CBCS SCHEME

USN

21ME62

Sixth Semester B.E. Degree Examination, June/July 2024
Heat Transfer

Time: 3 hrs. Max. Marks: 100

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

Module-1

1 a. Explain the modes of Heat Transfer. **(04 Marks)**

b. Derive General 3D heat conduction equation in Cartesian coordinates. **(08 Marks)**

c. An exterior wall of a house may be approximated by a 0.1 m layer of common brick (K = 0.7 W/m°C) followed by a 0.04 m layer of gypsum plaster (K = 0.48 W/m°C). What thickness of loosely packed rock wool insulation (K = 0.065 W/m°C) should be added to reduce the heat loss or (gain) through the wall by 80 percent? **(08 Marks)**

OR

2 a. Derive 2-D Heat conduction equation for Hollow cylinder. **(10 Marks)**

b. A standard cast iron pipe (ID = 50 mm and OD = 55 mm) is insulated with 85 percent magnesium insulation (K = 0.02 W/m°C). Temperature at the interface between the pipe and insulation is 300°C. The allowable heat loss through the pipe is 600 W/m length of pipe and for safety, the temperature of the outside surface of insulation must not exceed 100°C. Determine:
(i) Minimum thickness of insulation required
(ii) The temperature of inside surface of pipe assuming its thermal conductivity 20 W/m°C. **(10 Marks)**

Module-2

3 a. Derive heat dissipation equation for a fin with insulated end. **(10 Marks)**

b. A steel rod (K = 32 W/m°C), 12 mm in diameter and 60 mm long, with an insulated end is to be used as a spine. It is exposed to surroundings with a temperature of 60°C and a heat transfer coefficient of 55 W/m^2°C. The temperature at the base of the fin is 95°C. Determine:
(i) Fin efficiency
(ii) The temperature at the edge of the spine
(iii) The heat dissipation **(10 Marks)**

OR

4 a. Obtain an expression for Instantaneous and total heat transfer for lumped system analysis of heat conduction. **(12 Marks)**

b. A 50 cm × 50 cm copper slab 6.25 mm thick has a uniform temperature of 300°C. Its temperature is suddenly lowered to 36°C. Calculate the time required for the plate to reach the temperature of 108°C. Take ρ = 9000 kg/m^3, c = 0.38 kJ/kg°C, k = 370 W/m°C and h = 90 W/m^2°C. **(08 Marks)**

Module-3

5 a. Explain: (i) Stefan-Boltzmen law (ii) Wien's displacement law (iii) Radiation shield (iv) Radiosity (v) Black body **(10 Marks)**

b. Consider two large parallel plates one at $t_1 = 727°C$ with emissivity $\varepsilon_1 = 0.8$ and other at $t_2 = 227°C$ with emissivity $\varepsilon_2 = 0.4$. An aluminum radiation shield with an emissivity, $\varepsilon_3 = 0.05$ on both sides is placed between the plates. Calculate the percentage reduction in heat transfer rate between the two plates as a result of the shield. **(10 Marks)**

OR

6 a. Explain how Stefan Boltzman constant is determined using Stefan Boltzman apparatus experimentally. **(10 Marks)**

b. An electric heating system is installed in the ceiling of a room 5 m (length) × 5m (width) × 2.5 m (height). The temperature of the ceiling is 315 K whereas under equilibrium conditions the walls are at 295 K, if the floor is non-sensitive to radiations and the emissivities of the ceiling and wall are 0.75 and 0.65 respectively. Calculate the radiant heat loss from the ceiling to the walls. **(10 Marks)**

Module-4

7 a. Explain briefly with sketches:
(i) Boundary layer thickness (ii) Thermal boundary layer thickness **(08 Marks)**

b. A cylindrical body of 300 mm diameter and 1.6 m height is maintained at a constant temperature is 36.5°C. The surrounding temperature is 13.5°C. Find out the amount of heat to be generated by the body per hour if $\rho = 1.025$ kg/m^3, $C_p = 0.96$ kJ/kg°C, $V = 15.06 \times 10^{-6}$ m^2/s, K = 0.0892 kJ/m-h°C and $\beta = \frac{1}{298} K^{-1}$. Assume $Nu = 0.12\,(Gr.Pr)^{1/3}$. **(12 Marks)**

OR

8 a. Explain the significance of :
(i) Reynolds number (ii) Prandtl number
(iii) Grashoff number (iv) Stenton number **(10 Marks)**

b. Air at 30°C and at atmospheric pressure flows at a velocity of 2.2 m/s over a plate maintained at 90°C. The length and the width of the plate are 900 mm and 450 mm respectively. Using exact solution calculate the heat transfer rate from:
(i) First half of the plate (ii) Full plate (iii) Next half of the plate
The properties of air at temperature 60°C are $\rho = 1.06$ kg/m^3, $\mu = 7.211$ kg/hm, $V = 18.97 \times 10^{6}$ m^2/s, Pr = 0.696, k = 0.02894 W/m°C. **(10 Marks)**

Module-5

9 a. With a neat sketch, explain the different regimes of pool boiling. **(10 Marks)**

b. A vertical plate 350 mm high and 420 mm wide at 40°C is exposed to saturated steam at 1 atm. Calculate the following:
(i) The film thickness at the bottom of plate.
(ii) The maximum velocity at the bottom of plate
(iii) The total heat flux to the plate. **(10 Marks)**

OR

10 a. Derive the expression for LMTD of a parallel flow heat exchanger. **(10 Marks)**

b. Water (C_p = 4200 J/kg°C) enters a counter flow double pipe heat exchanger at 38°C flowing at 0.076 kg/s. It is heated by oil (C_p = 1880 J/kg°C) flowing at the rate of 0.152 kg/s from an inlet temperature of 116°C. For an area of 1 m^2 and U = 340 W/m^2°C. Determine the total heat transfer rate. **(10 Marks)**

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