CBCS SCHEME

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18ME63

Sixth Semester B.E. Degree Examination, Dec.2023/Jan.2024
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, thermodynamic data handbook and steam tables are permitted.

Module-1

1 a. Write down three-dimensional heat conduction for Cartesian coordinates. Explain all the terms involved. Also reduce this equation as the Poisson's, Laplace, Fourier equation and one dimensional equation. **(08 Marks)**

b. A plane wall of thickness L is subjected to a heat supply at a rate of q_0 W/m^2 at one boundary surface and dissipates heat from the surface by convection to the ambient which is at a uniform temperature of T_∞ with a surface heat transfer coefficient of h_∞. Write the mathematical formulation of the boundary conditions for plane wall. **(08 Marks)**

c. What is meant by thermal diffusivity? What is its significance? **(04 Marks)**

OR

2 a. Derive the general three dimensional conduction equation in Cartesian coordinates and state the assumptions made. **(08 Marks)**

b. 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 thermal conductivities of silica and magnesite bricks are 1.7 W/m°C and 5.8 W/m°C. Calculate:
(i) The rate of heat loss unit area of wall
(ii) The temperature drop at the interface **(08 Marks)**

c. What is meant by critical insulation? What is its significance on steam pipe and electrical cables? **(04 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 coefficient and ambient temperature being constant. **(08 Marks)**

b. A rod [K = 200 W/mK] 5 mm in diameter and 5 cm long has its one end maintained at 100°C. The surface of the rod is exposed to ambient air at 25°C with convection heat transfer coefficient of 100 W/m^{2}K. Assuming other end is insulated. Determine:
(i) The temperature of rod at 20 mm distance from the end at 100°C.
(ii) Heat dissipation rate from the surface. **(08 Marks)**

c. Differentiate between effectiveness and efficiency of fin. **(04 Marks)**

OR

4 a. Obtain an expression for instantaneous heat transfer for lumped heat transfer analysis of heat conduction problem. **(08 Marks)**

b. A 12 cm diameter long bar initially at a uniform temperature of 40°C is placed in a medium at 650°C with a convective coefficient of 22 W/m^2K. Calculate the time required for the bar to reach 255°C. Take K = 20 W/mK, $\rho = 580\ kg/m^3$, c = 1050 J/kgK. **(08 Marks)**

c. What are Heisler charts? Explain their significance. **(04 Marks)**

Module-3

5 a. Explain formulation of differential equation 1-D steady heat conduction. **(08 Marks)**

b. Explain different solution method used in numerical analysis of heat conduction. **(08 Marks)**

c. Explain application and computations error of numerical analysis heat conduction. **(04 Marks)**

OR

6 a. State and explain:
(i) Stefan Boltzman law (ii) Krichoff's law
(iii) Wien's displacement law (iv) Lambert's cosine law **(08 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, $\in_{hotplate} = 0.9$, $\in_{coldplate} = 0.6$. If a polished aluminium shield is placed between them. Find the percentage reduction in heat transfer, $\in_{shield} = 0.04$. **(08 Marks)**

c. Write concept of Black Body. **(04 Marks)**

Module-4

7 a. Explain physical significance of:
(i) Grashoff number (ii) Prandtl Number
(iii) Nusselt number (iv) Reynolds number **(08 Marks)**

b. A tube of 0.036 m OD, 40 cm length is maintained at a uniform temperature of 100°C. It is exposed to air at a uniform temperature of 20°C. Determine the rate of HT from the surface of the tube (i) If tube is vertical (ii) if tube is horizontal **(08 Marks)**

c. A vertical door of a hot oven is 0.5 m high and is maintained at 200°C. It is exposed to atm air at 20°C find local heat transfer coefficient half way up to the door. Take properties of air at 110°C, $\nu = 24.29 \times 10^{-6}\ m^2/s$, Pr = 0.687, K = 0.03274 W/mL. **(04 Marks)**

OR

8 a. Using dimensional analysis, obtain the dimensionless parameters in forced convection heat transfer. **(08 Marks)**

b. Air at 20°C and 1 atm flows over a flat plate at 35 m/s. The plate is 75 cm long and is maintained at 60°C. Assuming unit depth in the z-direction. Calculate heat transfer from the plate. **(08 Marks)**

c. What is difference between:
(i) free and forced convection
(ii) Laminar and turbulent flow **(04 Marks)**

Module-5

9 a. Derive an expression for LMTD of counter flow heat exchanger. State the assumptions made. **(08 Marks)**

b. The flow rate of hot and cold flux streams running through a parallel flow heat exchanger are 0.2 kg/s and 0.5 kg/sec respectively. The inlet temperature 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 650 $W/m^2{}^\circ C$. Calculate area of heat transfer. **(08 Marks)**

c. Write a note on Fouling Factor. **(04 Marks)**

OR

10 a. Water is boiled at a rate of 30 kg/hour in a copper pan 30 cm dia at atmospheric pressure. Estimate temperature at bottom of the surface of the pan. Assuming nucleate boiling condition. **(08 Marks)**

b. A vertical cooling fin approximate a flat plate of 40 cm height and is exposed to saturated steam at 100°C. (h_{fg} = 2257 kJ/kg). The fin is maintained at a temperature of 90°C. Calculate:
(i) Thickness of film at bottom of film
(ii) Average heat transfer coefficient
(iii) Heat transfer after incorporating Mc-Adam's correction factor.
Take $\rho = 965.8$ kg/m^3, K = 0.68 W/mK, $\mu = 3.153 \times 10^{-4}$ kg/m-s **(08 Marks)**

c. Differentiate:
(i) Sub cooled boiling and saturated boiling
(ii) Drop wise condensation and film wise condensation. **(04 Marks)**

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