Roll No. ..... Total Pages : 3

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BT-5/DX

HEAT-TRANSFER

Paper : ME-305(E)

Time : Three Hours] [Maximum Marks : 100

Note : Attempt *five* questions, selecting at least *one* question from each unit. Assume the suitable value of any missing data.

UNIT–I

1. Derive the general heat conduction equation in a cylindrical coordinate system. Deduce it to a single coordinate system i.e. radial direction, steady state and no heat generation. 20

2. (a) Derive the expression for the effectiveness and efficacy of the fin. What is the relation between effectiveness and efficacy of a insulated fin? 10

(b) One end of a long rod 35 mm in diameter is inserted into a furnace with the other end projecting in the outside air. After the steady state is reached the temperature of the rod is measured at two points 180 mm apart and found to be 180°C and 145°C. The atmospheric air temperature is 25°C. If the heat transfer coefficient is 65 W/m^2°C, calculate the thermal conductivity of the rod. Assume that end of the fin is insulated. 10

UNIT–II

3. (a) Prove that the Von-Karm Integral momentum equation is given by

$$\frac{\tau}{\rho u_\infty^2} = \frac{d}{dx}\left[\int_0^\delta \frac{u}{u_\infty}\left(1 - \frac{u}{u_\infty}\right)dy\right]. \quad 10$$

(b) Air at atmospheric pressure and 200°C flows over a plate with a velocity of 5m/s. The plate is 15 mm wide and is maintained at a temperature of 120°C. Calculate the thicknesses of hydrodynamic and thermal boundary layers and the local heat transfer coefficient at a distant of 0.5 m from the leading edge. Assume that flow is on one side of the plate. 10

4. (a) For the free convection prove the following relation

$$Nu = CPr^m C_T^n$$

Where C, m, n are constants. 10

(b) Air at 20°C is flowing over a flat plate which is 200 mm wide and 500 mm long. The plate is maintained at 100°C. Find the heat loss per hour from the plate if the air is flowing parallel to 500 mm side with 2 m/s velocity. What will be the effect on heat transfer if the flow is parallel to 200 mm side ?

The properties of air at (100 + 20)/2 = 60°C are : $\gamma = 18.97 \times 10^{-6}$ m^2/s, k = 0.025 W/m°C and Pr = 0.7. 10

UNIT–III

5. (a) Derive the expression for the LMTD of a counter flow heat exchanger. 10

(b) Oil (C_p = 3.6 kJ/kg°C) at 100°C flows at the rate of 30000 kg/h and enters into a parallel flow heat exchanger. Cooling water (C_p = 4.2 kJ/kg°C) enters the heat exchanger at 10°C at the rate of 50000 kg/h. The heat transfer area is 10 m^2 and U = 1000 W/m^2°C. Calculate the following:

(i) The outlet temperature of oil, and water.

(ii) The maximum possible outlet temperature of water. 10

6. (a) How the heat exchangers are classified ? Derive an expression for the LMTD for a parallel flow heat exchanger. 10

(b) An oil cooler for a lubrication system has to cool 1000 kg/hr of oil (C_p = 2.09 kJ/kg°C) from 80°C to 40°C by cooling water flow of 1000 kg/hr at 30°C. Give your choice for a parallel flow or counter flow heat exchanger, with reasons. Calculate the surface area of the heat exchanger, if the overall heat transfer coefficient is 23 W/m^2°C.

Take C_p of water = 4.18 kJ/kg°C. 10

UNIT–IV

7. (a) State and prove the Stefan's Boltzman law of Radiation

$E_b = \sigma A T^4$. 7

(b) State and Prove the Kirchhoff's law of radiation

$\epsilon = Q$. 6

(c) State and prove the Wien's displacement law of Radiation

$\lambda_{max} T = 2898\ \mu m°K$. 7

8. (a) Derive an expression for the radiation exchange between black bodies separated by a non-absorbing medium and shape factor is given by

$$F_{1\text{-}2} = \frac{1}{\pi A_1} \int_{A2} \int_{A1} \frac{\cos \theta_1 \cos \theta_2 \, dA_1 \, dA_2}{S^2}$$ 12

(b) Assume the sun to a black body emitting radiation with maximum intensity at λ = 0.49 μm. Calculate (i) Surface temperature of the Sun (ii) Heat flux at the surface of Sun. 8
