CBCS SCHEME

USN | | | | | | | | | | | **15ME63**

Sixth Semester B.E. Degree Examination, June/July 2023
Heat Transfer

Time: 3 hrs. Max. Marks: 80

Note: Answer any FIVE full questions, choosing ONE full question from each module.

Module-1

1 a. State the laws governing three basic modes of heat transfer. **(06 Marks)**

b. Derive the general three-dimensional conduction equation in Cartesian coordinates and state the assumptions made. **(10 Marks)**

OR

2 a. Derive an expression for the temperature distribution through the plane wall with uniform thermal conductivity. **(06 Marks)**

b. A metal [K = 45 W/m°C] steam pipe of 5 cm inside diameter and 6.5 cm outside diameter is lagged with 2.75 cm thickness of high temperature high insulation having thermal conductivity 1.1 W/m°C. convective heat transfer coefficients on the inside and outside surfaces are 4650 W/m^2K and 11.5 W/m^2K respectively. If the steam temperature is 200°c and the ambient temperature is 25°C. Calculate:

i) Heat loss per metre length of pipe

ii) Temperature at the interfaces

iii) Overall heat transfer coefficient to inside and outside surfaces. **(10 Marks)**

Module-2

3 a. Derive an expression for the temperature distribution and heat flow for a pinfin, when the tip of the fin is insulated. **(08 Marks)**

b. A thin rod of copper K = 100 W/m°C, 12.5 mm in diameter spans between two parallel plates 150 mm apart. Air flows over the rod providing a heat transfer co-efficient of 50 $W/m^2°C$. The surface temperature of the plate exceeds the air by 40°C. Determine (i) The excess temperature at the centre of the rod over that of air and (ii) Heat lost from the rod in watts. **(08 Marks)**

OR

4 a. Show that the temperature distribution under lumped analysis is given by,

$$\frac{T - T_\infty}{T_i - T_\infty} = e^{-BiFo}$$

Where T_i = Initial temperature

T_∞ = Ambient temperature **(08 Marks)**

b. A 15mm diameter mild steel sphere (K = 42W/m°C) is exposed to coding air flow at 20°C resulting in the convective co-efficient h = 120$W/m^2°C$. Determine the following:

i) Time required to cool the sphere from 550°C to 90°C.

ii) Instantaneous heat transfer rate for 2 mins after start of cooling.

iii) Total energy transferred from the sphere during first 2 mins.

Take for mild steel S = 7850kg/m^3, C_p = 475J/kg°C, α = 0.045m^2/hr. **(08 Marks)**

Module-3

5 a. Explain formulation of differential equation 1-D steady heat conduction. (06 Marks)
b. Explain different solution method used in numerical analysis of heat conduction. (06 Marks)
c. Explain applications and computation error of numerical analysis heat conduction. (04 Marks)

OR

6 a. Define (i) Blackbody (ii) Planks law (iii) Wein displacement law (iv) Lamberts law. (06 Marks)
b. Prove that emissive power of the black body in hemispherical enclosures in π terms of intensity of radiation. (06 Marks)
c. The temperature of black surface of 0.2 m^2 area is 540°C. calculate (i) the total rate of energy emission (ii) the intensity of normal radiation (iii) the wavelength of maximum monochromatic emission power. (04 Marks)

Module-4

7 a. Explain the physical significance of:
(i) Prandtl number (ii) Reynolds number (iii) Nusselt number (06 Marks)
b. Air at 1 atm pressure and temperature 25°C flowing with a velocity 50 m/s crosses an industrial heater made of long solid rod of diameter 20 mm. The surface temperature of the heater is 457°C. Determine the allowable electrical power density (W/m^3) within the heater per meter length. (10 Marks)

OR

8 a. A circular plate of 25 cm diameter with both surfaces maintained at a uniform temperature of 100°C is suspended horizontally in atmospheric air at 20°C. Determine the heat transfer from the plate. (10 Marks)
b. Obtain the fundamental relationship between Nusselt, Prandtle and Reynolds number using Buckingham's π - theorem for forced convection heat transfer. (06 Marks)

Module-5

9 a. With assumptions, determine LMTD for counter flow heat exchanger. (08 Marks)
b. A parallel flow heat exchanger uses 1500 kg/hr of cold water entering at 25°C to cool 600 kg/hr of hot water entering at 70°C. The exit temperature on the hot side is required to be 50°C. Neglecting the effects of fouling make calculations for the area of heat exchanger. It may be assumed that the individual heat transform co-efficient on both sides are 1600 W/m^2K. Use LMTD and NTU approaches. (08 Marks)

OR

10 a. With a neat sketch, explain the different regimes of pool boiling. (08 Marks)
b. A vertical square plate 300m × 300m is exposed to steam at atmospheric pressure. The plate temperature is 98°C. Calculate the heat transfer and the mass of steam condensed per hour. (08 Marks)

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