SCHEME OF COURSE WORK

Course Details:

Course Title	**Design of Thermal Equipment**		
Course Code	19ME2255	**L T P C**	**:3 0 0 3**
Program:	**M.Tech.**		
Specialization:	**THERMAL ENGINEERING**		
Semester	**II**		
Prerequisites	**Thermodynamics, Heat Transfer**		
Courses to which it is a prerequisite	**:NO**		

Course Outcomes (COs):

1	Classify and design heat exchangers.
2	Evaluate convective heat transfer in ducts, concentric annuli, circular pipes
3	Determine pressure drop and effect of fouling in heat exchangers
4	Design double pipe heat exchangers and compact heat exchangers by considering fin effects
5	Design shell and tube heat exchangers and condensers for application in refrigeration and air-conditioning

Program Outcomes (POs)

At the end of the programme, the students in THERMAL ENGINEERING will be able to

PO Code	Program Outcome (PO)
PO 1	exhibit in-depth knowledge in thermal engineering specialization
PO 2	think critically and analyze complex engineering problems to make creative advances in theory and practice
PO 3	solve problem, think originally and arrive at feasible and optimal solutions with due consideration to public health and safety of environment
PO 4	use research methodologies, techniques and tools, and will contribute to the development of technological knowledge
PO 5	apply appropriate techniques, modern engineering tools to perform modeling of complex engineering problems with knowing the limitations
PO 6	understand group dynamics, contribute to collaborative multidisciplinary scientific research
PO 7	demonstrate knowledge and understanding of engineering and management principles and apply the same with due consideration to economical and financial factors
PO 8	communicate complex engineering problems with the engineering community and society, write and present technical reports effectively
PO 9	engage in life-long learning with a high level of enthusiasm and commitment to improve knowledge and competence continuously
PO 10	exhibit professional and intellectual integrity, ethics of research and scholarship and will realize the responsibility towards the community
PO 11	examine critically the outcomes of actions and make corrective measures

Course Outcome Versus **Program Outcomes:**

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	M		M	S			M					
CO2	M	S		S		S	M					
CO3	M	S	S	M			M					
CO4		S	S	M			M					
CO5		S	S	S			M					

S - Strongly correlated, *M* - *Moderately* correlated, *Blank* - *No correlation*

Assessment Methods:	Assignment / Quiz / Seminar / Case Study / Mid-Test / End Exam

Teaching-Learning and Evaluation

Week	TOPIC / CONTENTS	Course Outcomes	Sample questions	Teaching-learning strategy	Assessment Method & Schedule
1	Classification of heat exchangers: Tubular heat exchangers, plate heat exchangers, extended surface heat exchangers.	CO1	1. Why are baffles used in shell and tube heat exchangers. 2. what are the types of fins that are used in heat exchangers.	Lecture	Mid-Test 1 (Week 9)
2	flow arrangements – applications Basic design methods of heat exchangers: Overall heat transfer coefficient	CO1	Determine the overall heat transfer coefficient U for liquid-to-liquid heat transfer through a 0.003-m thick steel plates(k= 50 W/mK) for the following het transfer coefficients and fouling factor on one side.	Lecture / Discussion Problem solving	Assignment (Week 4 - 6) Mid-Test 1 (Week 9)
3	multi pass and cross flow heat exchangers - log mean temperature difference method	CO1	Air flowing at a rate of 5 kg/s is to be heated in a shell-and- tube heat exchanger from 20 to 50^0 C with hot water entering at 90^0 C and exiting at 60^0 C. The overall heat transfer coefficient is 400 W/m^2 K. The length of the heat exchanger is 2m. Determine the surface area of the heat exchanger and the number of tubes required by using 1. 1 to 2 shell-and-tube type 2. 2 to 4 shell-and-tube type	Lecture / Discussion Problem solving	Assignment (Week 4 - 6) Mid-Test 1 (Week 9)
4	effectiveness-NTU	CO1		▫ Lecture /	Assignment

