

M.E (Thermal Engineering)

Program Educational Objectives

- ☞ Provide a sound and in-depth knowledge and training in various aspects of design, manufacture, testing, control and evaluation of Thermal Equipments and Systems.
- ☞ Develop the ability to synthesize data, interpret them appropriately and be able to apply concepts to Thermal system design or to a Thermal subsystem of an interdisciplinary system.
- ☞ Broaden and deepen their capabilities in analytical and experimental research methods, analysis of data, and drawing relevant conclusions for scholarly writing and presentation.
- ☞ Provide guidance to students for their choices in research and professional carrier outlook and to encourage students to take up research.

Program Outcomes

The students of Master of Engineering in Thermal Engineering will have the ability to

- ☞ The students of Master of Engineering in Thermal Engineering will have the ability to:
 - ☞ Acquire fundamental knowledge and understanding of Thermal Engineering.
 - ☞ Acquire abilities to identify, formulate and solve mechanical engineering related problems.
 - ☞ Formulate relevant research problems, conduct experimental and /or analytical work and analyze results using modern mathematical and scientific methods.
 - ☞ Design and validate technological solutions to defined problems and write clearly and effectively, for the practical utilization of work.
 - ☞ Review and document the knowledge developed by predecessor and critically assess the relevant technological issues.

SCHEME OF COURSES FOR ME (THERMAL ENGINEERING)

First Semester

S. No.	Course No.	Course Name	L	T	P	Cr
1	PTH101	Advanced Thermodynamics	3	1	0	3.5
2	PTH103	Internal Combustion Engines	3	1	2	4.5
3	PTH104	Advanced Fluid Mechanics	3	1	0	3.5
4	PTH202	Refrigeration and Air Conditioning System Design	3	1	2	4.5
5	PCL105	Statistical Methods and Algorithms	3	0	2	4.0
TOTAL			15	4	6	20.0

Second Semester

S. No.	Course No.	Course Name	L	T	P	Cr
1	PTH102	Advanced Heat Transfer	3	1	0	3.5
2	PTH201	Advanced Power Plant Engineering and Industrial Utility	3	1	0	3.5
3	PTHXXX	Applied Solar Energy	3	1	0	3.5
4	PTH212	Fuels and Combustion	3	1	0	3.5
5		Elective-I*	3	2/0	0/2	4.0
6	PTH291	Seminar	-	-	-	2.0
TOTAL			15	4/6	2/0	20.0

Third Semester

S. No.	Course No.	Course Name	L	T	P	Cr
1	PCD312	Computational Fluid Dynamics	3	0	2	4.0
2		Elective-II	3	1	0	3.5
3	PTH392	Minor Project				4.0
4	PTH 491	Dissertation starts				
TOTAL			6	1	2	11.5

Fourth Semester

S. No.	Course No.	Course Name	L	T	P	Cr
1	PTH491	Dissertation	-	-	-	12
TOTAL						12
<u>ELECTIVE-I</u>						
S. No.	Course No.	Course Name	L	T	P	Cr
1	PTH321	Hydrodynamic Machines	3	2	0	4.0
2	PTH213	Design of Compressors and Gas Turbines	3	2	0	4.0
3	PCD107	Finite Element Methods	3	0	2	4.0
<u>ELECTIVE-II</u>						
1	PTH211	Boundary Layer Theory	3	1	0	3.5
2	PTH203	Thermal Systems Modeling and Analysis	3	1	0	3.5
3	PTH323	Two-Phase Flow and Heat Transfer	3	1	0	3.5

Total Number of Credits: 63.5

PTH101: ADVANCED THERMODYNAMICS				
	L	T	P	Cr
	3	1	0	3.5
<p>Course objective: To impart knowledge on the principles of energy quality and the significance of the same for industrial and domestic applications of thermal systems. To impart knowledge on the real gas behaviour and the application of statistical thermodynamics towards understanding the same. To impart knowledge on different thermodynamic property relations and their applications.</p>				
<p>Exergy Analysis: Concept of exergy, energy analysis for open and closed systems with fixed and moving boundaries, dead state and irreversibility, exergy loss due to mixing of fluids, second law efficiency, exergy analysis for power and refrigerating cycles.</p> <p>Real Gases: Assumptions of real gases, equations of state for real gases, compressibility factor, compressibility chart, reduced pressure and temperature, pressure and energy equations using kinetic theory, RMS velocity, equi-partition of energy, mean free path, Maxwell distribution function.</p> <p>Thermodynamic Property Relations: Maxwell relations, Clapeyron equation, Clapeyron-Clausius equation, Mayer equation, thermodynamic potentials, residual property functions, Helmholtz and Gibbs functions, Tds equations, Fugacity of gases, thermodynamic properties of homogeneous mixtures, partial molal properties.</p> <p>Reacting Systems and Chemical Equilibrium: Chemical systems, enthalpy of reaction, combustion and formation, Ist and IInd law analysis of reacting systems, adiabatic flame temperature, fuel cells – types and applications, criteria for chemical equilibrium, Henry and Rault's law, Gibbs phase rule, Hess's law.</p> <p>Research Assignment: Students in a group of 4/5 will submit a typed project report on exergy analysis of industrial systems (thermal power plants/refinery/chemical/paper plants etc). The work/report will constitute collection of literature from library, plant visit and formulation, analysis of the problem and recommendation. Each group will deliver a presentation.</p>				
<p>Course learning outcome (CLO): The students will be able to:</p> <ul style="list-style-type: none"> • apply theoretical principles of energy analysis, thermodynamic property relations and reactive systems. • analyze on the approaches of micro or statistical thermodynamics. • evaluate the thermodynamic processes used in different industries. • perform case-study based evaluation prepare and present technical report. 				

