CBCS SCHEME

USN | | | | | | | | | | | **18MR61**

Sixth Semester B.E. Degree Examination, June/July 2023
Heat 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 hand book allowed.

Module-1

1 a. Explain briefly: i) Thermal conductivity ii) Thermal diffusivity iii) Overall heat transfer coefficient. **(06 Marks)**

b. Derive the general three dimensional conduction equation in cartesian coordinates. **(08 Marks)**

c. A reactor wall, 320mm thick, is made up of an inner layer of fire brick (K = 0.84 W/m°C) covered with a layer of insulation (K = 0.16 W/m°C). The reactor operates at a temperature of 1325°C and the ambient temperature is 25°C.

i) Determine the thickness of fire brick and insulation which gives minimum heat loss.

ii) Calculate the heat loss assuming the insulating material has a maximum temperature of 1200°C. **(06 Marks)**

OR

2 a. What is critical thickness of insulation? Derive an expression for critical thickness of insulation for sphere. **(10 Marks)**

b. A wire of 6.5mm diameter at a temperature of 60°C is to be insulated by a material having K = 0.174W/m°C. Convection heat transfer coefficient is 8.722W/m^2°C. The ambient temperature is 20°C. For maximum heat loss, what is the minimum thickness of insulation and heat loss per meter length? Also find percentage increase in heat dissipation. **(10 Marks)**

Module-2

3 a. Derive an expression for heat transfer and temperature distribution for pin fin, when the tip of fin is insulated. **(10 Marks)**

b. Define: i) Fin efficiency ii) Fin effectiveness. **(04 Marks)**

c. A carbon steel (K = 54W/m°C) rod with a cross section of an equilateral triangle each of 5mm side is 80mm long. It is attached to a plane wall which is maintained at a temperature of 400°C. The surrounding environment is at 50°C and unit surface conductance is 90W/m^2°C. Compute the heat dissipated by the rod. **(06 Marks)**

OR

4 a. Derive an expression for temperature distribution of lumped system. Also obtain an expression for instaneous and total heat transfer. **(14 Marks)**

b. A thermocouple junction of spherical form is to be used to measure the temperature of gas stream h = 400W/m^2°C, K = 20W/m°C, C = 400J/kg°C, ρ = 8500kg/m^3. Calculate the following :

i) Junction diameter needed for the thermocouple to have thermal time constant of 1 second.

ii) Time required for the thermocouple junction to reach 198°C. If junction is initially at 25°C and is placed in a gas stream which is at 200°C. **(06 Marks)**

Module-3

5 a. Explain the physical significance of : i) Grashoff Number ii) Prandtl Number iii) Nusselt number iv) Reynolds number v) Peclet number. **(10 Marks)**

b. In a straight tube of 60mm diameter, water is flowing at a velocity of 12m/s. The tube surface temperature is maintained at 70°C and the flowing water heated from inlet temperature 15°C to an outlet temperature of 45°C. Taking the physical properties of water at its mean bulk temperature, calculate the following.
i) The heat transfer coefficient from the tube surface to the water.
ii) The heat generated.
iii) Length of tube
Take thermophysical properties at 30°C, ρ = 995kg/m^3, k = 0.617W/m°k, $\gamma = 0.805 \times 10^{-6}$m^2/s, $P_r = 5.42$. **(10 Marks)**

OR

6 a. Using dimensional analysis, obtain the dimensionless parameter in free convection heat transfer. **(10 Marks)**

b. A 350mm long glass plate is hung vertically in the air at 24°C while its temperature is maintained at 80°C. Calculate the boundary layer thickness at the trailing edge of the plate. If a plate is placed in a wind tunnel and air is blown over it at a velocity of 5m/s, find the boundary layer thickness at its trailing edge.
Also determine the average heat transfer coefficient for natural and forced convection for the above mentioned data.
Take properties at t_f = 52°C is
$K = 28.15 \times 10^{-3}$W/m°C, $\gamma = 18.41 \times 10^{-6}$m^2/s, $P_r = 0.7$, $\beta = 3.07 \times 10^{-3}$k^{-1}. **(10 Marks)**

Module-4

7 a. Derive an expression for LMTD for a heat exchanger where fluids flow opposite to each other. Also state the assumptions. **(10 Marks)**

b. The flow rates of hot and cold water streams running through a parallel flow heat exchanger are 0.2kg/s and 0.5kg/s respectively. The inlet temperatures on the hot and cold sides are 75°C and 20°C respectively. The exit temperature of hot water is 45°C. If the individual heat transfer coefficient on both sides are 650W/m^2°C. Calculate the area of the heat exchanger. **(10 Marks)**

OR

8 a. With a neat diagram, explain the regimes of pool boiling. **(08 Marks)**

b. A vertical cooling fin approximating a flat plate 40cm in height is exposed to standard steam at atmospheric pressure. The fin maintained at a temperature of 90°. Estimate the following:
i) Thickness of film at the bottom of plate.
ii) Overall heat transfer coefficient.
iii) Heat transfer rate after incorporating MC Adam's correction. **(12 Marks)**

Module-5

9 a. Prove that the emissive power of black body is π-Times the intensity of radiation for a black body enclosed in hemispherical space. **(10 Marks)**

b. Consider two large plates one at 727°C with emissivity $\epsilon_1 = 0.8$ and other at 227°C with emissivity $\epsilon_2 = 0.4$. An aluminium radiation shield with an emissivity $\epsilon_s = 0.05$ 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. Also determine the temperature of radiation shield. **(10 Marks)**

OR

10 a. Explain the following: i) Concept of black body ii) Radiation shield iii) Lamberts cosine law iv) Stefan Boltzman law v) Kirchoff's law. **(10 Marks)**

b. Two large parallel plates with emissivity 0.6 are at 900K and 300K. A radiation shield with one side polished and having an emissivity of 0.05 and other side unpolished with emissivity of 0.4 is proposed to be used between them. Which side of shield should face the hotter plate if the temperature of shield to be kept minimum? Justify your answer. **(10 Marks)**