CBCS SCHEME

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15AE53

Fifth Semester B.E. Degree Examination, Dec.2023/Jan.2024
Heat and Mass Transfer

Time: 3 hrs. Max. Marks: 80

Note: 1. Answer any FIVE full questions, choosing ONE full question from each module.
2. Use of heat transfer and data handbook is permitted.

Module-1

1 a. Explain the modes of heat transfer with their corresponding basic equations. **(06 Marks)**

b. Define the term thermal diffusivity. **(02 Marks)**

c. Explain combined heat transfer mechanism. **(04 Marks)**

d. Briefly explain the boundary conditions of 1st, 2nd and 3rd kind. **(04 Marks)**

OR

2 a. Explain mass transfer and modes of mass transfer. **(08 Marks)**

b. Explain:
i) Convective heat transfer coefficient
ii) Radiation heat transfer coefficient
iii) Combined heat transfer coefficient
iv) Mass and Molar concentration. **(08 Marks)**

Module-2

3 a. One end of a long rod is inserted into furnace, while the other end projects into ambient air. Under steady state, the temperature of the rod is measured at two points, 75 mm apart and found to be 125°C and 88.5°C, while the ambient temperature is 20°C. If the rod is 25 mm in diameter and h is 23.36 W/m^{2}K, determine the thermal conductivity of the rod material. **(06 Marks)**

b. Derive the three dimensional general heat conduction equation in Cartesian coordinates. **(04 Marks)**

c. Derive an expression for instantaneous heat transfer and total heat transfer using lumped heat analysis for unsteady state heat transfer to a body from the surroundings. **(06 Marks)**

OR

4 a. Derive an expression for temperature distribution and heat flow through a fin of uniform cross section with the end insulated. **(06 Marks)**

b. A rod (K = 200 W/m.K), 5 mm in diameter and 5 cm long has its one end maintained at 100°C. The surface of the rod is exposed to ambient air at 25°C with convection heat transfer coefficient of 100 W/m^{2}K. Assuming other end is insulated, determine:
i) The temperature of rod at 20 mm distance from the end at 100°C
ii) Heat dissipation rate from the surface of the rod
iii) Effectiveness. **(06 Marks)**

c. Derive the three dimensional general heat conduction equation in cylindrical coordinates. **(04 Marks)**

Module-3

5 a. Explain briefly boundary layer concept for flow along a flat plate. **(08 Marks)**

b. Calculate the convection heat loss from a radiator 0.5m wide and 1m high maintained at a temperature of 84°C in a room at 20°C. Treat the radiator as a vertical plate. **(08 Marks)**

OR

6 a. What do you mean by velocity boundary layer thermal boundary layer? **(05 Marks)**

b. Explain the significance of following:
   i) Grashoff Number
   ii) Nusselt Number
   iii) Prandtl Number. **(06 Marks)**

c. A plate of length 750mm and width 250mm has been placed longitudinally in a stream of crude oil which flows with a velocity of 5m/s. If the oil has a specific gravity of 0.8 and kinematic viscosity of 1 stroke. Calculate:
   i) Boundary layer thickness at the middle of plate
   ii) Shear stress at the middle of plate
   iii) Friction drag on one side of the plate. **(05 Marks)**

Module-4

7 a. Obtain an expression for the rate of heat transfer when radiation shield is introduced between two parallel plates. **(10 Marks)**

b. A boiler furnace lagged with plate steel is lined with five clay bricks on the inside. The temperature of the outer side of the brick setting is 127°C and the temperature of the inside of the steel plate is 50°C. Assuming the gap between plate steel and fire clay bricks to be small compared with the size of the furnace, calculate the loss of heat per unit area by radiation between the lagging and setting ($\in$ for steel = 0.6, $\in$ for fire clay = 0.8). **(06 Marks)**

OR

8 a. Derive an expression for LMTD of a counter flow heat exchanger, state the assumption made. **(08 Marks)**

b. Hot oil is to be cooled by water in a 1-shell-pass and 8-tube-passes heat exchanger. The tubes are thin walled and are made of copper with an inner diameter of 1.4 cm. The length of each tube pass in the heat exchanger is 5m, and the overall heat transfer coefficient is 310 W/m^2°C water flows through the tubes at a rate of 0.2 kg/s and the oil through the shell at a rate of 0.3 kg/s. The water and the oil enters at the temperature of 20°C and 150°C respectively. Determine the rate of heat transfer in the heat exchanger and the outlet temperatures of the water and oil. **(08 Marks)**

Module-5

9 a. Write a short note on Aerodynamic heating. **(08 Marks)**

b. The flow rate of hot and cold fluids running through a parallel flow heat exchanger are 0.2 and 0.5 kg/s respectively. The inlet temperature on the hot and cold sides are 75°C and 20°C respectively. The exit temperature of hot water is 45°C. If the individual heat transfer coefficient on both sides are 650 W/m^{2}K, calculate the area of heat transfer (for hot and cold fluid, C_p = 4.2 kJ/kg.K) **(08 Marks)**

OR

10 a. Explain diffusive mass transfer with neat diagram. **(08 Marks)**

b. Write a short note on Ablative heat transfer. **(08 Marks)**

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