Roll No: -------------------------

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

End Semester Examination, December 2017

Program: M.Tech ES	**Semester – I**
Subject (Course): Thermodynamics and Heat Transfer Systems	**Max. Marks : 100**
Course Code : EPEC7007	**Duration : 3 Hrs**
No. of page/s: 3	

Section A **Answer all Questions** **5X4 = 20 Marks**

1. (CO3) Derive an expression for Logarithmic Mean Temperature Difference (LMTD) for counter flow heat exchanger stating the assumption made.
2. (CO1) Determine the heat flow across a plane wall of 10 cm thickness with a constant thermal conductivity of 8.5 W/mK when the surface temperatures are steady at 100°C and 30°C. The wall area is $3m^2$. Also determine the temperature gradient in the flow direction.
3. (CO2) By dimensional analysis show that for natural convection heat transfer the Nusselt number (Nu) can be expressed as a function of Grashof number (Gr) and Prandtl number (Pr).
4. (CO4) A new scale N of temperature is divided in such a way that the freezing point of ice is 100°N and the boiling point is 400°N. Determine the temperature reading on this new scale when the temperature is 150°C. Determine the temperature that, both the Celsius and the new temperature scale reading would be the same?
5. (CO5) A pump discharge a liquid into a drum at the rate of $0.032m^3/s$. the drum 1.50m in diameter and 4.20 m in length can hold 3000 kg of the liquids. Determine the density of the liquid and the mass flow rate the liquids handled by the pump.

Section B **Answer all Questions** **5X8 = 40 Marks**

6. (CO1) Give classification of Heat Exchanger and explain in brief.
7. (CO2) Show physical significance of Following non-dimensional numbers: Nu (Nusselt Number), Gr (Grashof Number) and Pr (Prandtl Number), Re (Reynold Number). Bi (Biot Number), Pe (Peclet Number), St (Stanton Number).
8. (CO3) A 2-shell passes and 4-tube passes heat exchanger is used to heat glycerin from 20°C to 50°C by hot water, which enters the thin-walled 2-cm-diameter tubes at 80°C and leaves at 40°C. The total length of the tubes in the heat exchanger is 60 m. The convection heat transfer coefficient is 25 $W/m^2{}^\circ C$ on the glycerin (shell) side and 160 $W/m^2{}^\circ C$ on the water (tube) side. Determine the rate of heat transfer in the heat exchanger (a) before any fouling occurs and (b) after fouling with a fouling factor of 0.0006 $m^2{}^\circ C/W$ occurs on the outer surfaces of the tubes.
9. (CO4) A room for four persons has two fans, each consuming 0.18 kW power, and three 100 W lamps. Ventilation air at the rate of 80 kg/h enters with an enthalpy of 84 kJ/kg and leaves with an enthalpy of 59 kJ/kg. If each person puts out heat at the rate of 630 kJ/h, Determine the rate at which heat is to be removed by a room cooler, so that a steady state is maintained in the room.

10. (CO5) At the beginning of the compression stroke of a two-cylinder internal combustion engine the air is at a pressure of 101.325 kPa. Compression reduces the volume to 1/5 of its original volume, and the law of compression is given by pv1.2 = constant. If the bore and stroke of each cylinder is 0.15 m and 0.25 m, respectively, Determine the power absorbed in kW by compression strokes when the engine speed is such that each cylinder undergoes 500 compression strokes per minute.

Section C	**Answer all Questions**	**2X20 = 40 Marks**

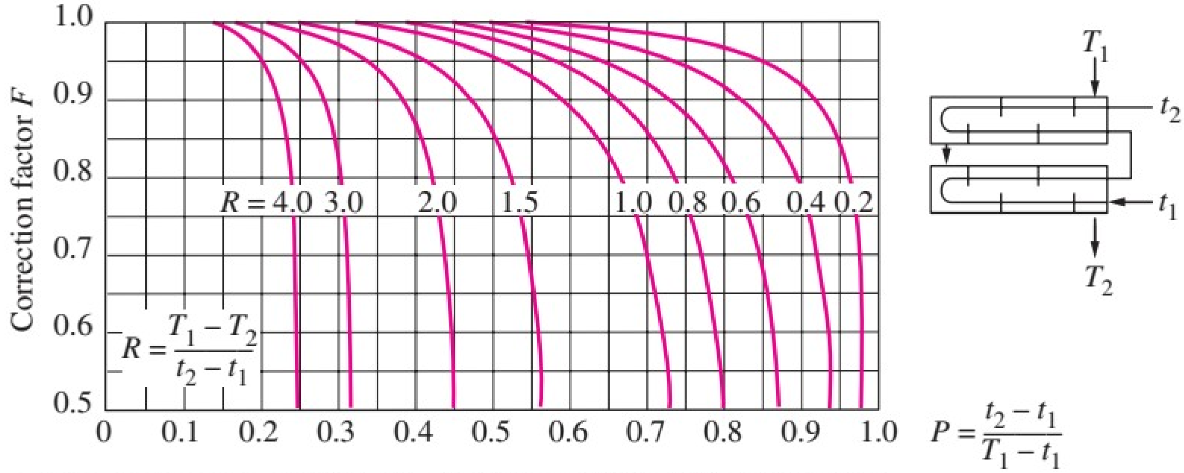
11. (CO1) (a) Derive general heat conduction equation in spherical co-ordinates.

