Reg. No. :

Question Paper Code: 1146151

B.E. / B.Tech. DEGREE EXAMINATIONS, NOV/ DEC 2024
Sixth Semester
Mechanical Engineering
ME8693 - HEAT AND MASS TRANSFER
(Regulation 2017)
(Use of standard HMT data book and steam tables is allowed)

Time: Three Hours Maximum: 100 Marks

Answer ALL questions

PART – A (10 x 2 = 20 Marks)

1. Compare steady-state with unsteady-state heat conductivity.
2. List the uses of Heister's charts.
3. Show the expression for the Prandtl number.
4. Differentiate between natural convection heat transfer and forced convection.
5. Define pool boiling.
6. Compare LMTD with the NTU method.
7. Define gray body.
8. What is meant by the shape factor and mention its physical significance.
9. State Fick's law of diffusion.
10. Differentiate between diffusion and convective mass transfer.

PART – B (5 x 13 = 65 Marks)

11. (a) A composite wall is made of a 15 mm thick steel plate lined inside with 200 mm thick silica brick and, on the outside, 250 mm thick magnesite brick. The inner and outer surface temperatures are 750°C and 100°C, respectively. The thermal conductivities (k) for silica, steel plate, and magnesite brick are 8 W/m°C, 68 W/m°C, and 20 W/m°C, respectively. Identify the value of the heat flux and interface temperature. (13)

(OR)

(b) Determine the heat transfer through a fin of thickness 5mm, height 50 mm, and width 100 mm. Additionally, determine the temperature at the tip of the fin. The atmospheric temperature is 28°C. The temperature at the base of the fin is 80°C, k = 58.139 W/m°C, h = 11.63 W/m^2°C, T_b = 80°C. The end of the fin is insulated. (13)

12. (a) Air at 25 °C flows over a flat plate at a speed of 5 m/s and is heated to 135 °C. The plate is 3 m long and 1.5 m wide. Calculate the local heat transfer coefficient at x = 0.5 m and the heat transferred from the first 0.5 m of the plate. (13)

(OR)

(b) A thin 80 cm long and 8 cm wide horizontal plate is maintained at 130°C temperature in a large tank full of water at 70°C. Estimate the heat input rate into the plate necessary to maintain the temperature of 130°C. (13)

13. (a) A vertical tube 40 mm in diameter and a length of 1 m is used for condensing dry steam at atmospheric pressure. The tube surface temperature is 60°C. (13)

(i) Determine the mass of condensate.

(ii) If the tube is held in a horizontal position, will there be any change in the mass of condensate? If yes, calculate the value and change.

Use the following properties of the fluid:

k_f = 0.675 W/m K

h_{fg} = 2257 kJ/kg

ρ = 971.8 kg/m^3

$\mu = 355 \times 10^{-6}$ kg/m s

(OR)

(b) A heat exchanger is required to cool 55,000 kg/h of alcohol from 66°C to 40°C using 40,000 kg/h of water entering at 5°C. Compare (i) the Exit temperature of the water, (ii) the Heat transfer rate, and (iii) the Surface area required for the parallel flow type and counter flow type of heat exchanger. Assume the overall heat transfer coefficient U = 580 W/m^2 K, $C_{p(alcohol)}$ = 3760 J/kg K, $C_{p(water)}$ = 4180 J/kg K. (13)

14. (a) A furnace emits radiation at 2000 K. Treating it as a block body radiation, Determine (a) The monochromatic radiant flux density at 1 μm wavelength. (b) The wavelength at which emission is maximum (c) The corresponding radiant flux density and (d) The total emissive power. (13)

(OR)

(}b) Two large parallel plates at temperatures 1000 K and 600 K have emissivity of 0.5 and 0.8 respectively. A radiation shield having an emissivity of 0.1 on one side and 0.05 on the other side is placed between the plates. Compare the heat transfer rate by radiation per square meter with and without a radiation shield. (13)

15. (a) CO_2 and air experience diffusion through a circular tube of 50 mm diameter and 1 m long. The system is at 1 atm, 25°C. The partial pressure of CO_2 at one end of the tube is 190 mm Hg and at the other end of the tube is 95 mm Hg. Determine the mass rate of flow of CO_2 and air. (13)

(OR)

(b) Air at 20°C (ρ = 1.205kg / (m^3); v = 15.06 $\times 10^{-6}$ m^2 / s; D = 4.166 $\times 10^{-5}$ m^2 / s) flows over a tray (length = 32 cm width = 42 cm) full of water with a velocity of 2.8 m/s. The total pressure of moving air is 1 atm and the partial pressure of water present in the air is 0.0068 bar. If the temperature on the water surface is 15°C, Calculate the evaporation rate of water. (13)

PART – C (1 x 15 = 15 Marks)

16. (a) Determine the three dimensional heat conduction governing equation in Cartesian Co-ordinates with neat sketch. (15)

(OR)

(b) A counter-flow double-pipe heat exchanger is to heat water from 20°C to 80°C at a rate of 1.2 kg/s. The heating is to be accomplished by geothermal water available at 160°C at a mass flow rate of 2 kg/s. The inner tube is thin-walled and has a diameter of 1.5 cm. If the overall heat transfer coefficient of the heat exchanger is 640 W/m^2 °C, determine the length of the heat exchanger required to achieve the desired heating. (15)

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