	method for heat exchanger analysis			Discussion ▫ Problem solving	(Week 4 - 6) Mid-Test 1 (Week 9)
5	heat exchanger design calculation– heat exchanger design methodology.	CO1	1. An arrangement of refrigeration system to take multiloads is shown in fig. F-12 is used as refrigerant in the system .Find Kw and C.O.P of the system. 2. Compound compression with inter cooling is effective method of operation Discuss.	▫ Lecture ▫ Problem solving	Assignment (Week 4 - 6) Mid-Test 1 (Week 9)
6	Correlations for forced convection heat transfer coefficients: Laminar forced convection in ducts and concentric annuli	CO2	In an absorption refrigeration system heating cooling refrigeration take place at the temperatures of 150 ^{0} C,30 ^{0} C and -20 ^{0} C. Find C.O.P of the system.	▫ Lecture ▫ Problem solving	Mid-Test 1 (Week 9)
7	turbulent forced convection in circular pipes – heat transfer in helical coils and spirals – heat transfer in bends.	CO2	1. What is equilibrium concentration. Find out the expression for the same. 2. Dry and saturated steam at 2.8 bar is available for an ejector refrigeration unit. Estimate steam consumption in kg/hr/ton of refrigeration if condenser pressure is 0.07 bar, recirculated water temp = 20 ^{0}C, Chilled water temp =10^{0} C, Nozzle efficiency = 0.94, entrainment efficiency = 0.65, diffuser efficiency = 0.75, Quality of flashed vapour= 0.97	▫ Lecture ▫ Problem solving	Mid-Test 1 (Week 9)
8	Heat exchanger pressure drop and pumping power: Tube side pressure drop in laminar and turbulent flows	CO3	City water will be cooled in a heat exchanger by sea water entering at 15^{0}C. The outlet temperature of the sea water is20^{0}C. City water will be recirculated to reduce water consumption. The suction line of the pump	▫ Lecture	Mid-Test 1 (Week 9)

			which has an inner diameter of 154 mm is 22 m long and has two 90^0 bends and a hinged check valve. The pipe from the pump to the heat exchanger has an inner diameter of 127 mm and is 140 m long. It also has six 90^0 bends. The 90^0 bends are all made of steel with a radius equal to the inner diameter of the pipe, ***R/d*** =1. The heat exchanger has 62 tubes in parallel and each tube is 6 m long. The inner diameter of the tube is 18 mm. All pipes are made of drawn mild steel (e = 0.0445*mm*). The sea water flow rate is120 m^3/h. Assume that there is one velocity head loss at the inlet and 0.5 velocity head loss at the outlet of the heat exchanger. The elevation difference is 10.5 m. Calculate: a) The total pressure drop in the system b)The power of the sea water pump (pump efficiency h = 60%)		
9	**Mid-Test 1**	CO1, CO2, CO3			
10	pressure drop in helical and spiral coils – pressure drop in bends and fittings.	CO3	Consider a piping circuit of a heat exchanger. In the circuit there are four 90^0 standard elbows, three close patterns return bends, 2 check valves (clear way swing type) 2 angle valves (with no obstruction in flat type seat) and three gate valves (conventional wedge type). The valves are fully open. The straight part of the circuit pipe is 150 m, and water at 50^0C flows with a	▫ Lecture ▫ Discussion	Seminar (Week 10) Mid-Test 2 (Week 18)

