrometry; solar radiation measurements, Introduction to IR emission measurements.

REFERENCES:

1. Eckert, E.R.G., and Goldstein, R.J., 1976, Measurements in Heat Transfer, 2nd ed. McGraw Hill.
2. Holman, J.P., 2012, Experimental Methods for Engineers, 8th ed., McGraw Hill.
3. Beckwith, T.G., Marangoni, R.D., and Lienhard V, J.H., 2007, Mechanical Measurements, 6 th ed., Pearson Prentice Hall.
4. Sirohi, R.S., and Radha Krishna, H.C., 1991, Mechanical Measurements, 3rd ed., New Age International.
5. Venkateshan, S.P., Mechanical Measurements; 2nd ed., John Wiley & Sons

M.Tech. (II Sem.) 25TE15–EQUIPMENT DESIGN FOR THERMAL SYSTEMS

L	T	P	Cr.
3	-	-	3

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

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

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

CO1: Apply LMTD and NTU approaches to solve problems on parallel, counter, and cross flow heat exchangers. (Applying Level -L3).
CO2: Analyze the design procedures in shell and tube heat exchangers. (Analysis Level -L4).
CO3: Describe the working procedures and calculate the heat transfer aspects in condenser and evaporators. (Understanding Level -L2).
CO4: Distinguishes the performance parameters in cooling tower performance and heat pipe applications. (Understanding Level -L2).
CO5: Analyze the various techniques for cooling electronic equipment. (Analsysis Level -L4).

UNIT – I

CLASSIFICATION OF HEAT EXCHANGERS: INTRODUCTION- Recuperation & Regeneration-Tubular heat exchangers-Double pipe, Shell and Tube heat exchangers, Plate heat exchanger Exchangers-Plate fin and Tubular fin heat exchangers BASIC DESIGN METHODS OF HEAT EXCHANGERS: Basic equations in Design, Overall heat transfer coefficient-LMTD method for heat exchanger analysis-Parallel flow, counter flow, Multi pass, CROSS FLOW HEAT EXCHANGER DESIGN CALCULATIONS – Effectiveness method (NTU))-Keys and London charts-Compact Heat exchangers – Heat Transfer optimization

UNIT - II

DOUBLE PIPE HEAT EXCHANGER: Film coefficient for fluids in annulus, fouling factors, calorific temperature, Average fluid temperature, Calculation of double pipe exchanger, double pipe exchangers in series parallel arrangements. Shell & Tube Heat Exchangers: Tube layouts for exchangers, Baffle heat exchangers, Calculation of shell and tube heat exchangers, Shell side film coefficients, Shell side equivalent diameter, The true temperature difference in a 1-2 heat exchanger. Influence of approach temperature on correction factor. Shell side pressure drop, Tube side pressure drop, Analysis of performance of 1-2 heat exchanger and design of shell & tube heat exchangers, Flow arrangements for increased heat recovery, the calculation of 2-4 exchangers.

UNIT – III

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

UNIT – IV

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

UNIT – V

COOLING OF ELECTRONIC EQUIPMENT: Introduction-The chip carrier-Printed circuit boards-Cooling load of electronic equipment CONDUCTION COOLING: Conduction in chip carriers-conduction in printed circuit boards-heat frames. AIR COOLING: Natural convection and radiation- Forced convection- Fan selection-cooling personal computers and Heat Pipes.

REFERENCES:

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

M.Tech. (II Sem.)	25TE16–FINITE ELEMENT METHOD IN THERMAL ENGINEERING	L	T	P	Cr.
		3	-	-	3

Pre-requisites : Mathematics, Fluid mechanics and heat transfer

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

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

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

UNIT - I
FORMULATION TECHNIQUES: Potential energy method, Raleigh Ritz method, Galerkin and weighted residual methods, calculus of variations, Essential and natural boundary conditions, introduction to FEM. 1-D STATIC ANALYSIS OF BARS: Element matrices, assembling of global stiffness matrix, Application of boundary conditions, Elimination and penalty approaches, solution for displacements, reaction, stresses, temperature effects, Stiffness matrix for a Quadratic Element.