(CO1) (b) Explain the critical radius of insulation? Draw rough sketch showing variation in heat transfer with respect to radius of insulation. Derive the equation for critical radius insulation for cylinder

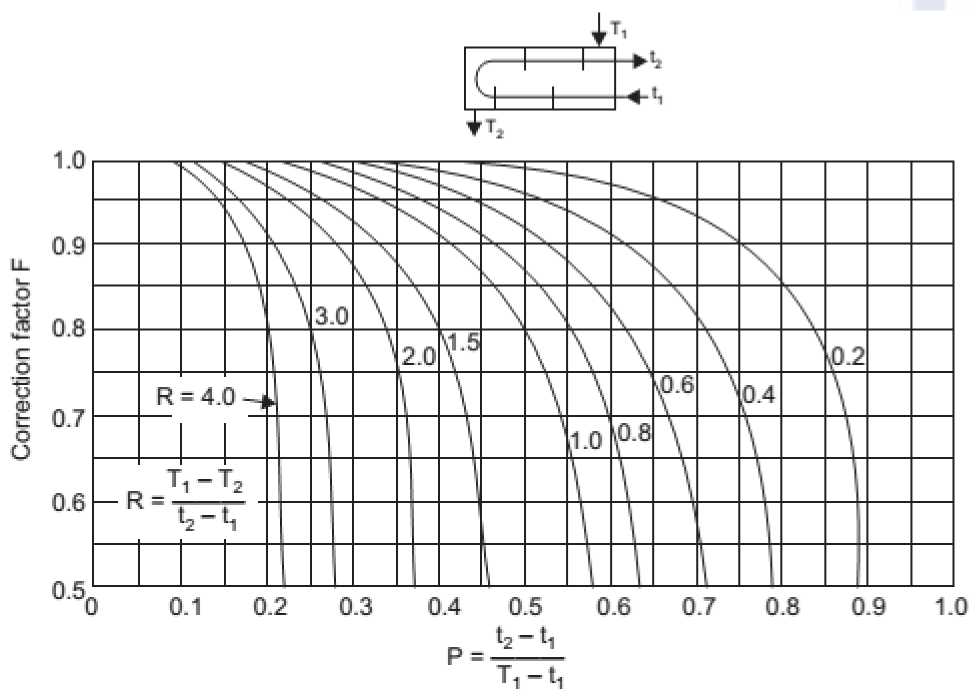
(or)

(CO3) Hot oil is to be cooled in a double-tube counter-flow heat exchanger. The copper inner tubes have a diameter of 2 cm and negligible thickness. The inner diameter of the outer tube (the shell) is 3 cm. Water flows through the tube at a rate of 0.5 kg/s, and the oil through the shell at a rate of 0.8 kg/s. Taking the average temperatures of the water and the oil to be 45°C and 80°C, respectively, determine the overall heat transfer coefficient of this heat exchanger. The properties of water at 45°C are, ρ = 990 kg/m^3, Pr = 3.91, k = 0.637 W/m°C, ν = 0.602 x 10^{-6} m^2/s. The properties of oil at 80°C are, ρ = 852 kg/m^3, Pr = 490, k = 0.138 W/m°C, ν = 37.5 x 10^{-6} m^2/s.

12. (CO4) (CO5) In water cooling tower air enters at a height of 1 m above the ground level and leaves at a height of 7 m. The inlet and outlet velocities are 20 m/s and 30 m/s respectively. Water enters at a height of 8 m and leaves at a height of 0.8 m. The velocity of water at entry and exit are 3 m/s and 1 m/s respectively. Water temperatures are 80°C and 50°C at the entry and exit respectively. Air temperatures are 30°C and 70°C at the entry and exit respectively. The cooling tower is well insulated and a fan of 2.25 kW drives the air through the cooler. Determine the amount of air per second required for 1 kg/s of water flow. The values of Cp of air and water are 1.005 and 4.187 kJ/kg K respectively.