Recommended Books:	
1.	<i>Bejan, A., Advanced Engineering Thermodynamics, John Wiley and Sons (2006) 3rd ed.</i>
2.	<i>Wark K., Advanced Thermodynamics for Engineers, McGraw Hill (1994).</i>
3.	<i>Bevan, O.J. & Juliana, B.J., Chemical Thermodynamics: Principles and Applications, Elsevierr (2005).</i>
4.	<i>Winterbone, D. & Turan, A., Advanced Thermodynamics for Engineers, Butterworth Heinemann (2015) 2nd ed.</i>

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Micro-Projects/Lab Evaluations)	25

PTH103: INTERNAL COMBUSTION ENGINES				
	L	T	P	Cr
	3	1	2	4.5
<p>Course objective: The students will learn to classify different types of internal combustion engines and their applications. Students will be exposed to fuel air cycles, combustion charts, two stroke engines. The students will study fuel supply systems in SI and CI engines, dual fuel and multi fuel engines, alternative fuels. Detailed study will be done on recent trends in IC engines, emission control strategies.</p>				
<p>Introduction: Preliminary analysis, cylinder number, size and arrangement, constructional details, thermodynamic properties of fuel-air mixture before and after combustion, deviations of actual cycle from ideal conditions, analysis using combustion charts, two stroke engine scavenging.</p> <p>Fuel Supply Systems: S.I. engines: carburetion multi-jet, Carter, Zenith, Solex carburetors, MPFI, combustion, Ignition systems Gasoline injection, EFI system, MPFI system, electronic control system, injection timing, C.I. engines: in-line injection, rotary injection, electronic diesel injection system and control.</p> <p>Recent Trends in I.C. Engines: Dual-fuel engines, multi-fuel engines, stratified charge engine, Sterling engine, variable compression ratio engine, bench marking, combustion chamber design in SI and CI engines, swirl & inlet ports design, DI models, combustion chambers in S.I. engines, Supercharging, turbo-charging & matching of turbo-charging, friction and lubrication, Performance.</p> <p>Alternate Fuels for IC Engines: Liquid alternative fuels, advantages, potential, problems associated with utilization, vegetable oils, bio-diesel, emulsified fuels, effect on lubricating oils, gaseous alternative fuels, hydrogen, compressed natural gas, liquefied petroleum gas, di-methyl ether, multi-fuel engines.</p> <p>Engine Emissions & Control: Air pollution due to IC engines, norms, engine emissions, HC, CO, NOx particulates, other emissions, Emission control methods, exhaust gas recirculation, modern methods.</p> <p>Simulation Technique: Application of simulation techniques for engine tuning, engine selection parameters,</p> <p>laboratory work: Performance characteristics of CRDI engine, variable compression ratio diesel engine, dual fuel engine, Kirloskar four stroke engine, Ruston diesel engine, two stroke petrol engine</p> <p>Minor Project: Preparation of Diesel emulsion with nanoparticles, biofuel and check for thermo physical, chemical properties of fuel and emission characteristics at various loads. Case studies of spark ignition and compression ignition engines and new technologies involve in fuel supply systems. Waste heat recovery in IC engines</p>				
<p>Course learning outcome (CLO): The students will be able to</p> <ul style="list-style-type: none"> analyse the engine thermodynamic characteristics using fuel air cycles and combustion 				

- charts.
- evaluate and analyse the parameters in the engine for issues of power generation, emissions and environmental impact, fuel economy.
 - analyse the effects of fuel composition on engine operation and mechanical limitations for ideal performance.
 - analyse the air induction and fuel supply processes for both SI and CI engines.
 - analyse the effect of spark timing, valve timing and lift , cylinder dimensions, compression ratio, combustion chamber design shape.

Recommended Books:

1.	<i>Heywood, J.B., Internal Combustion Engine Fundamentals, McGraw Hill (1988).</i>
2	<i>Stone, R., Introduction to Internal Combustion Engines, MacMillan (1999) 3rd ed</i>
3.	<i>Pulkrabek, W., Engineering Fundamentals of the Internal Combustion Engine, Prentice Hall (2007) 2nd ed.</i>
4.	<i>Ferguson Colin R. and Kirkpatrick, Allan T. Internal Combustion Engines: Applied Thermal Sciences, John Wiley and Sons, NY, 2000. 2nd ed</i>
5.	<i>Taylor, C.F., The Internal Combustion Engine in Theory and Practice, The MIT Press (1985) 2nd ed.</i>
6.	<i>Heisler, H., Advance Engine Technology, ButterWorthHienemann, USA (2000)</i>

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	25
2.	EST	35
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	40