UNIT - II
1-D STEADY-STATE HEAT TRANSFER: Finite Element Formulation using linear and quadratic elements, Numerical problems in composite walls and fins of uniform cross section using linear elements. 1-D TRANSIENT HEAT TRANSFER: Derivation of element matrices, solution techniques, A numerical problem with 2 elements.

UNIT - III
2-D STEADY-STATE HEAT TRANSFER: Finite Element Formulation using linear triangle elements, Problem modeling and boundary conditions. Isoparametric formulation, Numerical integration (1-D, 2-D).

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

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

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

M.Tech. (II Sem.) 25TE17–ENERGY CONSERVATION AND MANAGEMENT

L	T	P	Cr.
3	-	-	3

Pre-requisites: Thermodynamics, Thermal engineering, Heat Transfer

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

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

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

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

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

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

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

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

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

M.Tech. (II Sem.) 25TE18–INDUSTRIAL FOOD PRESERVATION

L	T	P	Cr.
3	-	-	3

Pre-requisites: Thermodynamics, Thermal engineering, Heat Transfer

COURSE EDUCATIONAL OBJECTIVES(CEOs): To provide detailed understanding of preventing food spoilage, know the food preservation methods, sanitation, additives, hygiene with exposure to real world food processing environments.

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

CO1: Understand microbial, enzymatic, and chemical causes of food spoilage (Understanding - L2)
CO2: Comprehend food preservation techniques like drying, freezing, irradiation, and chemical methods. (Understanding - L2)
CO3: Understand the role of preservatives and additives.(Understanding - L2)
CO4: Describe the hygiene, sanitation, and regulatory compliance.(Understanding - L2)
CO5: Demonstrate exposure to real-world food processing environments.(Understanding - L2)

UNIT-I
BASIC FOOD MICROBIOLOGY: Actions of microorganisms, microbiology of food spoilage, needs and benefits of industrial food preservation; applications of thermodynamics, reaction kinetics, heat and mass transfer and water activity in food preservation; principles of fresh food storage: nature of harvested crop, plant and animal product storage, effect of cold storage and quality, storage of grains, storage at chilling temperatures, applications and procedures; freezing: physicochemical principles of the freezing process, freezing technology, calculation of heat to be removed and freezing time.

UNIT-II
PRESERVATION PROCESSES-I: Thermal processing, interaction of thermal energy and food components, optimization of thermal processes for nutrient retention; concentration: principles of evaporator operation, membrane processes for food concentration; principles of dehydration process, energy and material balance on an air dryer, methods of drying, freeze drying; combining heat treatment, control of water activity and pressure to preserve foods; high hydrostatic pressure technology in food preservation;

UNIT-III
PRESERVATION PROCESSES-II: Food preservation by fermentation; fermented and pickled products; beverage processes; processing of meat, fish and poultry; principles of fish salting, meat curing and smoking, purpose of smoking; food preservation by chemicals-food additives, functional chemical additives applications; chemical preservatives and antibiotics.

UNIT-IV
FOOD PRESERVATION BY IRRADIATION: Technology aspects of radiations; pasteurization of foods, processing and storage of milk and dairy products; food packaging-principles of protective packaging; deteriorative changes in food stuff and packaging methods for prevention;

UNIT-V
FOOD CONTAINERS: Rigid containers and flexible packaging materials, and their properties; special problems in packaging perishables and processed food; evaluation of packaging, material and package performance, packaging equipment, package standards and regulation, shrink packaging, biodegradable packaging, active packaging.

REFERENCES:
1. M. Karel and D. B. Lund, Physical Principles of Food Preservation, 2nd ed.
2. Marcel Dekker, 2003. P. Zeuthen and L. B. Sorensen, Food Preservation Techniques, Woodhead Publishing Ltd., 2003.
3. M. S. Rahman, Handbook of Food Preservation, 2nd ed. CRC Press, 2007.
4. G. Tewari and V. K. Juneja, Advances in Thermal and Non-thermal Food Preservation, Blackwell Publishing, 2007.
5. D. R. Heldman, Food Preservation Process Design, Academic Press, 2011.