Two-shell passes and 4, 8, 12, etc. (any multiple of 4), tube passes



Correction factor F for shell-and-tube heat exchangers with one shell pass and any multiple of two tube passes (2, 4, 6, etc., tube passes).

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Section A | **Answer all Questions** | **5X4 = 20 Marks**

1. (CO3) Derive equation of Logarithmic Mean Temperature Difference (LMTD) for parallel flow Heat-exchanger
2. (CO1) For cylinder, prove that critical radius of insulation, $r_{critical} = k/h$. Explain effect of thickness of insulation on heat transfer.
3. (CO2) For natural convection heat transfer, show that $Nu = f(Gr, Pr)$
4. (CO4) A system comprising of gas in cylinder at pressure of 689 kPa. Fluid expands from a volume of 0.04 m^3 to 0.045 m^3 while pressure remains constant. Paddle wheel in the system does a work of 4.88 kJ on the system. Determine (a) work done by system on the piston (b) the net amount of work done on or by the system.
5. (CO5) A single cylinder double acting reciprocating water pump has an indicator diagram which is a rectangle 0.075 m long and 0.05 m high. The indicator diagram spring constant is 147 MPa per m. the pump runs at 50 rpm. The pump cylinder diameter is 0.15 m and the piston stroke is 0.20 m. Determine the rate in kW at which the piston does work on the water.

Section B | **Answer all Questions** | **5X8 = 40 Marks**

6. (CO1) Derive equation of heat transfer by conduction through composite wall.
7. (CO3) Determine the area required in parallel flow heat exchanger to cool oil from 60°C to 30°C using water available at 20°C. The outlet temperature of the water is 26°C. The rate of flow of oil is 10 kg/s.

The specific heat of the oil is 2200 J/kg K. The overall heat transfer coefficient U = 300 W/m^2 K. Compare the area required for a counter flow exchanger.

8. (CO5) A six-cylinder, 4-stroke gasoline engine is run at a speed of 2520 RPM. The area of the indicator card of one cylinder is 2.45 × 103 mm2 and its length is 58.5 mm. The spring constant is 20 × 106 N/ m^3. The bore of the cylinders is 140 mm and the piston stroke is 150 mm. Determine the indicated power, assuming that each cylinder contributes an equal power.

9. (CO5) A gas undergoes a thermodynamic cycle consisting of three processes beginning at an initial state where P_1=1 bar, V_1=1.5 m^3 and U_1=512 kJ. The processes are as follow: (U - internal energy)

(i) Process 1-2: Compression with pV= constant to P_2 = 2 bar, U_2 = 690 kJ

(ii) Process 2-3: W_{23} = 0, Q_{23}= -150 kJ, and

(iii) Process 3-1: W_{31} = +50 kJ. Neglecting KE And PE changes, Determine the heat interactions Q_{12} and Q_{31}

10. (CO4) A gas of mass 1.5 kg undergoes a quasi-static expansion which follow a relationship p= a+bV where a and b are constant. The initial and final pressures are 100kPa and 200kPa respectively and the corresponding volume are 0.20 m^3 and 1.20 m^3. The specific internal energy of the gas is given by the relation u= 1.5 pv- 85 (kJ/kg) where p is in the kPa and v is in m^3 /kg. Calculate the net heat transfer and the maximum internal energy of the gas attained during expansion?

Section C **Answer all Questions** **2X20 = 40 Marks**

11. (CO1) (a) Describe Fins and its Effectiveness and Efficiency. For long fin with insulated tip, show that η of fin = tanhmL/mL with usual notations

12. (CO3) (b) Draw rough sketch of temperature distribution curve for condenser and evaporator type heat exchangers. Derive the expression for overall heat transfer coefficient for shell and tube type heat exchanger.

(or)