PTH 104 : ADVANCED FLUID MECHANICS				
	L	T	P	Cr
	3	1	0	3.5
<p>Course Objective: To impart knowledge of boundary layer flows, governing equations of fluid flow for different flow regimes, different geometries under the effect of various boundary conditions. Also to get familiar with turbulent flows and its models.</p>				
<p>Governing Equations of Fluid Motion: Navier stokes equations, boundary layer equations, exact solutions of N -S equations, flow between concentric rotating cylinders</p>				
<p>Potential Theory: Kelvin's theorem, source, sink, vortex and doublet, development of complex potentials by super position, singularities – plane flow past bodies – Dirchlet theorem, conformal transformation thin aerofoil theory</p>				
<p>Laminar Boundary Layers: Blasius solution, boundary layers with non-zero pressure gradient, separation and vortex shedding</p>				
<p>Turbulent Flow: Mechanism of turbulence, derivation of governing equations for turbulent flow, K-E model of turbulence, universal velocity distribution law and friction factor, kinetic energy of the mean flow and fluctuations</p>				
<p>Research Assignment: Students in a group (3-5 students) will submit a project report on the computational techniques in fluid mechanics/ turbulence modelling/ practical applications in fluid flow. The report may be written by collection of literature from library, plant visit and formulation, analysis of the problem and recommendation. Each group will deliver a presentation.</p>				
<p>Course Learning Outcomes (CLO): The students will be able to</p> <ul style="list-style-type: none"> • solve the boundary layer equations for laminar flows • obtain the exact solutions to N-S equations for different geometries • solve the equations for turbulent flow and its models • apply the numerical techniques for fluid flow problems 				
<p>Recommended Books:</p>				
1.	<i>Schlichting, H., Boundary layer Thoery, Mc Graw Hill, (1987), 8th Ed.</i>			
2.	<i>Hinze, Jo., Turbulence, McGraw Hill, (1975).</i>			
3.	<i>Anderson D. A., Tannhill, I.C., and Pletcher, R.H., Computational Fluid Mechanics and Heat Transfer, Hemisphere Publication, (1984).</i>			
4.	<i>Fox, R. W. and McDonald, A. T., Introduction to fluid Mechanics, John, Wiley & Sons, (1985).</i>			
5.	<i>Tennekes, H. and Lumley, J. L., A First Course in Turbulence, M.I.T. Press, (1972).</i>			
6.	<i>Streeter, V.L. and Wylie, E.B., Fluid Mechanics, McGraw Hill, (1979).</i>			
<p>Evaluation Scheme:</p>				
S.No.	Evaluation Elements	Weightage (%)		
1.	MST	30		
2.	EST	45		
3.	Sessionals (assignments/projects/presentations tutorials/quizes/lab evaluations)	25		

PTH202 REFRIGERATION AND AIR CONDITIONING SYSTEM DESIGN				
	L	T	P	Cr
	3	1	2	4.5
<p>Course Objectives: To impart knowledge about principles of producing low temperatures by using multi-pressure systems and cascade systems. To provide concepts about designing, installation and servicing of air conditioning systems in residential, commercial and industrial buildings. To educate about various system components and accessories of refrigeration and air-conditioning systems.</p>				
<p>Refrigerants: Classification of refrigerants, refrigerant properties, secondary refrigerants, ozone depletion potential and global warming potential of CFC refrigerants, eco-friendly refrigerants, azeotropic and zeotropic refrigerants.</p> <p>Vapour Compression System: Multiple evaporator and compressor systems, cascade systems, manufacture of solid carbon oxide (Dry Ice).</p> <p>System Components and Accessories: Types of evaporators, compressors, condensers, expansion devices, driers/ filters, receiver, accumulator, functional aspects of the above components & accessories, System equilibrium and cycling controls, capacity control in compressors.</p> <p>Vapor Absorption System: Aqua ammonia & Li-Br systems, temperature-concentration diagram and enthalpy-concentration diagram for binary mixtures, thermodynamic analysis of aqua ammonia & Li-Br systems using enthalpy-concentration charts.</p> <p>Steam Jet Refrigeration System: Principle and working of steam jet refrigeration system, performance analysis of steam jet refrigeration system.</p> <p>Air Conditioning: Applied psychrometry, psychometric processes using chart.</p> <p>Ventilation and Infiltration: Requirement of ventilation air, various sources of infiltration air, ventilation and infiltration as a part of cooling load.</p> <p>Load Estimation: Inside and outside design conditions, study of various sources of the internal and external heat gains, heat losses, equivalent temperature difference method for heat load calculations, RSHE, GSHE, ESHE, etc.</p> <p>Air Distribution: Fundamentals of air flow in ducts, pressure drop calculations, design of ducts by velocity reduction method, equal friction method and static regain method, duct materials and properties, insulating materials, types of grills, diffusers.</p> <p>Minor Project: Students in a group of 4/5 will submit a research minor project on non-conventional refrigeration methods such as solar refrigeration, thermo-electric refrigeration, vortex tube refrigeration and magnetic cooling.</p> <p>Laboratory Work: Study of actual and theoretical COP of Cascade Refrigeration System, Rail Coach Unit, Ice plant tutor, Air Conditioning System, Absorption System, Study the Performance of Evaporative Condenser.</p>				
<p>Course Learning Outcomes (CLO):</p> <p>The students will be able to</p> <ul style="list-style-type: none"> analyse, evaluate and compare the performances of complex vapor compression systems. 				