M.Tech. (II Sem.) 25TE19–MICRO AND NANOSCALE HEAT TRANSFER

L	T	P	Cr.
3	-	-	3

Pre-requisites: Thermodynamics, Fluid Mechanics, Heat Transfer

COURSE EDUCATIONAL OBJECTIVES(CEOs): The course is intended to understand the concepts of Micro and Nanoscale Heat Transfer

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

CO1: Understand physics involved in fluid flow in micro scale fabricated systems and its applications (Understanding - L2)
CO2: Understand the conduction in integrated circuits and their constituent films. (Understanding - L2)
CO3: Analyze the convective heat transfer in micro tubes and channels(Apply – L3)
CO4: Analyze the heat transport at the nano scale(Apply – L3)
CO5: Understand the different analytical methods in nano scale heat transfer.(Understanding - L2)

UNIT-I:
INTRODUCTION TO MICROSCALE HEAT TRANSFER: Introduction to micro/nano scale transport phenomena, Material waves and energy quantization, Energy states in Solids, Statistical Thermodynamics and Thermal Energy Storage, Energy Transfer by waves, Particle description of transport process: Classical laws, Boltzmann transport equation– Basics of molecular dynamics modelling– Applications of Micro Scale Heat Transfer Microscale Heat Conduction– Conduction in Microscale– Space and time scales Thermal conductivity models– Thermal conductivity prediction using Molecular Dynamics- Boltzmann equation and Phonon transport– Heat conduction in electronic devices Measurement of heat conduction in microscale

UNIT II:
MICROSCALE HEAT CONVECTION: Thermodynamic considerations– Continuum approach, Conservation laws and governing equations Single phase forced convection– flow regimes– entry lengths-Non conventional analysis methods– Single phase liquid and gas flow measurements

UNIT III:
MICROSCALE RADIATIVE HEAT TRANSFER: Macro Vs Microscopic approach– Spatial and temporal scales– radiation interaction and scattering with micro structures and materials Modeling of microscale radiation– radiation properties in microscale regime

UNIT-IV:
INTRODUCTION TO NANOSCALE HEAT TRANSFER: Length scales for nanoscale heat transfer Heat transfer modes- nanofluids, nanostructure materials, base fluids, dispersion, sonication and stable suspension. Various types of nanofluids-volumetric concentration. Thermo-physical properties: Density; principles of measurement and apparatus. Theoretical equations and new empirical correlations to determine the density of different nanofluids. Viscosity: principles of measurement and apparatus. Andrade’s and other theoretical equations and new empirical correlations to determine the viscosity of different nanofluids. Effect of volumetric concentration and temperature. Thermal conductivity: principles of measurement and apparatus. Hamilton-Crosser and other theoretical equations and empirical correlations to determine the thermal conductivity of different nanofluid.

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

REFERENCES:

1. Microscale and Nanoscale Heat Transfer by C. Sobhan and G. Peterson, First edition, CRC Press
2. Fluid Mechanics by F. M. White, 5th Edition, McGraw-Hill 3. Heat Transfer by A. Bejan 2nd Edition, John Wiley
3.C.L. Tien, A. Majumdar, and F.M. Gerner, Microscale Energy Transport, Taylor & Francis
4.Zhuomin M. Zhang, Nano/Microscale Heat Transfer, McGraw Hill.
5. Handbook of Nanostructured Materials and Nanotechnology by H.S.Nalwa, I edition, Vol. I and II, American Scientific Publishers
6. Springer Handbook of Nanotechnology by Bharat Bhushan, 1st edition, Springer-Verlag Publication
7.Chen G., Nanoscale Energy Transport and Conversion, Oxford University Press.
8.Selected journal papers from IJ Heat and Mass Transfer, Nanoscale and Microscale Thermophysical Engineering.

