CBCS SCHEME

USN

21AU51

Fifth Semester B.E. Degree Examination, June/July 2024
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. Use of Heat Transfer data handbook is permitted.

Module-1

1 a. What is (i) conduction (ii) convection (iii) radiation heat transfer? **(06 Marks)**

b. What are (i) conductivity (ii) convective heat transfer coefficient? **(04 Marks)**

c. A horizontal steel pipe of 50 mm diameter maintained at 60°C is kept in a large room at 22°C. Assuming surface emissivity of steel as 0.8 and heat transfer coefficient of air as 6.5 $W/m^2{}^\circ C$, calculate the total heat lost by the pipe per unit length. **(10 Marks)**

OR

2 a. Derive 3D conduction equation in Cartesian coordinates. **(10 Marks)**

b. An exterior wall of a house may be approximated by a 10 cms layer of common brick (k = 0.7 W/mK) followed by a 4 cm layer of gypsum plaster (k = 0.48 W/m°K). What thickness of loosely packed rock wool insulation (k = 0.065 W/mK) should be added to reduce heat loss (or gain) through the wall by 80%? **(10 Marks)**

Module-2

3 a. Derive one dimensional fin equation for a rectangular fin of uniform cross-section. **(10 Marks)**

b. The end of a long rod is inserted into a furnace with the other end projecting into the outside air. After steady state is reached, the temperature of the rod is measured at two points 70 mm apart and found to be 150°C and 100°C when the ambient air is at 20°C. If the rod is 25 mm in diameter and heat transfer coefficient at the surface of the rod is 20 W/m^2K, find the thermal conductivity of the rod? **(10 Marks)**

OR

4 a. Derive the expression for the temperature distribution for the lumped heat analysis. **(10 Marks)**

b. Aluminum sphere of mass 5.5 kg and initially at a temperature of 290°C is suddenly immersed in a fluid at 15°C. The convective heat transfer coefficient is 58 W/m^2K. Estimate the time required for the sphere to reach 95°C, using lumped heat capacity method of analysis. Take properties of aluminum $\rho = 2700\ kg/m^3$; $C_p = 9005/kgK$, K = 205 W/mK. **(10 Marks)**

Module-3

5 a. Explain the significance of any five dimensionless numbers in forced and free convection. **(10 Marks)**

b. A thin 20 cm diameter horizontal plate is maintained at 120°C in a large body of water at 80°C. The plate convicts heat from its top and bottom surfaces. Determine the rate of heat input to the plate necessary to maintain the temperature of 120°C. **(10 Marks)**

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

OR

6 a. Derive the following equation for free convection Nu = ϕ(Gr, Pr) where Nu = Nusselt number Gr = Grashoff number Pr = Prandtl number. **(10 Marks)**

b. A fine wire having a diameter of 3.94×10^{-5} m is placed in a 1 bar an stream at 25°C having a velocity of 50 m/s perpendicular to the wire. An electric current is passed through the wire raising the temperature to 50°C. Calculate the heat loss per unit length. **(10 Marks)**

Module-4

7 a. Derive the expression for effectiveness of parallel flow heat exchanger by NTU method. **(10 Marks)**

b. Calculate the outside tube area for a single pass tube condenser to handle 3500 kg of dry saturated steam at 50°C. The tube has 25 mm OD and 22 mm ID and the tube material has K = 105 W/m°C. The average water velocity in each tube is limited to 2 m/s. Assume steam side film coefficient 5235 W/m^2°C and inlet and outlet water temperature as 15°C and 25°C respectively. C_p = 4181.85/kg°C, $\gamma = 1.006 \times 10^{-6}$ m^2/s, Pr = 7.02, K = 0.597 W/mK, ρ = 1000.52 kg/m^3 for water at 20°C. **(10 Marks)**

OR

8 a. Derive the expression for average heat transfer coefficient for condensation on vertical plane. **(10 Marks)**

b. Dry saturated steam at the pressure of 2.45 bar condenser on the surface of a vertical tube of height 1m. The tube surface temperature is kept at 117°C. Estimate the thickness of the condensate film and the local heat-transfer coefficient at a distance of 0.2 m from the upper end of the tube. Assume the condensate film to be laminar. **(10 Marks)**

Module-5

9 a. State : (i) Stefan-Boltzmann law (ii) Kirchoff's law (iii) Planck law (iv) Wein's displacement law **(10 Marks)**

b. The temperature of a black surface 0.2 m^2 in area is 540°C. Calculate:
(i) The total rate of energy emission
(ii) The intensity of normal radiation
(iii) The wavelength of maximum monochromatic emissive power. **(10 Marks)**

OR

10 a. State lamberts cosine law. **(04 Marks)**

b. Derive expression for heat transfer between two infinite parallel planes. **(06 Marks)**

c. Two parallel plates $T_1 > 900$ K and $T_2 = 500$ K have emissivities $\varepsilon_1 = 0.6$ and $\varepsilon_2 = 0.9$ respectively. A radiation shield having an emissivity $\varepsilon_{31} = 0.15$ on one side and emissivity $\varepsilon_{32} = 0.06$ 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)**

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