CBCS SCHEME

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15AU62

Sixth Semester B.E. Degree Examination, Feb./Mar. 2022
Heat and Mass Transfer

Time: 3 hrs. Max. Marks: 80

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

Module-1

1 a. Briefly illustrate the following modes of heat transfer and mention the respective 'governing laws'. i) Convection ii) Conduction iii) Radiation. **(08 Marks)**

b. An electric wire of 1mm diameter and 10cm long, carrying electric current is submerged in liquid water at atmospheric pressure. The current is increased until water boils. If the heat transfer coefficient is 5kN/m^{2}K and water temperature is 100°C, find how much electric power is supplied to the wire to maintain the wire surface at 114°C. **(08 Marks)**

OR

2 a. Derive one dimensional heat conduction equation in Cartesian coordinate, in general form. **(08 Marks)**

b. Calculate the rate of heat loss from a brick wall of 5m length 4m high and 0.25m thick. The temperature of the inner surface is 110°C and that of the outer surface is 40°C. Also find the temperature at an interior point located 20cm from the inner wall. Assume K = 0.7 W/mK for the brick. **(08 Marks)**

Module-2

3 a. Derive an expression for one dimensional find equation assuming uniform cross section. **(08 Marks)**

b. If plane wall of thickness L, is maintained with surface temperatures T_1 and T_2. The thermal conductivity of the wall material varies as $K = K_0T^2$. Find the heat transfer through the wall under steady state conditions. **(08 Marks)**

OR

4 a. Define Biot and Fourier numbers and explain their physical significance. Write the relevant equations. **(08 Marks)**

b. A steel ball maintained at 450°C is suddenly exposed to an air stream at 100°C. The ball reaches 150°C after 81 minutes. Assume surface heat transfer as 12W/m^{2}K, ρ = 7860kg/m^3, C_P = 461J/kgK. Neglecting internal temperature gradient, estimate the ball diameter. **(08 Marks)**

Module-3

5 a. Explain with a sketch thermal boundary layer. Deduce a general expression for :
i) Local and average heat transfer coefficient
ii) Heat transfer for flow over a flat plate. **(08 Marks)**

b. Air flows with a velocity (free stream) of 4m/s along a flat plate of one meter length, kept at 325K. The plate is 2m wide and air is at 375K. The average heat transfer coefficient is 8W/m^{2}K. Use Reynolds – Colburn analogy, $\frac{Cm}{2} = \left(\frac{hm}{\rho C_P U_\infty}\right) P_r^{2/3}$. **(08 Marks)**

OR

6 a. Using Buckingham - π theorem show that Nusselt number is a function of Prandtl and Grashoff number. **(08 Marks)**

b. Assuming that a man can be represented by a cylinder of 0.3m diameter and 1.7m high, with a surface temperature of 30°C, calculate the heat loss from his body while standing in a wind at 36kmph and 10°C. Use the correlation, $N_u = 0.027 R_e^{0.805} \cdot P_r^{0.33}$. **(08 Marks)**

Module-4

7 a. Using NTU method, derive an expression for effectiveness of a parallel flow heat exchanger. **(08 Marks)**

b. A counter flow heat exchanger cools oil (C_P = 2.45kJ/kg K) from 115°C to 40°C using water at 0.55kg/s. The inlet and outlet temperature of cooling water are 15°C and 75°C respectively. Taking an overall heat transfer coefficient of 1450W/m^2°C and C_{PW} = 4.178 kJ/kg K. Find : i) mass flow rate of water ii) effectiveness of heat exchanger. **(08 Marks)**

OR

8 a. Sketch and explain different regimes of pool boiling. Use h v/s ΔT plot. **(08 Marks)**

b. Explain Film wise and drop wise condensation. **(08 Marks)**

Module-5

9 a. Define the following terms :
i) Block body
ii) Solid angle
iii) Radiation intensity
iv) Configuration factor. **(08 Marks)**

b. Two large plates having emissivities of 0.6 and 0.8 respectively are at 727°C and 527°C respective temperatures. A radiation shield having emissivity of 0.1 on one side and 0.05 on the other side is placed in between them. Determine the radiation heat transfer per unit area with and without the radiation shield. **(08 Marks)**

OR

10 a. State and explain :
i) Stefan Boltzmann law
ii) Kirchoff's law of radiation. **(08 Marks)**

b. Two parallel rectangular surfaces 1m × 2m are opposite to each other at a distance of 4m. The surfaces are black and at 100°C and 200°C respectively. Calculate the heat exchange by radiation between the two surfaces. Also find configuration factor, F_{12}. **(08 Marks)**

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