M.Tech. (II Sem.) **25TE20–HVAC SYSTEMS**

L	T	P	Cr.
3	-	-	3

Pre-requisites: Thermodynamics, Fluid Mechanics, Heat Transfer

COURSE EDUCATIONAL OBJECTIVE(CEO): Gain knowledge of various HVAC components (compressors, condensers, evaporators, ducts, fans, filters, chillers, etc.) and their integration in designing efficient air conditioning and ventilation systems

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

CO1: Interpret and analyse the psychrometric processes, air properties, and their applications in air conditioning systems. (Apply – L3)
CO2: Perform cooling and heating load calculations for residential, commercial, and industrial buildings. (Apply – L3)
CO3: Apply sustainable and green building concepts in HVAC system design to reduce environmental impact. (Apply – L3)
CO4: Design and evaluate a complete air distribution system including fan, duct, and installation requirements for a typical HVAC system (Apply – L3)
CO5: Understand the effectiveness of modern HVAC control strategies (thermostats, sensors, BMS) for optimizing performance and energy use..(Understanding - L2)

UNIT-I: INTRODUCTION TO HVAC SYSTEMS: Brief history of air conditioning and impact of air conditioning. HVAC systems and classifications, Scope and applications of HVAC in residential, commercial, and industrial sectors, Principles of heating, ventilation, and air conditioning, Psychrometric properties of air – humidity, enthalpy, dry bulb/wet bulb temperature
PSYCHROMETRY OF AIR CONDITIONING PROCESSES: Thermodynamic properties of moist air, Important Psychrometry properties, Psychrometric chart; Psychrometric process in air conditioning equipment, applied Psychrometry, air conditioning processes, air washers.

UNIT-II: COMFORT AIR CONDITIONING: Thermodynamics of human body, metabolic rate, energy balance and models, thermoregulatory mechanism. Comfort & Comfort chart, Effective temperature, Factors governing optimum effective temperature, Design consideration. Selection of outside and inside design conditions.

UNIT-III: HEAT TRANSFER THROUGH BUILDING STRUCTURES: Solar radiation; basic concepts, sun-earth relationship, different angles, measurement of solar load, Periodic heat transfer through walls and roofs. Empirical methods to calculate heat transfer through walls and roofs using decrement factor and time lag method. Infiltration, stack effect, wind effect. CLTD/ETD method – Use of tables, Numerical and other methods, Heat transfer through fenestration – Governing equations, SHGF/SC/CLF Tables

UNIT-IV: VENTILATION SYSTEM: Introduction- Fundamentals of good indoor air quality, need for building ventilation, Types of ventilation system, Air Inlet system. Filters heating & cooling equipment, Fans, Duct design, Grills, Diffusers for distribution of air in the workplace, HVAC interface with fire and gas detection systems - system requirements, devices and their functioning.

UNIT-V: ADVANCED & SUSTAINABLE HVAC PRACTICES: Variable Refrigerant Flow (VRF/VRV) Systems, District Cooling and Heating Systems, Green Building Concepts in HVAC – Energy Conservation Techniques, HVAC Controls – Thermostats, Sensors, Building Management System (BMS), Recent Trends – Solar-Assisted Air Conditioning, Radiant Cooling, Smart HVAC.

REFERENCES:
1. Dossat, Roy J. and Horan, Thomas J., Principles of Refrigeration, 5th Edition, Prentice Hall, 2001.
2. Arora, R.C., Refrigeration & Air Conditioning, PHI, 2010.
3. R.S. Khurmi, J.K. Gupta, Refrigeration and Air Conditioning, 1st Revised and Updated Edition 2006, S. Chand & Company Ltd.
4. Gosney W.B., Principles of Refrigeration, Cambridge University Press, 1982.
5. Threlkeld, J.L., Thermal Environmental Engineering, Prentice Hall, 1962.
6. ISHRAE Handbook – Applications in HVAC (Indian Society of Heating, Refrigerating and Air Conditioning Engineers)
7. W.F. Stoecker & J.W. Jones – Refrigeration and Air Conditioning (McGraw Hill)

M.Tech. (II Sem.) 25TE21–ENERGY STORAGE TECHNOLOGIES

L	T	P	Cr.
3	-	-	3

Pre-requisites: Thermodynamics, Fluid Mechanics, Heat Transfer

COURSE EDUCATIONAL OBJECTIVE(CEO): To impart the knowledge on various types of energy storage systems, salient features, construction, operation and applications of storage systems in diverse fields of engineering.