			velocity of 4 m/s. The pressure drop through the heat exchanger is 12 kPa. Nominal pipe size is 2 in. OD (ID = 0.052m). 1) Calculate the total pressure drop in the system. Calculate the mass flow rate and pumping power (kW) assuming the isentropic efficiency of the pump to be 0.8.		
11	Fouling of heat exchangers: Basic considerations – effect of fouling and heat transfer and pressure drop – aspects of fouling – design of heat exchangers subject to fouling.	CO4	In a double pipe heat exchanger, deposits of calcium carbonate with a thickness of 1.12 mm and magnesium phosphate with a thickness of 0.88 mm on the inside and outside of the inner tube, respectively have formed over time. Tubes (ID = 1.9 cm, OD = 2.3 cm) are made of carbon steel (k = 43 W/ mK) calculate the total fouling resistance based on the outside surface area of the heat exchanger.	▫ Lecture ▫ Discussion Problem solving	Mid-Test 2 (Week 18)
12	Double pipe heat exchangers: Pressure drop – hydraulic diameter – hairpin heat exchanger – parallel and series arrangements of hairpins – total pressure drop.	CO4	A counter flow double-pipe heat exchanger is used to cool the lubricating oil for a large industrial gas turbine engine. The flow rate of cooling water through the inner tube is 0.2 kg/s, while the flow rate of oil through the outer annulus is 0.4 kg/s. The oil and water enter at temperatures of 60 ^{0}C and 30 ^{0}C, respectively. The heat transfer coefficient in the annulus is calculated to be 15 W/m^2 K. The inner tube diameter is 25 mm and the inside diameter of the outer annulus is 45 mm. The outlet temperature of the oil is 40 ^{0}C. Assume c_p = 4178	▫ Lecture ▫ Discussion	Assignment (Week 14 - 16) (Mid-Test 2 (Week 18)

			J/kg. K for water and c_p= 2006 j/kg K for oil. The tube wall resistance and curvature of wall are neglected. Calculate the length of the heat exchanger if fouling is neglected.		
13	Compact heat exchangers: Plate-fin heat exchangers – tube-fin heat exchangers	CO4	Air at 2 atm and 500 K with a velocity of U = 20 m/s flows across a compact heat exchanger matrix having the configuration of surface 11.32-0737-S-R. Calculate the heat transfer coefficient and the frictional pressure drop. The length of the matrix is 0.8 m.	▫ Lecture ▫ Discussion	Seminar (Week 13) (Mid-Test 2 (Week 18)
14	pressure drop for finned-tube heat exchangers – pressure drop for plate-fin heat exchangers.	CO4	Air at 1 atm and 400 K with a velocity of U = 10 m/s flows across a compact heat exchanger matrix having the configuration of surface CF-8.7-5/8J(A) and exists with a mean temperature of 300K. The core is 0.6m long. Calculate the total frictional pressure drop between the air inlet and outlet and the average heat transfer coefficient on the air side.	▫ Lecture	Assignment (Week 14 - 16) (Mid-Test 2 (Week 18)
15&16	Shell and tube heat exchangers: Basic components, basic design procedure of a heat exchanger, shell-side heat transfer and pressure drop, Bell Delaware's method.	CO5	A heat exchanger has to be designed to heat raw water by the use of condensed water at 67^{o}C and 0.2bar, which will flow in the shell side with a mass flow rate of 50,000kg/h. The heat will be transferred to 30,000kg/h of city water coming from supply at 17^{o}C (C_p=4184 kJ/kgK). A single shell and a single tube pass is preferable. A fouling resistance of	▫ Lecture Problem solving	Assignment (Week 14 - 16) (Mid-Test 2 (Week 18)

			$0.000176 m^2 K/W$ is suggested and the surface over design should not be over 35%. A maximum coolant velocity of 1.5m/s is suggested to prevent erosion. A maximum tube length of 5m is required because of space limitations. The tube material is carbon steel (k=60W/mK). Raw water will flow inside of ¾ inch straight tubes (19 mm OD with 16 mm ID). Tubes are laid out on a square pitch with a pitch ratio of 1.25. The baffle spacing is approximated by 0.6 of shell diameter and the baffle cut is set to 25%. The permissible maximum pressure drop on the shell side is 0.5psi. The water outlet temperature should not be less than 40^oC. Perform the preliminary analysis.		
17	Horizontal-shell-and-tube condensers, horizontal in-tube condensers, plate condensers, air cooled condensers, thermal design of shell-and-tube condensers, design and operational considerations.	CO5	What are the classifications of evaporators for refrigeration and air-conditioning? Explain with neat diagrams.	▫ Lecture Problem solving	Assignment (Week 14 - 16) (Mid-Test 2 (Week 18)
18	**Mid-Test 2**	**C03,CO4,CO5**			
19/20	**END EXAM**				