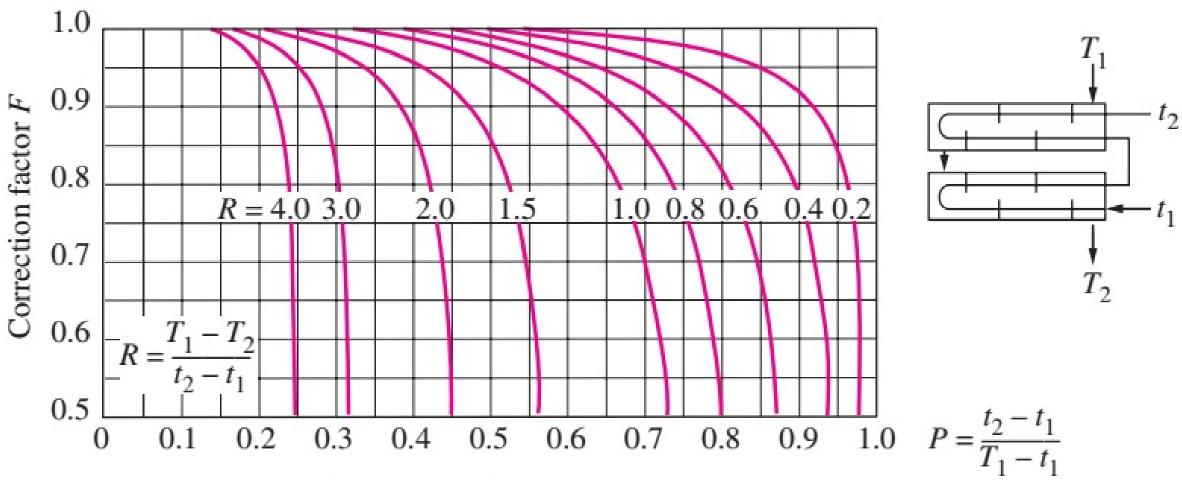
13. (CO3) (CO4) Air is contained in a vertical piston–cylinder assembly fitted with an electrical resistor. The atmosphere exerts a pressure of 1 bar on the top of the piston, which has a mass of 45 kg and a face area of 0.09 m2. Electric current passes through the resistor, and the volume of the air slowly increases by 0.045 m3 while its pressure remains constant. The mass of the air is 0.27 kg, and its specific internal energy increases by 42 kJ/kg. The air and piston are at rest initially and finally. The piston–cylinder material is a ceramic composite and thus a good insulator. Friction between the piston and cylinder wall can be ignored, and the local acceleration of gravity is *g* = 9.81 m/s2. Determine the heat transfer from the resistor to the air, in kJ, for a system consisting of **(a)** the air alone, **(b)** the air and the piston.

14. (CO4) (CO5) A nozzle is a device for increasing the velocity of a steadily flowing stream. At the inlet to a certain nozzle, the enthalpy of the fluid passing is 3000 kJ/kg and the velocity is 60 m/s. At the discharge end, the enthalpy is 2762 kJ/kg. The nozzle is horizontal and there is negligible heat loss from it.

(a) Determine the velocity at exists from the nozzle.

(b) If the inlet area is 0.1 m^2 and the specific volume at inlet is 0.187 m^3/kg, Determine the mass flow rate.

(c) If the specific volume at the nozzle exit is 0.498 m^3/kg, Determine the exit area of the nozzle



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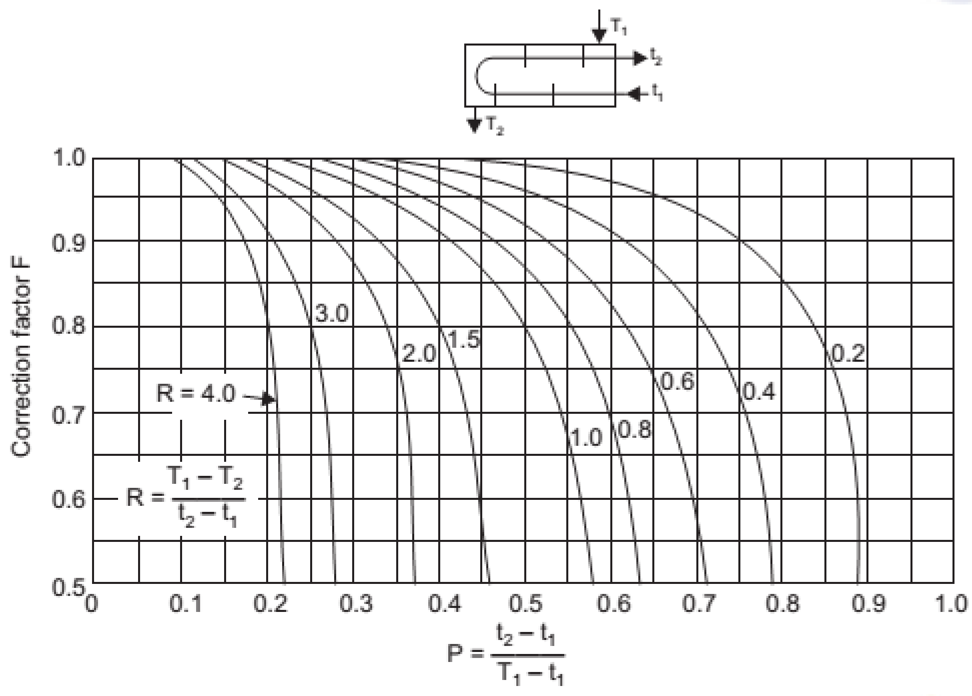

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