MAULANA ABUL KALAM AZAD UNIVERSITY OF TECHNOLOGY, WEST BENGAL

Paper Code : AUE-502

HEAT TRANSFER

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 : $10 \times 1 = 10$

i) The metal with highest value of thermal conductivity is
   a) steel b) silver
   c) copper d) saw dust.

ii) The concept of geometric mean area is normally used in the analysis of
   a) composite plane surface
   b) cylindrical surface
   c) spherical surface
   d) any plane surface.

iii) In the lumped parameter analysis the temperature variation with time is
   a) linear b) cubic
   c) exponential d) sinusoidal.

iv) Effectiveness of a fin of uniform cross-section will be high if
   a) k is less b) P is less
   c) h is less d) A is large.

v) In free convection, motion of the fluid is caused
   a) by the weight of the fluid element
   b) by the hydrostatic force on the element
   c) by the huoyancy force arising from density of fluid with the temperature
   d) none of these.

vi) Rate of heat conduction is ..... to the area normal to the direction of heat flow.
   a) inversely proportional
   b) proportional
   c) equal
   d) none of these.

vii) Temperature variation in a plain wall is

a) linear b) parabolic

c) logarithmic d) None of these.

viii) Thermal conductivity of metals with increase of pressure

a) increases b) decreases

c) remains constant d) none of these.

ix) Which law is related to heat conduction equation ?

a) Stefan-Boltzmann law

b) Fourier's law

c) Newton's law of cooling

d) None of these.

x) The internal thermal resistance of a solid can be ignored if the Biot number is less than

a) 1·0 b) 0·5

c) 0·1 d) Fourier number.

GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following 3 × 5 = 15

2. Starting with an energy balance on a rectangular volume element, derive the three-dimensional transient heat conduction equation in rectangular coordinate system with constant thermal conductivity.

3. A counter flow shell-and-tube heat exchanger is used to heat water at a rate of m = 0·8 kg/s from T_{c_1}=30°C to T_{c_2}=80°C, with hot oil entering at T_{h_1} 120°C and leaving at T_{h_2} 85°c. The over wall heat transfer coefficient is U = 125 W/(m^2.°C). Calculate the heat transfer area required.

4. What is shape factor ? Write the various features of shape factor. Calculate radiation shape factor for a hemispherical surface closed by a plane surface.

1 + 1 + 3

5. State Newton law of cooling and write the factors on which the value of 'h' depends.

6. What do you mean by logarithmic mean area and geometric mean area ?

GROUP – C
(Long Answer Type Questions)

Answer any *three* of the following. 3 × 15 = 45

7. a) Derive the three dimensional general heat conduction equation in Cartesian co-ordinates. Under what condition does this get reduced to Poisson equation; L aplace equation and Fourier equation ?

   b) A plane wall is made by fire clay brick. The wall thickness L = 300 mm, the temperature of wall surface $T_1 = 1550°C$ and $T_2 = 50°C$, Thermal conductivity of brick K = 0·96 (1 + 0·0008T) W/m°C. Calculate and represent graphically the temperature distribution through wall.

8. a) State and prove the reciprocity theorem.

   b) Two parallel plates 0·5 by 1·0 m are spaced 0·5 m apart, one plate is maintained at 1000°C and other at 500°C. The emissivities of the plates are 0·2 and 0·5 respectively. The plates are located in a very large room, the walls of which are maintained at 27°C. The plates exchange heat with each other and with the room, but only the plate surfaces facing each other are to be considered. Find the neat heat transfer to each plate and to the room considering shape factor $F_{12} = 0·285$. 5 + 10

9. a) A steel rod (k = 32 W/m°C), 12 mm in diameter and 60 mm long, with an insulated end, is to be used as spine. It is exposed to surroundings with a temperature of 60°C and a heat transfer coefficient of 55 $W/m^2°C$. The temperature at the base of fin is 95°C.

   Determine :

   i) The fin efficiency

   ii) The temperature at the edge of the spine

   iii) The heat dissipation.

   b) Write short note on Heisler charts. (3 + 3 + 3) + 6

10. a) What is natural convection ?

    b) A heated vertical plate maintained at a uniform temperature T_w, placed in a stagnant air $(u_a = 0)$ processing a constant temperature T_a $(T_a < T_w)$ inside a room. (i) Draw the temperature and velocity profile in the thermal boundary layer generated due to heat transfer from the plate to the surrounding air. (ii) Using the equations of motion, show that the volumetric coefficient of thermal expansion β is reciprocal to the absolute temperature T. (assume the boundary layer flow is steady and laminar).

    2 + 4 + 9

11. a) Consider two large parallel plates, one of $T_1 = 800K$ with emissivity $\varepsilon_1 = 0{\cdot}9$ and the other at $T_2 = 300K$ with emissivity $\varepsilon_2 = 0{\cdot}5$. A radiation shield is placed between the two plates.

i) Calculate the heat transfer rate per unit area without using the radiation shield in between.

ii) Calculate the emissivity of the radiation shield in order to reduce the radiative heat transfer to 10% of that without shield.

iii) Calculate the temperature of radiation shield.

b) What advantage does the effectiveness of NTU method have over the LMDT method ?

(4 + 4 + 4) + 3