- perform thermodynamic analysis of absorption refrigeration systems and steam jet refrigeration system.
- Evaluate the various sources of heat load on buildings and perform a heat load estimate.
- Design summer and winter air conditioning systems.
- Design ducts for central air condition systems

Recommended Books

1.	<i>Dossat, R.J., Principles of refrigeration, Dorling Kingsley (2008).</i>
2.	<i>Stoecker, W. F., Refrigeration and Air conditioning, McGraw Hill (1986).</i>
3.	<i>Goshnay, W.B., Principles and Refrigeration, Cambridge University Press (1982).</i>
4.	<i>Langley, B. C., Solid State Electronic Controls for HVACR, Prentice Hall (1989).</i>
5.	<i>Arora, S. C. and Domkundwar, S., A Course in Refrigeration and Air Conditioning, DhanpatRai (1997).</i>

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	25
2.	EST	35
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	40

PTH102: ADVANCED HEAT TRANSFER				
	L	T	P	Cr
	3	1	0	3.5
<p>Course Objective: To get familiar and understand the modes of heat transfer and heat transfer mechanisms. Write the appropriate equations, correlation for the different modes of heat transfer. To understand the analogy between fluid mechanics and heat transfer along with heat transfer during phase change. To learn some of the computational techniques to find out the solutions to the problems.</p>				
<p>Conduction: General conduction equations, boundary & initial conditions, radial fins & fin optimization, multidimensional heat conduction, transient heat conduction,</p> <p>Convection: Forced convection, velocity and thermal boundary layers, laminar and turbulent flow, boundary layer approximations, convection transfer equations, dimensionless parameters, empirical correlations, free convection, empirical correlations for external free convection flows for various geometries and orientations, heat pipes, nanofluids and their applications.</p> <p>Boiling and Condensation: Pool boiling, correlations, forced convection boiling, two phase flow, laminar film condensation on a vertical plate, turbulent film condensation, film condensation in horizontal tubes, drop wise condensation correlations</p> <p>Thermal Radiation: Thermal radiations and associated laws, radiation exchange between surfaces, view factor, network method, reradiating surfaces. Multimode heat transfer, gaseous emission and absorption.</p> <p>Research Assignment: Students in a group (3-5 students) will submit a project report on the case studies related to heat transfer problems. The report may be written by collection of literature from library, plant visit and formulation, analysis of the problem and recommendation. Each group will deliver a presentation.</p> <p>Course Learning Outcomes (CLO): The students will be able to</p> <ul style="list-style-type: none"> • develop the conduction equations for multi-dimensional heat transfer problems like; cylinder, sphere, rectangular pipe etc • develop the correlations for convection heat transfer problems • develop and learn the computational techniques for the heat transfer problems • develop and test new heat transfer fluids like; nanofluids 				

Recommended Books:

1.	<i>Frank P. Incropera, David P. Dewitt- Fundamental of Heat and Mass Transfer, Wiley India (2002) 6th Ed.</i>
2.	<i>Adrian Bejan-Convection Heat Transfer, Wiley India (2003)3rd Ed.</i>
3.	<i>Sadik, K. and Yaman, Y., Convective Heat Transfer, CRC Press (1995) 2nd ed.</i>
4.	<i>Kays, W.M. and Crawford, Convective Heat and Mass Transfer, McGraw Hill (2005).</i>
5.	<i>Brewster, M.Q., Thermal Radiative Transfer and Properties, John Wiley (2006).</i>
6.	<i>Holman, J.P., Heat Transfer, McGraw Hill (2007.)</i>

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1	MST	30
2	EST	45
3	Sessionals (assignments/projects/presentations tutorials/quizes/lab evaluations)	25

**PTH201: ADVANCED POWER PLANT ENGINEERING
AND INDUSTRIAL UTILITY**

	L	T	P	Cr
	3	1	0	3.5

Course objective: To impart knowledge on the principle of operation, layouts, components, construction, codes and standards, selection criteria and maintenance and troubleshooting of different types of power plants and industrial utility systems.

Introduction: energy sources for generation of electric power, types of power plant-their special features and applications, present status and future trends of energy resources, overview of utility systems, project implementation stages.

Coal Fired Thermal Power Plant: site selection, plant layout, steam generators, pulverizers and coal feeding, mill rejects, combustion in furnace, coal handling, ash handling, electrostatic precipitators and bag filters, water systems, condensers, cooling towers.

Nuclear Power Plant: Nuclear fuels, Nuclear energy, main components of nuclear power plants, nuclear reactors-types and applications, radiation shielding, radio-active waste disposal, safety aspects.

Recent Advancement in Thermal Power Systems: Fluidized Bed Combustion, CFBC, Environmental benefits, IGCC

Energy Economics: Load curves, effect of load on power plant design, methods to meet variable load, load prediction, cost of energy, system optimization, depreciation, tariff methods.

Hydroelectric Power Plant: Hydroelectric survey, precipitation, run-off, hydrograph, flow duration curve, mass curve, reservoirs and dams and their different types and constructions,

Materials Handling: Belt, chain, metallic, pneumatic and slurry conveying, hoppers and silos, feeders.

Turbo Machines: Compressors, pumps and fan systems used in power plants, design and selection of components and systems, operating and system characteristics of dynamic machines, conventional and high concentration slurry pumps.

