CBCS SCHEME

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18AU62

Sixth Semester B.E. Degree Examination, Dec.2023/Jan.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 and steam tables are permitted.

Module-1

1 a. Explain three modes of heat transfer with their basic laws. **(06 Marks)**

b. Explain any two boundary conditions involved in heat transfer problems. **(04 Marks)**

c. A steel tube 80 mm ID and 100 mm OD of K = 40 W/mK is covered with 10 mm thick insulation of K = 0.17 W/mK. The tube transports a fluid at 180°C with a inner surface conductance of 250 W/m^{2}K and exposed to ambient air at 30°C with an outer surface conductance of 25 W/m^{2}K. Calculate heat transfer per meter length and the interface temperatures. **(10 Marks)**

OR

2 a. Derive 3-dimentional heat conduction equation in Cartesian coordinate system. **(10 Marks)**

b. A square plate heater of size 20 × 20 cm is inserted between two slabs. 'A' is 3 cm thick (K = 50 W/mK) and slab 'B' is 1.5 cm (K = 0.2 W/mK). The outside heat transfer coefficients on both sides of A and B are 200 and 50 W/m^{2}K respectively. Temperature of surrounding air is 25°C. If the rating of the heater 1 kW, find:
(i) Maximum temperature in the system.
(ii) Outer surface temperature of two slabs **(10 Marks)**

Module-2

3 a. Explain the importance of critical thickness of insulation. **(04 Marks)**

b. Derive an expression for critical thickness of insulation for sphere. **(06 Marks)**

c. Calculate critical radius of insulation for asbestors (K = 0.17 W/m°C) surrounding a pipe and exposed to room air at 20°C with h = 3 W/m^2°C. Calculate the heat loss from a 200°C, 50 mm dia meter pipe when covered with critical radius of insulation and without insulation. **(10 Marks)**

OR

4 a. Derive an equation of temperature distribution using lumped parameter model. **(10 Marks)**

b. A 15 mm diameter mild steel sphere K = 42 W/m°C is exposed to cooling air flow at 20°C resulting in convective coefficient h = 120 W/m^{2}K. Determine the following :
(i) Time required to cool sphere from 550°C to 90°C.
(ii) Instantaneous heat flow rate 2 min after the start of cooling.
Take for mild steel ρ = 7850 kg/m^3; C_p = 475 J/kg°C, α = 0.045 m^2/hr. **(10 Marks)**

Module-3

5 a. Explain velocity boundary layer and thermal boundary layer with sketch. **(10 Marks)**

b. Assuming that a man can be represented by a cylinder 30 cm in diameter and 1.8 m height with a surface temperature of 37°C. Calculate the heat he would lose while standing in a 24 km/hr wind at 3°C. **(10 Marks)**

OR

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

b. A steam pipe 100 mm diameter maintained at 170°C is exposed to air at 30°C. The length of the pipe is 2m and is kept horizontal. Determine the heat loss by the pipe per hour. **(10 Marks)**

Module-4

7 a. Derive an expression for log mean temperature difference [LMTD] for parallel flow heat exchanger. **(10 Marks)**

b. Water to water heat exchanger of a counter flow arrangement has heating surface area of 2 m^2. Mass flow rates of hot and cold fluids are 200 kg/hr and 1500 kg/hr respectively. Temperatures of hot and cold fluids at inlet are 85°C and 25°C respectively. Determine the amount of heat transferred from hot to cold water and their temperatures at exit if the overall heat transfer coefficient U = 1400 W/m^2K. **(10 Marks)**

OR

8 a. Explain different regimes of pool boiling. **(10 Marks)**

b. A vertical plate 30 cm × 30 cm 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. **(10 Marks)**

Module-5

9 a. Derive an expression of emissivity for two large parallel gray planes. **(10 Marks)**

b. Two concentric cylinders having diameters 10 cm and 20 cm have a length of 2m. Calculate the radiation shape factor between the open ends of the cylinders. **(10 Marks)**

OR

10 a. Define the following:
(i) Stefan's Boltzman law (ii) Planck's law (iii) Wein's displacement law
(iv) Lambert's law (v) Kirchoff's law **(10 Marks)**

b. Calculate the net radiant heat exchange per unit area for two large parallel plates at temperature of 427°C and 27°C respectively. $\epsilon_{hot\ plate} = 0.9$, $\epsilon_{cold\ plate} = 0.6$. If a polished alluminium shield is placed between them. Find the percentage reduction in the heat transfer $\epsilon_{shield} = 0.04$. **(10 Marks)**

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