GANPAT UNIVERSITY

B.Tech. Semester VI (Mechanical) CBCS Regular Examination May-June 2013

Subject: 2ME603 Heat & Mass Transfer

Time: 3 hours **Marks: 70**

Instructions:

(1) Attempt all question
(2) Right figure indicates full marks.
(3) Assume required data if necessary
(4) Allow Steam Table, Properties chart

Section-I

Que.1. **(a)** Derive general heat conduction equation in Cartesian coordinates (5)

(b) The maximum operating temperature of a kitchen oven is set at 310^0C. Due to seasonal variations, the kitchen temperature may vary from 12^0C to 32^0C. If the average heat transfer coefficient between the outside oven surface and kitchen air is 12 W/m^2 ^{0}C, determine the necessary thickness of fiber glass (k= 0.036 W/m^{0}C) insulation to ensure that the outside surface temperature of oven does not exceed 45^0C. Assume that the steady state conditions prevail and the thermal resistance of metal wall is negligible. (7)

OR

Que.1. **(a)** How is thermal conductivity of a material defined? What are its units? (5)

(b) Standard cast iron pipe (ID= 50 mm, OD = 55 mm) is insulated with 85 percent magnesium insulation (k= 0.02 W/m^{0}C). Temperature at the interface between the pipe and insulation is 300^0C. The allowable heat loss through the pipe is 600 W/m length of pipe and for the safety the temperature of the outside surface of insulation must not exceed 100^0C. Determine: (7)

(i) Minimum thickness of insulation required, and

(ii) The temperature of inside surface of the pipe assuming its thermal conductivity 20 W/m^{0}C.

Que.2. **(a)** Derive expressions for temperature distribution and heat dissipation in a straight fin of rectangular profile for fin insulated at the tip. (6)

(b) An electric motor drives a centrifugal pump which circulates a hot liquid metal at 480^0C. The motor is coupled to the pump impeller by a horizontal steel shaft (k= 32 W/m^{0}C) 25 mm in diameter. If the ambient air temperature is 20^0C, the temperature of the motor is limited to a maximum value of 55^0C and the heat transfer coefficient between the steel shaft and the ambient air is 14.8 W/m^2 ^{0}C, what length of shaft should be specified between the motor and the pump? (6)

OR

Que.2. A copper conductor (k= 380 W/m ^{0}C, resistivity $\rho = 2 \times 10^{-8}$ W m) having inner and outer radii 1.0 cm and 2.25 cm respectively is carrying a current density of 4800 amperes/cm^2. The conductor is internally cooled and a constant temperature of 65^0C is maintained at the inner surface and there is no heat transfer through insulation surrounding the conductor. Determine (12)

(i) The maximum temperature of the conductor and the radius at which it occurs (ii) The internal heat transfer rate.

Que.3. **Attempt the following question**

(a) Explain briefly the terms thermal capacity and thermal diffusivity of a material (4)

(b) What is Fourier's law of conduction? State also the assumptions on which this law is based. (4)

(c) Explain the concept of Black body (3)

Section-II

Que.4. (a) What is a Heat exchanger? How are heat exchangers classified? (5)

(b) The flow rates of hot and cold water streams running through a parallel flow heat exchanger are 0.2 kg/s and 0.5 kg/s respectively. The inlet temperature on the hot and cold sides is 75^0C and 20^0C respectively. The exit temperature of hot water is 45^0C. If the individual heat transfer coefficients on both sides are 650 $W/m^{2\,0}C$, calculate the area of the heat exchanger. (7)

OR

Que.4. (a) Derive expressions for effectiveness by NTU method for the parallel flow heat exchanger (5)

(b) Steam condenses at atmospheric pressure on the external surface of the tubes of a steam condenser. The tubes are 12 in number and each is 30 mm in a diameter and 10 m long. The inlet and outlet temperature of cooling water flowing inside the tubes are 25^0C and 60^0C respectively if the flow rate is 1.1 kg/s calculate the following (7)

(i) The rate of condensation of steam (ii) The mean overall heat transfer coefficient based on the inner surface area. (iii) The number of transfer units (iv) The effectiveness of the condenser.

Que.5. (a) Define the following terms: (5)

Boundary layer thickness, Momentum thickness, Energy thickness.

(b) Consider flow of water over a flat plate with a velocity of 2 m/s. The length of the plate is 5m. The properties of water are ρ = 1000kg/m^3, μ = 0.0007975 Pa.s. Determine: (i) Hydrodynamic boundary layer thickness at x = 0.1 m and 1 m (ii) Shear stress at x = 0.1 m and 1 m. (iii) Thermal boundary layer thickness at x = 0.1 m and 1 m ($Pr = 5$) Comment on these values. (7)

OR

Que.5. (a) Derive momentum equation for hydrodynamic boundary layer over a flat plate. (5)

(b) A thin, flat plate that is 0.2 m by 0.2 m on a side is oriented parallel to an atmospheric airstream having a velocity of 40 m/s. The air is at a temperature of 20°C while the plate is maintained at 120°C. The air flows over the top and bottom surfaces of the plate, and measurement of drag force reveals a value of 0.075 N. What is the rate of heat transfer from both sides of the plate to the air? Properties of air ρ = 1.125 kg/m^3 and μ = 18.4 × 10^{-6}Pa.s, Pr = 0.71, k = 0.02635 W/m.K. (7)

Que.6. **Attempt following questions**

(a) Define Nusselt number and Prandtl number. (3)

(b) Explain the forced and free convection heat transfer (4)

(c) Explain Kirchhoff's law for radiation (4)