

CBCS SCHEME

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

OR

- 2 a. Derive 3-dimensional heat conduction equation in Cartesian coordinate system. (10 Marks)
b. A square plate heater of size $20 \times 20 \text{ cm}$ is inserted between two slabs. 'A' is 3 cm thick ($K = 50 \text{ W/mK}$) and slab 'B' is 1.5 cm ($K = 0.2 \text{ W/mK}$). The outside heat transfer coefficients on both sides of A and B are 200 and $50 \text{ W/m}^2\text{K}$ 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 ($K = 0.17 \text{ W/m}^\circ\text{C}$) surrounding a pipe and exposed to room air at 20°C with $h = 3 \text{ W/m}^2\text{C}$. 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 $K = 42 \text{ W/m}^\circ\text{C}$ is exposed to cooling air flow at 20°C resulting in convective coefficient $h = 120 \text{ W/m}^2\text{K}$. 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 $\rho = 7850 \text{ kg/m}^3$; $C_p = 475 \text{ J/kg}^\circ\text{C}$, $\alpha = 0.045 \text{ m}^2/\text{hr}$. (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)

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

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 $U = 1400\text{ W/m}^2\text{K}$. (10 Marks)

OR

- 8 a. Explain different regimes of pool boiling. (10 Marks)
- b. A vertical plate $30\text{ cm} \times 30\text{ cm}$ 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. $\epsilon_{\text{hot plate}} = 0.9$, $\epsilon_{\text{cold plate}} = 0.6$. If a polished alluminium shield is placed between them. Find the percentage reduction in the heat transfer $\epsilon_{\text{shield}} = 0.04$. (10 Marks)