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

CO1: Understand the fundamentals of energy storage system and its components. (Understanding - L2)
CO2: Comprehend the prospects of chemical energy storage systems(Understanding - L2)
CO3: Demonstrate the importance of electromagnetic energy storage systems (Understanding - L2)
CO4: Understand the significance of electrochemical energy storage systems(Understanding - L2)
CO5: Simple design and optimization of battery packs(Apply – L3)

UNIT I:
ENERGY STORAGE SYSTEMS OVERVIEW: Scope of energy storage, needs and opportunities in energy storage, Technology overview and key disciplines, comparison of time scale of storages and applications, Energy storage in the power and transportation sectors. Importance of energy storage systems in electric vehicles, Current electric vehicle market. Thermal storage system-heat pumps, hot water storage tank, solar thermal collector, application of phase change materials for heat storage-organic and inorganic materials, efficiencies, and economic evaluation of thermal energy storage systems.

UNIT II:
CHEMICAL STORAGE SYSTEM: Hydrogen, methane etc., concept of chemical storage of solar energy, application of chemical energy storage system, advantages and limitations of chemical energy storage, challenges, and future prospects of chemical storage systems.

UNIT III:
ELECTROMAGNETIC STORAGE SYSTEMS: Double layer capacitors with electro-statically charge storage, superconducting magnetic energy storage (SMES), concepts, advantages and limitations of electromagnetic energy storage systems, and future prospects of electrochemical storage systems.

UNIT IV:
ELECTROCHEMICAL STORAGE SYSTEMS : Batteries-Working principle of battery, primary and secondary (flow) batteries, battery performance evaluation methods, major battery chemistries and their voltages- Li-ion battery& Metal hydride battery vs lead-acid battery. Supercapacitors- Working principle of supercapacitor, types of supercapacitors, cycling and performance characteristics, difference between battery and supercapacitors, Introduction to Hybrid electrochemical supercapacitors Fuel cell: Operational principle of a fuel cell, types of fuel cells, hybrid fuel cell-battery systems, hybrid fuel cell-supercapacitor systems.

UNIT V:
BATTERY DESIGN FOR TRANSPORTATION: Mechanical Design and Packaging of Battery Packs for Electric Vehicles, Advanced Battery-Assisted Quick Charger for Electric Vehicles, Charging Optimization Methods for Lithium-Ion Batteries, Thermal run-away for battery systems, Thermal management of battery systems, State of Charge and State of Health Estimation Over the Battery Lifespan, Recycling of Batteries from Electric Vehicles.

REFERENCES:
1.Frank S. Barnes and Jonah G. Levine, Large Energy Storage Systems Handbook (Mechanical and Aerospace Engineering Series), CRC press (2011)
2. Ralph Zito, Energy storage: A new approach, Wiley (2010)
3. Pistoia, Gianfranco, and Boryann Liaw. Behaviour of Lithium-Ion Batteries in Electric Vehicles: Battery Health, Performance, Safety, and Cost. Springer International Publishing AG, 2018.
4. Robert A. Huggins, Energy storage, Springer Science & Business Media (2010)

M.Tech. (II Sem.) **25TE22–THERMAL MANAGEMENT OF EV BATTERY AND FUEL CELL SYSTEMS**

L	T	P	Cr.
3	-	-	3

Pre-requisites: Thermodynamics, Fluid Mechanics, Heat Transfer

COURSE EDUCATIONAL OBJECTIVE(CEO): To impart the knowledge on various aspects of thermal management of EV battery systems salient features, construction, operation and methodologies.

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

CO1: Understand the fundamentals of electric vehicles, battery management systems, and fuel cells. (Understanding - L2)
CO2: Demonstrate the heat transfer principles to analyze and manage battery systems (Understanding - L2)
CO3: Understand the critical role of heat transfer in the successful functioning of fuel cells(Understanding - L2)
CO4: Understand different measurements for battery applications (Understanding - L2)
CO5: Design and implement effective thermal management strategies for modern applications involving batteries and fuel cells (Apply – L3)

UNIT-I:
INTRODUCTION TO BATTERY MANAGEMENT SYSTEMS AND DEVICES- Fuel Cells & Batteries, Nominal voltage and capacity, Energy and power.
BATTERY CELLS: Electrochemical and lithium-ion cells, Rechargeable cell, Charging and Discharging Process, Overcharge and Undercharge, Lithium-ion aging: Negative electrode, Lithium-ionaging:Positiveelectrode,CellBalancing,TemperatureSensing,CurrentSensing,BMS Functionality, High-voltage contactor control, Isolation sensing, Thermal control, Protection, Communication Interface, Range estimation, State-of charge estimation.

