CS/B.Tech(AUE-OLD)/SEM-4/AUE-402/2012

2012

HEAT TRANSFER AND COMBUSTION

Time Allotted : 3 Hours *Full Marks* : 70

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

GROUP – A

(Multiple Choice Type Questions)

1. Choose the correct alternatives for the following : 10x1 = 10

i) The concept of log mean area is normally used in the analysis of

a) composite plane surface

b) cylindrical surface

c) spherical surface

d) any plane surface.

ii) The value of '*k*' in (w/m°C) for glass is near about

a) 20 – 35 b) 0·2 – 0·4

c) 0·7 – 0·75 d) 0·03 – 0·05.

iii) The wavelength of thermal radiation in m is

a) $10^{2} – 10^{5}$ b) $0·01 – 10^{2}$

c) $10^{-2} – 10^{-5}$ d) $10^{5} – 10^{10}$.

iv) The rate of radial heat transfer through a hollow cylinder increases as the ratio of outer radius to inner radius

a) decreases b) increases

c) remains same d) unpredictable.

v) The unit of the thermal diffusivity is

a) m^2/hr°C b) kcal/hr°C

c) m^2/s d) m/s^2 .

vi) A non-dimensional number not associated with natural convection is

a) Reynolds number b) Nusselt number

c) Grashoff number d) Prandtl number.

vii) The statement of reciprocity theorem is

a) $F_{12} = F_{21}$

b) $A_1F_{12} = A_2F_{21}$

c) $A_2F_{12} = A_1F_{21}$

d) all of these.

viii) For a white body transmissivity is equal to

a) reflectivity b) one

c) constant d) zero.

ix) All grey bodies obey the

a) Kirchhoff's law b) Stefan-Boltzman law

c) Fourier's law d) Wien's law.

x) Nusselt number is given by

a) C_p/k b) k/C_p

c) hL/k d) hk/L.

GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following. 3x5 = 15

2. Derive an expression for heat flow in radial direction for a hollow cylinder (inside radius r_i and outside radius r_o) of

length L and uniform thermal conductivity k under steady state and without any heat generation. The inner and outer surface temperatures of the cylinder are T_i and T_o respectively.

3. Prove that for unidirectional heat conduction through a slab of uniform thermal conductivity (k) under steady state and with constant heat generation (q) per unit volume, the differential equation is $d^2T/dx^2 + q/k = 0$.

4. What is shape factor ? Write the various features of shape factor.

5. A slab of length 'L' and uniform thermal conductivity k is generating heat at a constant rate (q) per unit volume. The temperatures at two ends are found to be T_1 and T_2 $\left(T_1 > T_2 \right)$. Find out the temperature at a distance x measured from the end where the temperature is T_1.

6. a) Explain the term 'critical radius of insulation'. 2

b) Derive an expression for critical radius of insulation for the case of a cylinder. 3

GROUP – C

(Long Answer Type Questions)

Answer any *three* of the following. 3x15 = 45

7. a) Derive the general three dimensional differential equation of heat conduction with internal heat generation for a rectangular coordinate system. 7

b) The wall in a furnace consists of 125 mm thick refractory bricks (k = 1·6 W/mK), 150 mm thick insulating firebricks (k = 0·3 W/mK). A 15 mm plaster (k = 0·14 W/mK) covers the outer wall. The inner surface of the wall is at 1100°C and the ambient temperature is 25°C. The heat transfer coefficient on the outside wall to the air is 17 W/m^2 K. Calculate

i) the rate of heat loss per unit area of wall surface

ii) the two interface temperatures

Draw the equivalent thermal cicuit. 8

8. a) Derive an expression for heat flow in radial direction and maximum temperature for a solid cylinder of radius R and length L, uniform thermal conductivity k under steady state and with internal heat generation q/unit volume. The outer surface temperature of the cylinder is T_w. 7

b) A spherical ball (k = 0·5 W/m°C) 100 mm diameter generates heat at 6500 W/m^3. If the external surface temperature is 15°C, calculate

i) temperature at the centre

ii) heat flow from outer surface. 8

9. a) Derive an expression for heat flow in a very long fin. 8

b) One end of a very long steel rod is maintained at 200°C while the other end is into a fluid with temperature 25°C. The diameter of the rod is 3 mm and the thermal conductivity of the rod material is 240 W/mK. If the heat transfer co-efficient between the rod surface and fluid is 400 W/m^{2}K, determine the heat dissipation rate of the fin. 7

10. a) Derive an expression for log mean temperature

difference (LMTD) in case of parallel flow heat exchanger. 8

b) In a parallel flow heat exchanger hot water $\left(C_p = 4\cdot2 \text{ kJ/kg} \right)$K flows at the rate of 50000 kg/hr, and gets cooled from 95°C to 65°C. At the same time 13.89 kg/s cooling water at 30°C enters the heat exchanger. The overall heat transfer coefficient is 2270 W/m ^{2}°C. Determine the heat transfer area and the effectiveness of heat exchanger. 7

11. a) Derive an expression for the shape factor in case of radiation heat exchange between two black bodies and prove that $F_{1-2} A_1 = F_{2-1} A_2$. 9

b) What is the difference between natural and forced convection ? 6