Piping, Valves, Control and Instrumentation: Various specifications in the industry, stresses in pipes and thickness calculation criteria, pipe supports, various types of valves and application purpose of each type of valve, fittings and other pipe mounted instruments, overview of control systems.

Fire Protection Systems: Recommended codes and standards, fire hydrant system, HV water spray system, NV water spray system, Foam system,

Research Assignment (s):

Students in a group of 4/5 will submit a typed project report on deliver a presentation on the design of

pipng system for boilers, selection of pumps and compressors and designing of systems, belt, pneumatic, slurry conveying design and piping system design. The work will include literature review, site visit (if necessary), designing using information provided in codes/standards, manufacturers' catalogues etc.

Course learning outcome (CLO):

The students will be able to:

- apply the latest practices of power plant and industrial utility systems towards designing systems;
- evaluate the operation and troubleshooting requirements and solutions to plants
- perform design calculations to find important process/system and equipment parameters.
- apply the guidelines of codes, standards and catalogs to design systems/select equipment's
- select system components and present technical reports

Recommended Books:

1.	<i>Nag, P.K., Power Plant Engineering, McGraw-Hill (2007) 3rd ed.</i>
2.	<i>Raja, A.K., Srivastava, A.P. & Dwivedi, M., Power Plant Engineering, New Age Int. (2006) 1st ed.</i>
3.	<i>Elanchezhian, C., Saravankumar, L., Ramnath, B. V., Power Plant Engineering, I-K Int. (2007) 1st ed.</i>
4.	<i>Elliot, T.C., Chen, K., Swanekamp, R., Stanadard Handbook of Power Plant Engineering, McGrawhill Education (1998) 1st ed.</i>

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Micro-Projects/Lab Evaluations)	25

PTH-XXX APPLIED SOLAR ENERGY

L T P Cr
3 1 0 3.5

Course Objectives: To introduce the fundamental concepts of solar energy and radiation measuring instruments. To impart knowledge of solar energy with respect to its availability, utilization, collection and storage. To educate about how to utilize solar energy to achieve the sustainable energy systems. To introduce various types of solar energy collecting devices and their performance analysis.

Solar Radiation: Solar constant, solar angles and basic definitions, extraterrestrial and terrestrial solar radiation, solar time, local standard time, equation of time.

Solar Radiation Measurement and Estimation: Measurement of solar radiation using pyranometer and pyrliometer, sunshine recorder, atmospheric attenuation of solar radiation, estimation of average solar radiation using empirical equations.

Radiation Transmission through Glazing: Reflection and absorption by glazing, optical properties of glass cover system, transmittance for diffuse radiation, transmittance-absorptance product, effects of surface layers on transmittance.

Flat Plate Collectors: Description of flat plate collectors, liquid heating collectors, air heating collectors, collector overall heat loss coefficient, collector efficiency factor, collector heat removal factor, flow factor, thermal and thermohydraulic performance of flat plate collector.

Concentrating Collectors: Types of concentrating collectors, geometry of concentrating collectors, concentration ratio, thermal performance of concentrating collectors.

Evacuated Tube Collector (ETC): Description and working principle of ETC systems. construction details of ETC, selection and installation of ETC systems, performance parameter tests of ETC systems.

Solar Still: Basics of solar still and solar distillation, types of solar stills, single effect and multiple effect solar stills, design of solar still, heat and mass transfer analysis for basin type solar still.

Solar Energy Storage: Packed bed storage, phase change energy storage, chemical energy storage, solar ponds.

Research Assignment: Students in a group of 4/5 will submit a research assignment on the topics such as industrial process heating, desalination, solar pumps and solar refrigeration.

Research assignment will constitute collection of literature from library/internet, visit to solar parks and

formulation and analysis of the problem. (10% weightage of total marks shall be given to this assignment).

Course Learning outcomes (CLO):

The students will be able to

- Estimate the terrestrial solar radiation on an arbitrary tilted surface.
- Use flat plate solar collector mathematical model to calculate the efficiency and performance parameters of the same.
- Determine the useful gain and thermal efficiency of concentrating collectors.
- Explain the selection and installation of evacuated tube collector systems.
- Perform heat and mass transfer analysis for simple solar still.

Recommended Books

1. Duffie, J.A. and Beckmann, W.A., *Solar Engineering of Thermal Processes*, John Wiley & Sons (2006), 3rd ed.
2. Goswami, D.Y., Kreith, F. and Kreider J., *Principles of Solar Energy*, Taylor & Francis (2003), 2nd ed.
3. Kalogirou, A.S., *Solar Energy Engineering: Processes and Systems*, Academic Press Inc. (2014), 2nd ed.
4. Sukhatma, S and Nayak, J., *Solar Energy Principle of Thermal Collection and Storage*, McGraw-Hill (2009), 3rd ed.
5. Garg, H.P. and Prakash, J., *Solar Energy: Fundamentals and Applications*, Tata McGraw Hill (2000), 1st ed.