UNIT-II:
INTRODUCTION – WORKING AND TYPES OF FUEL CELL – low, medium and high temperature fuel cell, liquid and methanol types, proton exchange membrane fuel cell solid oxide, hydrogen fuel cells – thermodynamics and electrochemical kinetics of fuel cells.
BASIC CONVECTIVE HEAT TRANSFER AND FLUID FLOW- The fundamental of BTMS: Liquid cooling and Air cooling, Thermoelectric cooling, Heat Transfer Fluids in phase change materials, Heat Pipe (HP), Vapor compression, Direct refrigerant cooling Electric Motor Cooling.

UNIT-III:
HEAT DISSIPATIONS: Dependence on cold plate's channel's pattern, Heat dissipations dependence on the cold plate's number of channels and their shape, Heat dissipations dependence on the placement of the cooling plate.

UNIT-IV:
PHEV AND BEV BATTERY SYSTEMS: Thermal Conductivity Measurements for EV Battery Applications, Battery State Estimation. EV Battery Cooling- challenges and solutions. Heat Exchanger Design and Optimization Model for EV Batteries using PCMs-system set up, selection of PCMs. Chevrolet Volt Model Battery, Thermal Management System - Case study. Modeling Liquid Cooling of a Li-Ion Battery Pack with software- simulation concepts.
UNIT-V:
FUEL CELL SYSTEM: Balance of plant-components required. Fuel cell power plant sizing problems-Fuel Cell Electric Vehicle, Fuel economy calculations-Battery EVs Vs Fuel Cell EVs, High pressure hydrogen tank, Boost convertor, NiMH Battery, Internal circulation system, Case studies-Battery and fuel cells, Challenges and Risks.

REFERENCES:

1. Dinçer,I.,Hamut,H.S.andJavani,N., Thermal Management of Electric Vehicle Battery Systems, Wiley Network, 2017.
2. HartA.B.and WomackG.J.,"Fuel Cells–Theory and Applications", Chapman and Hall,1967.
3 Andrea,D.,Battery Management Systems for Large Lithium-Ion Battery Packs,Artech,2010.
4 SöffkerD.,and Moulik,B.,Battery Management System for Future Electric,MdpiAG,2020.
5 LindenD.,andReddy,T.S.,HandbookofBatteries,3rd Edition,McGraw-Hill,2002.
6 Kiehne,H.A.,BatteryTechnologyHand book,Marcel Dekker,NYC,2003.
7 NazriG.A., and Pistoa G.,Lithium Batteries, Science and Technology, Kluwer Academic Publisher, 2003.
8 Husain,I.,ElectricandHybridVehicles,Design:Fundamentals,3rdEdition,CRCpress,2021.
9 Jiang,J.,andZhang,C.,FundamentalsandApplicationsofLithium-IonBatteriesinElectric Drive Vehicles, John Wiley & Sons, 2015.
10.Revankar,S.T.,andMajumdar,P.,FuelCells:Principles,Design,andAnalysis,CRCpress, 2014.
Sammes,N.ed.,FuelCellTechnology:ReachingTowardsCommercialization,SpringerScience & Business Media, 2006

M.Tech. (II Sem.) **25TE53–RENEWABL ENERGY TECHNOLOGIES LABORATORY COURSE**

L	T	P	Cr.
-	1	2	2

Pre-requisites : Renewable Energy Sources

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

COURSE OUTCOMES(COs): After the completion of the course, students should be able to
CO1 Discuss the principles of renewable energy conversion techniques.(Understanding-L2)
CO2 Estimate the performance characteristics of renewable energy devices. (Apply - L3)
CO3 Estimate the performance of renewable energy devices. (Apply - L3)
CO4 Comprehend the performance parameters of the renewable energy devices. (Understanding - L2)

