CBCS SCHEME

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21AE734

Seventh Semester B.E./B.Tech. Degree Examination, Dec.2024/Jan.2025
Heat and Mass Transfer

Time: 3 hrs. Max. Marks: 100

Note: Answer any FIVE full questions, choosing ONE full question from each module.

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.

Module-1

1 a. Explain heat transfer and its modes with an examples. **(10 Marks)**

b. State the laws governing three basic modes of heat transfer and explain. **(10 Marks)**

OR

2 a. Explain types of mass transfer with examples. **(06 Marks)**

b. Explain the thermal boundary condition. **(06 Marks)**

c. Define the following terms with their units :

(i) Thermal conductivity
(ii) Specific weight
(iii) Viscosity
(iv) Overall heat co-efficient **(08 Marks)**

Module-2

3 a. Derive the general three dimensional conduction equations in Cartesian coordinates and state the assumption made. **(12 Marks)**

b. A $50\text{cm} \times 50\text{cm}$ copper slab 6.25 mm thick has a uniform temperature of $300\,^\circ\text{C}$. Its temperature is suddenly lowered to $36\,^\circ\text{C}$. Calculate the time required for the plate to reach the temperature of $108\,^\circ\text{C}$. Assume $\rho = 9000\ \text{kg/m}^3$, $C = 0.38\ \text{kJ/kg}\,^\circ\text{C}$.
Take $K = 370\ \text{W/m}\,^\circ\text{C}$, $h = 90\ \text{W/m}^2\text{C}$. **(08 Marks)**

OR

4 a. Derive an expression for instantaneous heat transfer and total heat transfer, for lumped heat analysis treatment of heat conduction problem. **(12 Marks)**

b. A solid copper sphere of 10 cm diameter $\rho = 8954\ \text{kg/m}^3$, $C = 383\ \text{J/kgK}$, $K = 386\ \text{W/mK}$, initially at a uniform temperature $250\,^\circ\text{C}$ is suddenly immersed in a wall-stirred fluid which is maintained at a uniform temperature $T_\infty = 50^\circ\text{C}$. The heat transfer co-efficient between sphere and the fluid $h = 200\ \text{W/m}^2\text{K}$. Determine the temperature of the copper sphere at time 5 min after the immersion. **(08 Marks)**

Module-3

5 a. Using Buckingham's π theorem, obtain a relationship between N_u, P_r and R_e for forced convection heat transfer. **(10 Marks)**

b. Calculate the convection heat loss from a radiator 0.5 m wide and 1 m high maintained at a temperature of $84\,^\circ\text{C}$ in a room at $20\,^\circ\text{C}$. Treat the radiator as a vertical plate. **(10 Marks)**

OR

6 a. Explain the development of hydrodynamic and thermal boundary layer when a fluid flow over a flat plate. **(08 Marks)**

b. Air at 10 °C and at a pressure of 100 KPa is flowing over a plate at a velocity of 3 m/s. If the plate is 30 cm wide and at a temperature of 60 °C. Calculate the following at x = 0.3 m:

(i) Boundary layer thickness (ii) Local friction coefficient
(iii) Local shearing stress (iv) Total drag force
(v) Thermal boundary layer thickness
(vi) Local convection heat transfer co-efficient
(vii) The heat transfer from the plate. **(12 Marks)**

Module-4

7 a. With assumption, derive an expression for LMTD for a parallel flow heat exchanger. **(10 Marks)**

b. Exhaust gases flowing through a Heat exchanger at the rate of 20 kg/min is cooled from 400 °C to 120 °C by water initially at 10 °C. Specific heat of gases may be taken as 1.13 KJ/kgK and overall heat transfer coefficient based on outside diameter as 502.3 KJ/m^2hrK. If water flow rate is 25 kg/min. Calculate the surface area needed for, (i) Parallel flow (ii) Counter flow and suggest which type of Heat exchanger is good. **(10 Marks)**

OR

8 a. Obtain an expression for the rate of heat transfer when radiation shield is introduced between two parallel plates. **(10 Marks)**

b. Two large parallel plates with $\varepsilon = 0.5$ each are maintained at different temperature and exchanging heat only by radiation. Two equally large radiation shields with surface emissivity 0.05 are introduced in parallel to the plates. Find the percentage reduction in net radiative heat transfer. **(10 Marks)**

Module-5

9 a. Explain the heat transfer concept for the following :

(i) Rocket thrust chamber.
(ii) Gas turbine combustion chamber. **(12 Marks)**

b. Discuss the heat transfer problems and possible solution in nozzle and turbine blade of gas turbine engine. **(08 Marks)**

OR

10 a. Explain the following terms :

(i) Aerodynamic heating.
(ii) Ablative heat transfer. **(06 Marks)**

b. With a neat sketch, explain the types of combustion chamber. **(09 Marks)**

c. Describe various methods of turbine blade cooling employed for gas turbine engines. **(05 Marks)**

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