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes)	25

PTH212: FUELS AND COMBUSTION				
	L	T	P	Cr
	3	1	0	3.5
<p>Course objective: The learner will be exposed to various types of fuels e.g. solid, liquid and gaseous fuels, their origin, properties, processing and applications. In addition the learner will be exposed to combustion stoichiometry and thermodynamics, combustion related pollution and control techniques.</p>				
<p>Fuels: Introduction and Classification.</p> <p>Solid Fuels: Coal and its classification, composition of coal, analysis and properties of coal, natural coke, oxidation and hydrogenation of coal, processing of solid fuels: coal preparation, coal storage, coal carbonization and gasification, briquetting, gasification and liquefaction of solid fuels.</p> <p>Liquid Fuels: Petroleum-origin and production, composition and classification of petroleum, processing of petroleum, properties of various petroleum products, petroleum refining, liquid fuels from sources other than petroleum.</p> <p>Gaseous Fuels: Natural Gas, methane from coal mines, producer gas, water gas, coal gas, blast furnace gas, refinery gases, LPG, cleaning and purification of gaseous fuels, biomass gasification.</p> <p>Combustion: Principles of combustion, combustion of oil, coal and gas, combustion equations, stoichiometric fuel air ratio, exhaust and flue gas analysis, practical analysis of combustion products, dissociation, internal energy and enthalpy of reaction, enthalpy of formation, calorific value of fuels, air and fuel-vapour mixtures, heat balance sheet of a boiler, boiler draft, design of chimney.</p> <p>Combustion Related Pollution: Sources and effects - acid rain, smog, greenhouse gases and effect, air sampling and measurement, pollutants: classification, monitoring and control, control equipment viz. (mechanical collectors, wet scrubbers, and ESP)</p> <p>Research Assignment:(i) Investigations of rheological properties of CWS/COS slurry. (ii) Study of performance parameters and emissions of a biomass gasification-dual fuel engine.</p>				
<p>Course learning outcome (CLO): The students will be able to</p> <ul style="list-style-type: none"> • determine and analyse proximate and physical properties of a given fuel sample. • determine and analyse heat balance sheet in a boiler. • design a stack /chimney. 				

<ul style="list-style-type: none"> analyse flue gas samples and determine combustion stoichiometry. determine and analyse properties of liquid and gases fuels.
Recommended Books:
1. <i>Sarkar, S., Fuels and Combustion, Orient Longman (1989) 2nd ed.</i>
2. <i>Eastop, T.D. and McConkey, A., Applied Thermodynamics, Dorling Kingsley (2008).</i>
3. <i>Glassman, I., Combustion, Academic Press (2008).</i>
4. <i>Theodore, L., Air Pollution Control Equipment Calculations, John Wiley (2008).</i>

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	25

PTH211: BOUNDARY LAYER THEORY				
	L	T	P	Cr
	3	1	0	3.5
To impart knowledge on the governing equations of boundary layer flow. To impart knowledge on the Laminar and turbulence flow Boundary Layer Equations.				
<p>Review of Fluid Mechanics: Ideal and real fluids, Concept of boundary layer, Navier—Stokes equation; Limiting cases of large and small Reynolds number, Energy equation.</p> <p>Laminar Boundary Layer Equations: Displacement and momentum thicknesses; General properties of the boundary layer equations, Skin function, Similarity solutions, Wedge flow and its particular cases, Flow past a cylinder; Two dimensional inlet flow in straight channel. Approximate methods, Karman-Pohlhausen method, Numerical methods, Axially symmetrical boundary layer, Circular jet, Body of revolution, Mangler transformations, Boundary layer control, flow over a flat plate with uniform suction.</p> <p>Turbulent Boundary Layer: Prandtl's mixing length theory, Karman's hypothesis; Universal velocity distribution, Flow over a flat plate; Skin friction drag.</p> <p>Thermal Boundary Layer: Convection, Forced flow over flat plate at zero incidences, Natural flow over a vertical plate.</p> <p>Research Assignment: Students in a group of 4/5 will submit a typed project report on deliver a presentation evaluating the effects of boundary layer formation on latest designs of automobile and aircrafts</p>				
<p>Course learning outcome (CLO): The students will be able to:</p> <ul style="list-style-type: none"> • apply the fundamental concepts related to viscous flows in general, and to boundary layer flows. • evaluate exact solutions of the Navier-Stokes equations, including parallel flows, flow between two concentric rotating cylinders, Stoke's solutions • evaluate the differences in flow mechanism through different across various designs of aerofoil • perform analysis of the effects of hydrodynamic and thermal boundary layers on the design of equipments, especially at elevated temperatures 				

- evaluate the effects of boundary layer formation for automobile and aircraft applications and present technical reports

Recommended Books:

1.	<i>Schlichting, H. and Gersten, K., Boundary Layer Theory, Springer India (2003).</i>
2.	<i>White, F.M., Viscous Fluid Flow, McGraw-Hill (2005) 3rd ed.</i>
3.	<i>Streeter, V.L., Wylie, E. B., and Bedford, K.M., Fluid Mechanics, McGrawHill (1997) 7th ed.</i>
4.	<i>Douglas, J.F., Swaffield, J.A., and Gasiorek, J.M., Fluid Mechanics, Dorling Kingsley (2006).</i>

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Micro-Projects/Lab Evaluations)	25

