CBCS SCHEME

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18AE/AS734

Seventh Semester B.E. Degree Examination, Jan./Feb. 2023
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 is permitted.

Module-1

1 a. Explain Fourier's law of conduction. Also, state the assumptions on which this law is based. **(08 Marks)**

b. A carbon steel plate (thermal conductivity = 45 W/m°C) 600 mm × 900 mm × 25 mm is maintained at 310°C. Air at 15°C blows over the hot plate. If convection heat transfer coefficient is 22 W/m^2°C and 250 W is lost from the plate surface by radiation, calculate the inside plate temperature. **(12 Marks)**

OR

2 a. Explain the following terms:
(i) Thermal conductivity of materials
(ii) Thermal resistance
(iii) Conduction heat transfer
(iv) Convection heat transfer
(v) Radiation heat transfer **(10 Marks)**

b. A surface having an area of 1.5 m^2 and maintained at 300°C exchanges heat by radiation with another surface at 40°C. The value of factor due to the geometric location and emissivity is 0.52. Determine:
(i) Heat lost by radiation
(ii) The value of thermal resistance
(iii) The value of equivalent convection coefficient **(10 Marks)**

Module-2

3 a. Derive an expression for heat conduction equation in cylindrical coordinates. **(10 Marks)**

b. An exterior wall of a house may be approximated by a 0.1 m layer of common brick (k = 0.7 W/m°C) followed by a 0.04 m layer of gypsum plaster (K = 0.48 W/m°C). What thickness of loosely packed rock wool insulation (K = 0.065 W/m°C) should be added to reduce the heat loss or gain through the wall by 80 percent? **(10 Marks)**

OR

4 a. Derive an expression for temperature distribution and heat dissipation in a straight fin of rectangular profile for infinitely long fin. **(12 Marks)**

b. A 15 mm diameter mild steel sphere (K = 42 W/m°C) is exposed to cooling airflow at 20°C resulting in the convective coefficient h = 120 W/m°C. Determine the following:
(i) Time required to cool the sphere from 550°C to 90°C.
(ii) Instantaneous heat transfer rate 2 minutes after the start of cooling.
(iii) Total energy transferred from the sphere during the first 2 minutes.
For mild steel, take ρ = 7850 kg/m^3, C = 475 J/kg°C and α = 0.045 m^2/h. **(08 Marks)**

Module-3

5 a. With suitable equations, explain the following terms:
(i) Displacement thickness
(ii) Momentum thickness
(iii) Energy thickness **(12 Marks)**

b. Air at 1 bar and at a temperature of 30°C ($\mu = 0.06717$ kg/hrs) flows at a speed of 1.2 m/s over a flat plate. Determine the boundary layer thickness at distance of 250 mm and 500 mm from the leading edge of the plate. Also, calculate the mass entrainment between these two sections. Assume the parabolic velocity distribution as:

$$\frac{u}{U} = \frac{3}{2}\left(\frac{y}{\delta}\right) - \frac{1}{2}\left(\frac{y}{\delta}\right)^3$$ **(08 Marks)**

OR

6 a. Derive expressions for momentum and energy equations for laminar free convection heat transfer on a vertical flat plate. **(08 Marks)**

b. A hot plate 1.2 m wide, 0.35 m high and at 115°C is exposed to the ambient still air at 25°C. calculate the following:
(i) Maximum velocity at 180 mm from the leading edge of the plate.
(ii) The boundary layer thickness at 180 mm from the leading edge of the plate.
(iii) Local heat transfer coefficient at 180 mm from the leading edge of the plate.
(iv) Average heat transfer coefficient over the surface of the plate.
(v) Total mass flow through the boundary.
(vi) Heat loss from the plate.
Use the approximate solution. **(12 Marks)**

Module-4

7 a. Explain the following terms:
(i) Total emissive power (ii) Emissivity (iii) Monochromatic emissive power
(iv) Intensity of radiation (v) Blackbody **(10 Marks)**

b. Calculate the net radiant heat exchange per m^3 area for two large parallel plates at temperature of 427°C and 27°C respectively. $\in$ (hot plate) = 0.9 and $\in$ (cold plate) = 0.6. If a polished aluminium shield is placed between them, find the percentage reduction in the heat transfer $\in$ (shield) = 0.4. **(10 Marks)**

OR

8 a. Derive an expression for logarithmic mean temperature difference for parallel flow heat exchanger. Also, state the assumptions made. **(12 Marks)**

b. The velocity of water flowing through a tube of 22 mm diameter is 2 m/s. Steam condensing at 150°C on the outside surface of the tube heats the water from 15°C to 60°C over the length of the tube. Neglecting the tube and steam side film resistance, calculate the following: (i) The heat transfer coefficient and (ii) The length of the tube.
Take the following properties of water at mean temperature:
$\rho = 990$ kg/m^3, $C_p = 4.2$ kJ/kg°C, $K = 0.5418$ W/m°C, $\mu = 700 \times 10^{-6}$ kg/ms **(08 Marks)**

Module-5

9 a. Explain the following terms: (i) Aerodynamic heating (ii) Ablative heat transfer **(10 Marks)**

b. Describe various methods of turbine blade cooling employed for gas turbine engines. **(10 Marks)**

OR

10 a. Illustrate the distribution of airflow for the gas turbine combustor with neat sketch. **(10 Marks)**

b. List out the heat transfer problems occurred in gas turbine combustor and rocket thrust chamber. **(10 Marks)**

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