CBCS SCHEME

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18AE/AS734

Seventh Semester B.E. Degree Examination, Dec.2024/Jan.2025
Heat and Mass Transfer

Time: 3 hrs. Max. Marks: 100

Note:1. Answer any FIVE full questions, choosing ONE full question from each module.
2. Heat transfer data book is permitted.

Module-1

1 a. What are the three modes of Heat transfer? Explain their potential for occurrence. **(10 Marks)**

b. State the modes of mass transfer with suitable examples. **(10 Marks)**

OR

2 a. Define mass fraction, mole fraction, molar concentration, mass flux and molar flux. **(10 Marks)**

b. Explain Fick's law of diffusion. What is mass diffusivity? What is its dimension? **(10 Marks)**

Module-2

3 a. Derive the three dimensional heat conduction equation in Cartesian coordinates to obtain one dimensional steady state heat conduction equation with heat generation and constant thermal conductivity. **(10 Marks)**

b. The composite wall of an oven consists of three materials, two of them are of known thermal conductivity, $K_A = 20$ W/m.K and $K_C = 50$ W/m.K and known thickness $L_A = 0.3$ m and $L_C = 0.15$ m. The third material B which is sandwitched between material A and C of known thickness, $L_B = 0.15$ m, but of unknown thermal conductivity K_B.
Under steady state operating conditions, the measurement reveals an outer surface temperature of material C is 20°C and inner surface of A is 600°C and oven air temperature is 800°C. The inside convection coefficient is 25 W/m^{2}K. What is the value of K_B? **(10 Marks)**

OR

4 a. If a thin and long fin, insulated at its tip is used. Show that the heat transfer from the fin is given by,
$Q_{fin} = \sqrt{hPKA_C}(T_0 - T_\infty)\tanh(mL)$. **(12 Marks)**

b. What is Lumped system analysis? Define Biot and Fourier number and explain their physical significance. **(08 Marks)**

Module-3

5 a. Derive an equation for energy transfer for flow over a flat plate of Laminar boundary layer. **(10 Marks)**

b. A vertical plate 0.5 m high and 1 m wide is maintained at uniform temperature of 124°C. It is exposed to ambient air at 30°C. Calculate the heat transfer rate from the plate. **(10 Marks)**

OR

6 a. With a neat sketch, explain boundary layer concept for flow along a flat plate. **(12 Marks)**

b. Engine oil at 40 °C (H = 0.21 kg/(m.s) ; $\rho = 875$ kg/m^3) flows inside 2.5 cm diameter, 50 m long tube with a mean velocity of 1 m/s. Determine the pressure drop of flow through the tube. **(08 Marks)**

Module-4

7 a. Explain absorptivity, reflectivity and transmissivity of radiation. **(10 Marks)**

b. Two large parallel plates at temperature 1000 K and 600 K have emissivity of 0.5 and 0.8 respectively. A radiation shield having emissivity 0.1 on one side and 0.05 on the other side is placed between the plates. Calculate the heat transfer rate by radiation per square meter with and without radiation shield. **(10 Marks)**

OR

8 a. Explain the classification of Heat Exchanger. **(12 Marks)**

b. A thin walled concentric tube heat exchanger is used to cool engine oil from 160°C to 60°C and water, which is available at 25°C acts as coolant. The oil and water flow rates are each 2 kg/s and the diameter of the inner tube is 0.5 m and corresponding value of overall heat transfer coefficient is 250 W/m^2.K. How long must the heat exchanger takes to accomplish the desired cooling? Take, C_p of water = 4.187 kJ/kg.K, C_p of engine oil = 2.035 kJ/kg.K **(08 Marks)**

Module-5

9 a. Explain Ablative heat transfer. **(10 Marks)**

b. Calculate the temperature distribution, temperature at the middle and rate of heat flow at the root of a turbine blade with 80 mm long, 600 mm^2 in cross section and 150 mm in perimeter. The blade is made of stainless steel (K = 23.3 W/m.K) and is exposed to steam at 1000°C, while its root is maintained at 600°C. The heat transfer coefficient between the blade surface and steam is 500 W/m^2.K. **(10 Marks)**

OR

10 a. Explain aerodynamic heating in Aerospace Engineering. **(08 Marks)**

b. Air at 10°C and at a pressure of 100 kPa is flowing over a flat plate at a velocity of 3 m/s. If the plate is 30 cm wide and at a temperature of 60°C. Calculate the following quantities at x = 0.3 m.

(i) Boundary layer thickness
(ii) Local friction coefficient
(iii) Local shearing stress
(iv) Total drag force
(v) Thermal boundary layer thickness
(vi) Local convective heat transfer coefficient
(vii) The heat transfer from the plate **(12 Marks)**

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