Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS/B.Tech (AUE)/SEM-4/AUE-402/2011

2011

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 : $10 \times 1 = 10$

   i) LMDT in case of parallel flow as compared to counter-flow heat exchanger is

      a) higher

      b) lower

      c) same

      d) dependent on temperature distribution.

   ii) A composite plane wall is made of two different materials of same thickness with thermal conductivities k_1 and k_2. The equivalent thermal conductivity of the slab is

      a) $k_1 + k_2$ b) $k_1 k_2$

      c) $(k_1 + k_2)/k_1 k_2$ d) $2k_1 k_2/(k_1 + k_2)$.

iii) The critical radius of insulation for a sphere is equal to

a) $2kh$ b) $2\ k/h$

c) $h/2k$ d) k/h.

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) Grashof 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) $\mu C_p / k$ b) $\mu k / C_p$

c) hL/k d) hk/L.

GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following. 3 × 5 = 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. Calculate overall heat transfer coefficient of a cylinder when heat is flowing from inside to outside direction.
4. What is shape factor ? Write the various features of shape factor.
5. What do you mean by logarithmic mean area and geometric mean area ?
6. a) Explain the term 'critical radius of insulation'. 2
   b) Derive an expression for critical radius of insulation for the case of sphere. 3

GROUP – C

(Long Answer Type Questions)

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

7. a) Derive the general three dimensional differential equation of heat conduction with internal heat generation for a rectangular coordinate system. 8
   b) A wall of 0·5 m thickness is to be constructed from a material which has an average thermal conductivity of 1·4 W/mK. The wall is to be insulated with a material having an average thermal conductivity of 0·35 W/mK so that the heat loss per square metre will not exceed 1450 W. Assume that the inner and outer surface temperatures are 1200° C and 15° C respectively. Calculate the thickness of insulation required. 7

8. a) Derive an expression for heat flow in radial direction and maximum temperature for a solid sphere of radius R and, 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 and atmospheric temperature is T_a. 7

   b) A hollow sphere with ID 10 cm is made up of two materials; first with steel (k = 70 W/mK) and second with iron (k = 15 W/mK). Steel layer is 10 cm thick and iron layer is 5 cm thick. The inside and outside surface temperatures are 300° C and 30° C respectively. Calculate the rate of heat flow and temperature between two layers. 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 1400° C while the other end is into a fluid with temperature 15° 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^2K, 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) Hot oil with a capacity rate of 2500 W/K flows through a double pipe heat exchanger. It enters at 360° C and leaves at 300° C. Cold fluid enters at 30° C and leaves at 200° C. If the overall heat transfer coefficient is 800 W/m^2K, determine the heat exchanger area required for

       i) parallel flow

       ii) counter flow. 7

11. a) What is intensity of radiation ? Prove that total emissive power of a diffuse surface is equal to π times its intensity of radiation. 9

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