CBCS SCHEME

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18ME63

Sixth Semester B.E. Degree Examination, Dec.2024/Jan.2025
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 heat transfer data hand book and steam tables are permitted.

Module-1

1 a. Explain briefly : (i) Thermal conductivity (ii) Thermal diffusivity. **(05 Marks)**

b. Write down three-dimensional heat conduction equation for Cartesian co-ordinates, write the Poisson's, Laplace, Fourier equations and one-dimensional equation for the same. **(05 Marks)**

c. The interior of a refrigerator having inside dimension $0.5\text{m} \times 0.5\text{m}$ base area and 1 m height, is to be maintained at 6°C. The walls of the refrigerator are constructed with two mild steel sheets of 3 mm thick (K = 46.5 W/m$^\circ$C) and with 50 mm of glass wall insulation (K = 0.046 W/m$^\circ$C) between them. If the average heat transfer coefficient at the outer and inner surfaces are 11.6 W/m^2°C and 14.5 W/m^2°C respectively. Calculate

(i) The rate at which heat must be removed from the interior to maintain the specified temperature in the kitchen at 25°C.

(ii) Temperature on the outer surface of the metal sheet. **(10 Marks)**

OR

2 a. What is meant by Boundary condition? Explain. **(05 Marks)**

b. Discuss the design aspects for providing insulation scheme for cable wire and steam pipes. **(05 Marks)**

c. A wall of a furnace is made up of inside layer of silica brick 120 mm thick covered with a layer of magnesite brick 240 mm thick. The temperatures at the inside surface of silica brick wall and outside surface of magnesite brick wall are 725°C and 110°C respectively. The contact thermal resistance between the two walls at the interface is 0.0035 C/W per unit wall area. If the thermal conductivities of silica and magnesite bricks are 1.7 W/m$^\circ$C and 5.8 W/m$^\circ$C. Calculate

(i) The rate of heat loss per unit area of walls.

(ii) The temperature drop at the interface. **(10 Marks)**

Module-2

3 a. Derive the differential equation governing the temperature distribution for a fin of a uniform cross section by assuming thermal conductivity, the heat transfer co-efficient and ambient temperature being constant. **(10 Marks)**

b. In a thermal conductivity measuring experiments two identical rods are used. One of the rod is base aluminium (K = 200 W/mK). The other rod is a specimen. One end of both the rod is fixed to a wall at 100°C. While other end is suspended in air at 25°C. The steady temperature at the same distance along the rods were measured and found to be 75°C on aluminium and 60°C on specimen rod. Find the thermal conductivity of specimen rod, if the fin tip is insulated. **(10 Marks)**

OR

4 a. What is lumped parameter analysis? Prove that the temperature distribution in a body at time 't' during Newtonian heating or cooling is given by $\dfrac{T - T_\infty}{T_i - T_\infty} = e^{-B_i F_o}$, where T_i is temperature at time t = 0. **(10 Marks)**

b. An apple which can be considered as sphere of 8 cm diameter is initially at a uniform temperature of $25^\circ C$ is put into a freezer at $-15^\circ C$. The heat transfer co-efficient between the surface of the apple and surrounding in the freezer is $15\ \omega/m^{2^\circ}C$. The thermo-physical properties of apple are given to be,
density $= 840\ kg/m^3$, Specific heat $= 3.6\ kJ/kg^\circ C$
Thermal conductivity $= 0.513\ W/m^\circ C$ and Thermal diffusivity $= 1.3\times10^{-7}\ m^2/s$
Determine (i) Centre temperature of apple after 1 hour.
(ii) Surface temperature of apple at that time.
(iii) Amount of heat transferred from the apple. **(10 Marks)**

Module-3

5 a. Explain the following : (i) Solid angle (ii) Shape factor (iii) Irradition (iv) Absorptivity (v) Emissive power **(10 Marks)**

b. Consider two large parallel plates one at 100 K with emissivity 0.8 and other is at 300 K having emissivity 0.6. A radiation shield is placed between them. The shield has emissivity as 0.1 on the side facing hot plate and 0.3 on the side facing cold plate. Calculate percentage reduction in radiation heat transfer. **(10 Marks)**

OR

6 a. Explain formulation of differential equation 1D steady heat conduction. **(10 Marks)**

b. Explain application and computational error of numerical analysis heat conduction. **(10 Marks)**

Module-4

7 a. Explain velocity and thermal boundary layer. **(10 Marks)**

b. Consider the body of a mass has vertical cylinder with 300 mm dia and 170 cm height. Calculate heat generated by the body in 1 day. Take body temperature as $36^\circ C$ and ambient temperature as $14^\circ C$. **(10 Marks)**

OR

8 a. Using dimensional analysis, obtain fundamental relation between dimensionless parameter in forced convection. **(10 Marks)**

b. A long 10 cm dia steam pipe whose external surface temperature is $110^\circ C$ passes through some open area. Determine the rate of heat loss from pipe per unit of its length when air is at 1 atm pressure and $10^\circ C$. The wind is blowing across the pipe at velocity 8 m/s. **(10 Marks)**

Module-5

9 a. Obtain expression for LMTD for parallel flow heat exchanger. **(10 Marks)**

b. The flow rate of hot and cold flux stream running through a parallel heat exchanger are 0.2 kg/s and 0.2 kg/s respectively. The inlet temperature of hot and cold sides are $75^\circ C$ and $20^\circ C$ respectively. The Exit temperature of hot water is $45^\circ C$. If Individual heat transfer coefficient on both sides are $650\ W/m^2C$. Calculate area of heat transfer. **(10 Marks)**

OR

10 a. Sketch and explain boiling curve. **(10 Marks)**

b. Saturated steam at $80^\circ C$ condenses as film on a vertical plate at a temperature of $70^\circ C$. Calculate Heat transfer coefficient and rate of condensation. Assume Latent heat of vapourization at $80^\circ C$ as 2309 kJ/kg. **(10 Marks)**

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