PTH213 DESIGN OF COMPRESSORS AND GAS TURBINES				
	L	T	P	Cr
	3	2	0	4
<p>Course objective: To provide students with a thorough understanding of energy systems, heat transfer and thermodynamic applications to gas turbines and compressors. The student will be exposed to design and operation of compressors and turbines. In addition the student will also learn about gas turbine cycles and modifications of gas turbine cycles. Three-dimensional flows in turbo machines, design of individual components, and the prediction of design off-design performance blade materials, blade attachments and cooling, gas turbine power, plant performance and matching, applications of gas turbine power plants</p>				
<p>Review: Development, classification and field of application of gas turbines, Gas turbine cycle, Multistage compression, Reheating, Regeneration combined and cogeneration, Energy transfer between fluid and rotor, Axi-symmetric flow in compressors and gas turbines.</p>				
<p>Compressors: Classification, Centrifugal compressors, Adiabatic efficiency, Slip factor, Design consideration for impeller and diffuser systems, Performance characteristics, Axial flow compressors, Vortex theory, Degree of reaction, Simple design, Aerofoil theory, Cascade theory, Stages, Stage efficiency and overall efficiency, performance characteristics. Combustion systems, Design considerations, Flame stabilization</p>				
<p>Turbines: Classification - axial flow and radial flow turbines, Impulse and reaction turbines, Elementary vortex theory, Aerodynamic and thermodynamic design considerations, Blade materials, Blade attachments and cooling, Gas turbine power plants, Plant performance and matching, Applications of gas turbine power plants.</p>				
<p>Fans and Blowers: Fan applications, Types, Fan stage parameters, Design parameters</p>				
<p>Research Assignments: Axial flow gas turbine design. Radial flow gas turbine design, centrifugal and axial flow compressor design. Methodology for improving power to weight ratio, turbine efficiency, blade design calculations. Turbine blade cooling and attachment methods to rotor drum gas turbine maintenance and trouble shooting.</p>				
<p>Course learning outcome (CLO): The students will be able to</p> <ul style="list-style-type: none"> • analyse and design centrifugal compressor. • analyse and design axial flow compressors for various blade configurations. • analyse and design axial and radial flow gas turbine 				

- design for matching of the components of gas turbine power plant.
- analyse and evaluate gas turbine cycle performance.

Recommended Books:

1.	<i>Cohen, H., Rogers, G.F.C., and Saravanamuttoo, H.I.H., Gas Turbine Theory, Longman (2008) 5th ed.</i>
2.	<i>Oates, G.C., Aero-thermodynamics of Gas Turbine and Rocket Propulsion AIAA Education Series (1997) 3rd ed</i>
3.	<i>Yahya, S.M, Turbines, Compressors and Fans, Tata McGrawHill (2005).</i>
4.	<i>Dixon, S.L., Fluid Mechanics and Thermodynamics of Turbomachinery, Elsevier .</i>
5.	<i>Ganesan, V., Gas Turbines, Tata McGrawHill (2003)</i>

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	40
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	30

PTH321: HYDRODYNAMIC MACHINES				L	T	P	Cr
				3	2	0	4.0
<p>Course objective:The learner will be exposed to the basic fundamentals of momentum equation, boundary layer theory of the fluid. The learner will also be study the working principle of the hydropower plant, selection of design parameter of hydro turbine, centrifugal pump, reciprocating pump and axial flow pump.</p>							
<p>Introduction: Basic fluid mechanics of turbo machinery, Euler’s equation, two-dimensional theory.</p> <p>Hydraulic turbines: Classification of turbines; Forms of runners, general theory of impulse turbines, design of nozzles and wheel, bucket size, reaction turbine theory, francis and Kaplan turbines, design of guide and runner blades, design of spiral casing, draft tube theory, speed control and performance curves, cavitations, performance characteristics.</p> <p>Hydraulic pumps: Pumps and its classification, theory of pumps and design of impellers, classification, selection, installation, centrifugal pumps, head, vane shape, pressure rise, velocity vector diagrams, work, efficiency, design parameters, multistage, operation in series and parallel, axial thrust, balancing devices , self-priming arrangements ,head slip – correction ,off-design performance, hydraulic losses ,volumetric losses, Disc friction ,Mechanical losses,cavitations,NPSH, specific speed,Submersible pumps.</p> <p>Reciprocating pumps: Indicator diagram, work, efficiency, effect of acceleration and friction, air vessels.</p> <p>Minor Project (if any): Erosion and Cavitation phenomena of fluid machinery componen , Design the fluid machinery component using CFD Tools</p>							
<p>Course learning outcome (CLO):</p> <p>The students will be able to</p> <ul style="list-style-type: none"> • develop dimensionless groups using Buckingham’s Pi method • determine the drag and lift forces of various shapes • determine the various flow characteristics of pumps and turbine • design the fluid machinery system 							
<p>Recommended Books:</p>							
1.	<i>Dixon, S.L., Fluid Mechanics, Thermodynamics of Turbomachinery, Elsevier Butterworth Heinemann (2005).</i>						
2.	<i>Turton, R.K., Principles of Turbomachinery, Springer (2009) 2nd ed.</i>						
3.	<i>Earl, Logan Jr. and Roy, R., Turbomachinery, CRC Press (2003) 2nd ed.</i>						
4.	<i>Japikse, D. and Baines, N.C., Introduction to Turbomachinery, Concept (1997).</i>						

5.	<i>Douglas, J.F., Gasiorek, J. M. and Swaffield, J. A., Fluid Mechanics, prentice Hall (2000) 4th ed.</i>
6.	<i>Kovats, A., Design and Performance at Centrifugal and Axial Flow Pumps and Compressors, Pergamon (1964).</i>
7.	<i>Stepanoff, A.J., Centrifugal and Axial Flow Pump, Krieger (1992) 2nd ed.</i>

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	25
2.	EST	45
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes)	30

PTH203: THERMAL SYSTEMS MODELING AND ANALYSIS

L	T	P	Cr
3	2	0	4

Course Objective: To get familiar with the design, thermal modeling and its objectives. Also, to understand and apply optimization in the analysis of various types of thermal equipments.

