5E3176

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B. Tech. (Sem. V) (Main/Back) Examination, December - 2013
Mechanical Engg.
5ME2 Heat Transfer

Time : 3 Hours] [Total Marks : 80
[Min. Passing Marks : 24

Attempt any five questions. Selecting one question from each unit. All questions carry equal marks. Schematic diagrams must be shown wherever necessary. Any data you feel missing suitably be assumed and stated clearly. Units of quantities used / calculated must be stated clearly.

Use of following supporting material is permitted during examination.
(Mentioned in form No. 205)

1. NIL 2. NIL

UNIT - I

1 (a) What are the modes of heat transfer ? Explain their principle. **6**

(b) An infinite slab of 50 mm thickness and 0.1 m^2 cross-sectional area has its sides maintained at temperatures of 300°C and 30°C respectively. Measurements indicate that when 1 kW of energy as heat flow through it, the temperature at its center plane is 125°C. Set up an expression for thermal conductivity of the slab material if it is varies linearly with temperature. **10**

OR

1 (a) Discuss the nature and role of differential equations in heat transfer. **6**

(b) Derive an expression for the heat flow rate through a hollow sphere of inside radius r_1 and outside radius r_2, whose internal and external surfaces are maintained at temperatures t_1 and t_2 respectively. The thermal conductivity of the sphere material has a quadratic variation with temperature : $k = k_0\left(1+\alpha t+\beta t^2\right)$.

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UNIT - II

2 (a) Explain following terms : fin efficiency, fin effectiveness, periodic heat conduction.

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(b) A fin has 5 mm diameter and 100 mm length. The thermal conductivity of fin material is 400 W/m K. One end of the fin is maintained at 130°C and its remaining surface is exposed to ambient air at 30°C. If the convective heat transfer coefficient is 40 W/m^2 K. Calculate the heat loss (in W) from the fin.

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OR

2 (a) Discuss the role of natural and forced convection on heat transfer. How convective heat transfer coefficient affected with temperature and pressure for constant volumetric convective fluids (relative to air and water).

2+4

(b) Write the Newton-Rikhman law. Write the parameters on which film coefficient depends. Explain the Nusselt number for a flat plat considering hydrodynamic boundary layer and thermal boundary layer; also draw velocity and temperature profiles.

2+2+6

UNIT - III

3 (a) Explain Reynolds number, Grashof number, Prandtl number, Stanton number, Peclet number and Nusselt number.

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(b) A hot square plate 40 cm × 40 cm at 100°C is exposed to atmospheric air at 20°C. Make calculations for the heat loss from both surface of the plate, if

(i) the plate is kept vertical

(ii) the plate is kept horizontal.

The following empirical correlations have been suggested :
Nu = 0.125 (Gr Pr)$^{0.33}$ for the vertical position of plate, and
Nu = 0.72 (Gr Pr)$^{0.25}$ for upper surface
Nu = 0.35 (Gr Pr)$^{0.25}$ for lower surface
where the air properties are evaluated at the mean temperature.

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OR

3 (a) Explain the different regimes of boiling heat transfer with help of boiling curve.

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(b) A 0.5 m square plate is exposed to dry saturated steam at 0.08 bar. If surface of the plate is to be maintained at 18.5°C, make calculations for the :

- Film thickness, local heat transfer coefficient and mean flow velocity of condensate at 25 cm from the top of the plate.
- Average heat transfer coefficient for the entire plate and
- Total steam condensate rate and the total heat transfer rate to the plate.

What change, if any, would result in the average heat transfer coefficient if the plate is inclined at 60°C to the vertical plane ?

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UNIT - IV

4 (a) Define the effectiveness of a heat exchanger.

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(b) It is desired to use a double-pipe counter-current heat exchanger to cool 3 kg/s of oil (C_p = 2.1 kJ/kg K) from 120°C. Cooling water at 20°C enters the heat exchanger at a rate of 10 kg/s. The overall heat transfer coefficient of the heat exchanger is 600 W/m^2 K and the heat transfer area is 6 m^2. Calculate the exit temperature of oil and water.

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OR

4 0.5 kg/s ethylene glycol flows through a thin walled copper tube of 1.25 cm diameter and 0.35 kg/s of water flows in the opposite direction through the annular space formed by this tube and a tube of diameter 2 cm. the ethylene glycol, which enters at 100°C is required to leave at 60°C, while the water enters at 10°C.

Calculate :

- Heat transfer coefficient on ethylene glycol side
- Heat transfer coefficient on water side
- Overall heat trnsfer coefficient and
- Length of tube required

Use the correlation $Nu = 0.023\ Re^{0.8}\ Pr^{0.3}$ and consider the properties of water and ethylene glycol for the bulk temperature as listed below :

Property	Ethylene glycol at 80°C	Water at 27°C
ρ (kg/m³)	1075	995
μ (kg/ms)	3200×10^{-6}	850×10^{-6}
C_p (J/kg K)	2650	4180
k (W/m K)	0.26	0.615

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UNIT - V

5 (a) Explain Plank distribution law, Kirchoff's law and Lambart's law.

8

(b) Calculate the shape factor for a thick hollow sphere of inside radius, r_i and outside radius r_o, whose internal and external surfaces are maintained at temperatures T_i and T_o respectively.

8

OR

5 (a) Describe various properties of radiation. How these properties varies with solar intensity.

3+3=6

(b) A jet of liquid metal at 2000°C pours from a crucible. It is 3 mm in diameter. A long cylindrical radiation shield, 5 cm diameter, surrounds the jet through an angle of 330° but there is a 30° slit in it. The jet and the shield radiate as black bodies. They sit in a room at 30°C, and the shield has a temperature of 700°C. Calculate the net heat transfer from the jet to the room through the slit; from the jet to the shield; and from the inside of the shield to the room.

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