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

L	T	P	Cr.
-	1	2	2

M.Tech. (II Sem.) 25TE54–COMPUTATIONAL FLUID DYNAMICS LABORATORY COURSE

Pre-requisites: Computational Fluid Dynamics

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

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

CO1: Develop codes for numerical methods to tackle simple problems. (Apply - L3)
CO2: Build up the skills in the actual implementation of CFD methods for 1D and 2D heat conduction problems (Apply - L3)
CO3: Analyze and validate output of written codes with analytical solution. (Analyze - L4)
CO4: Develop skill in CFD analysis to real engineering designs. (Analyze - L4)

LIST OF EXPERIMENTS

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

M.Tech. (II Sem.) **25PI02–SEMINAR-II**

L	T	P	Cr.
-	-	2	1

Pre-requisites : Nil

COURSE EDUCATIONAL OBJECTIVE(CEO): To improve the presentation skills of the students

COURSEOUTCOMES(COs): After the completion of the course, students should be able

CO1 Identify a topic of his choice in the area of thermal engineering

CO2 Prepare the slides minimum 10-15 slides on the selected topic

CO3 Present the PPT in front of the panel members with confidence

CO4 Make corrections in the PPT or presentation style, time management and confidence levels

R25-Regulation(w.e.f A.Y.2025-26)

M.Tech-Thermal Power Engineering

Detailed Syllabus
(Third Semester)

M.Tech. (III Sem.) **25RM01–RESEARCH METHODOLOGY AND IPR**

L	T	P	Cr.
3	-	-	3

Pre-requisites: Nil

COURSE OBJECTIVES (CEOs): To understand the knowledge on basics of research and its types. • To impart the concept of Literature Review, Technical Reading, Attributions and Citations. • To know the Ethics in Engineering Research. • To know the concepts of Intellectual Property Rights in Engineering.

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

CO1 Explain the meaning of engineering research and apply to develop an appropriate framework for research studies. CO2 Identify the procedure of Literature Review, Technical Reading, etc. and apply to develop a research design during their project work.
CO3 Explain and apply the fundamentals of patent laws and drafting procedure in their research works.
CO4 Demonstrate the copyright laws, subject matters of copyrights, designs etc. to apply in patent filing.
CO5 Identify the new developments in IPR and employ the applications of computer software in writing/filing patents in Future.

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

UNIT-II: Effective literature studies approaches, analysis Plagiarism, Research ethics, 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: 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: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

UNIT – V: New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR.

TEXT BOOKS:
1. C.R. Kothari , 2nd Edition, "Research Methodology: Methods and Techniques".
2. Ranjit Kumar, 2nd Edition, "Research Methodology: A Step-by-Step Guide for beginners"

REFERENCE BOOKS:
1. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students.
2. Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction".
3. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.
4. Mayall, "Industrial Design", McGraw Hill, 1992.
5. Niebel, "Product Design", McGraw Hill, 1974.
6. 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

WEB REFERENCES: Please include hyperlinks related to NPTEL/VLabs etc.

M.Tech. (III Sem.) 25PI03–SUMMER INTERNSHIP/INDUSTRIAL TRAINING

L	T	P	Cr.
-	-	-	3

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

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

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

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

M.Tech. (III Sem.) **25PI04–COMPREHENCIVE VIVA**

L	T	P	Cr.
-	-	-	2

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

COURSE EDUCATIONAL OBJECTIVES(CEOs): To test student knowledge in the courses studied in First and second Semesters.

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

CO1 Face the interviews and answer questions confidently
CO2 Gain thorough knowledge in the theory concepts
CO3 Develop the intellectual ability to interpret the technical data independently
CO4 Ability to develop the well organized interpersonal skills

M.Tech. (III Sem.) **25PI05– DISSERTATION PART-A**

L	T	P	Cr.
-	-	20	10

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

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

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

CO1 Identify a topic in advanced areas of thermal engineering

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

CO3 Employ the ideas from literature and develop research methodology

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

R25-Regulations(w.e.f A.Y.2025-26)

M.Tech-Thermal Power Engineering

Detailed Syllabus
(Fourth Semester)

		L	T	P	Cr.
M.Tech. (IV Sem.)	**25PI06– DISSERTATION PART-B**	-	-	32	16

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

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

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

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

CO2 Reorganizetheprocedureswithaconcernforsociety,environmentandethics

CO3 Analyze and discuss the results to draw valid conclusions

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

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