Thermal System Design: Design principles, workable systems, optimal systems, matching of system components, economic analysis, depreciation, gradient present worth factor

Mathematical Modeling: Equation fitting, empirical equation, regression analysis, different modes of mathematical models, selection, computer programmes for models

Thermal Equipments Modeling: Modeling of heat exchangers, evaporators, condensers, absorption and rectification columns, compressor, pumps, simulation studies, information flow diagram, optimization of thermal systems.

Dynamic Behavior of Various Thermal Systems: Steady state simulation, Laplace transformation, feedback control loops, stability analysis, non-linearities

Research Assignment: Students in a group (3-5 students) will submit a project report on the modeling, optimization of the various types of actual thermal equipments/systems. The report may be written by collection of literature from library, plant visit and formulation, analysis of the problem and recommendation. Each group will deliver a presentation.

Course Learning outcomes (CLO): The students will be able to

- design and select the materials/equipments for a particular application based upon its thermal response
- model the thermal equipments
- analyze and optimize the thermal problems
- apply the mathematical techniques for control loops, stability analysis

Recommended Books:

1.	<i>Hodge, B.K. and Taylor, R.P., Analysis and Design of Energy Systems, Prentice Hall (1999,) 3rd ed.</i>
2.	<i>Bejan, A., Tsatsaronis, G. and Moran, M., Thermal Design and Optimization, John Wiley (1996).</i>
3.	<i>Jaluria, Y., Design and Optimization of Thermal Systems, CRC Press (2008).</i>
4.	<i>Ishigai, S., Steam Power Engineering Thermal and Hydraulic Design Principle, Cambridge University Press (1999).</i>

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	25
2.	EST	45
3.	Sessionals (assignments/projects/presentations)	30

PTH323: TWO PHASE FLOW AND HEAT TRANSFER

L	T	P	Cr
3	1	0	3.5

Course Objective: To study and understand the role of heat exchangers in many heat transfer problems. To learn different types of heat exchangers, their design, functioning and related concepts. Also to understand the working and design methodology of heat exchangers where fluid undergoes phase change

Basic Design Methods for Heat Exchangers: Introduction, arrangement of flow path in heat exchangers , basic equations in design, overall heat transfer coefficient , log mean temperature difference method for heat exchanger analysis , NTU method for heat exchanger analysis, heat exchanger design calculations, variable overall heat transfer coefficient and heat exchanger design methodology

Design for Condensers and Evaporators: Introduction, condensation, film condensation on a single horizontal tube-laminar film condensation, forced convection, film condensation in tube bundles-effect of condensate inundation, flow boiling-sub-cooled boiling, shell-and-tube condensers, steam turbine exhaust condensers, plate condensers, air-cooled condensers, direct contact condensers, condensers for refrigeration and air-conditioning applications

Shell and Tube Heat Exchangers: Introduction, basic components-shell types, tube bundle types, Tubes and tube passes, Tube layout, Baffle type and geometry, Allocation of streams, Basic design procedure of a heat exchanger-preliminary estimation of unit size, Rating of preliminary design, Shell-side heat transfer and pressure drop-shell-side heat transfer coefficient, shell-side pressure drop, tube-side pressure drop, Bell-Delaware method

Compact Heat Exchangers: Introduction, plate-fin heat exchangers, tube-fin heat exchangers, heat transfer and pressure drop-heat transfer, pressure drop for finned-tube exchangers, pressure drop for plate-fin exchangers

Research Assignment: Students in a group (3-5 students) will submit a project report on design of various types of heat exchangers involved in actual thermal systems. The report may be written by collection of literature from library, plant visit and formulation, analysis of the problem and recommendation. Each group will deliver a presentation.

Course Learning outcomes (CLO): Students will be able to

- apply the designing methods for heat exchangers
- design the heat exchangers for various thermal applications where fluid does not change its phase
- design the heat exchangers for various thermal applications where fluid undergo phase change
- investigate the performance of the compact heat exchangers

Recommended Books:

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| 1. | <i>Krieth. F. and Bohn. M.S., Principles of Heat Transfer, Asian Books Pvt. Ltd. Delhi (1977).</i> |
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| 2. | <i>Whalley, P.B., Boiling, Condensation and Gas-Liquid Flow, Oxford University Press (1990)</i> |
| 3. | <i>Sadik, K. and Yaman, Y., Convective Heat Transfer, CRC Press (1995) 2nd Ed.</i> |

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessionals (assignments/projects/presentations tutorials/quizes/lab evaluations)	25