[4459] – 113

Seat No.	

T.E. (Mech., Automobile, Mech S/W) (Semester – I) Examination, 2013
HEAT TRANSFER
(2008 Course)

Time : 3 Hours Max. Marks : 100

Instructions : *1) Answer* ***three*** *questions from Section –* ***I*** *and* ***three*** *questions from Section –* ***II****.*
2) Answers to the ***two*** *Sections should be written in* ***separate*** *books.*
3) ***Neat*** *diagrams must be* ***drawn wherever*** *necessary.*
4) Black figures to the ***right*** *indicate* ***full*** *marks.*
5) Use of Electronic pocket calculator is allowed.
6) ***Use*** *of external data books is* ***not allowed****.*
7) Assume ***suitable*** *data, if necessary.*

SECTION – I

1. a) Derive a general three dimensional heat conduction equation in Cartesian coordinate system. Reduce it as
   1) Poisson equation,
   2) Fourier equation
   3) Laplace equation. **10**

   b) Write a note on : **8**
   i) Insulating materials and
   ii) Variable Thermal Conductivity.

OR

2. a) Differentiate between steady state and unsteady state heat transfer. Give examples of each. **4**

b) A furnace wall is made up of three layers of thickness 250 mm, 100 mm and 150 mm with thermal conductivities of 1.65, 'k' and 9.2 W/m°C respectively. The inside is exposed to gases at 1250°C with a convection coefficient of 25 W/m^2 °C and the inside surface is at 1100°C. The outside surface is exposed to air at 25°C with convection coefficient of 12 W/m^2°C. Determine the unknown thermal conductivity 'k' and all the intermediate wall surface temperatures. **8**

c) A horizontal steel pipe having a diameter of 5 cm is maintained at a temperature of 50°C in a large room where the air and wall temperature are at 20°C. The surface emissivity of the steel may be taken as 0.8 and the convection heat transfer coefficient as 25 W/m^2K. Calculate the total heat lost by the pipe per unit length. **6**

3. a) Derive an expression for critical radius of insulation for a cylinder using standard notations. **8**

b) A steel pipe (k = 50 W/mK) of 100 mm I.D and 110 mm O.D is to be covered with two layers of insulation each having thickness of 50 mm. The thermal conductivity of first insulation material is 0.06 W/mK and that of the second is 0.12 W/mK. Estimate heat loss per metre length of pipe when temperature of inside tube surface is 523 K and that of outer surface is 323 K. If order of insulation is reversed, calculate change in heat loss with all other conditions kept unchanged. Comment on the results. **8**

OR

4. a) A 3 mm diameter and 100 m long stainless steel wire having k = 20 W/m°C and resistivity, $\rho = 10\times10^{-8}$ has a voltage of 100 V. The outer surface of the wire is maintained at 100°C. Calculate the centre temperature of the wire. If the heated wire is submerged in a fluid maintained at 50°C, find the heat transfer coefficient on the surface of the wire. **8**

b) Write a note on Thermal Contact Resistance. **4**

c) A gas filled tube has 2 mm inside diameter and 25 cm length. The gas is heated by an electrical wire of diameter 0.05 mm located along the axis of tube. Current and voltage drop across the heating element are 0.5 amperes and 4 volts respectively. If the wire temperature is 175°C and inside tube wall temperature is 150°C respectively, find the thermal conductivity of the gas filling the tube. **4**

5. a) Derive the governing differential equation for rectangular fin and further obtain the expression for temperature distribution. Assume insulated tip condition. **8**

b) Two identical balls made up of pure iron and pure copper having diameter of 6 cm and initial temperature of 500°C are being cooled in an oil having temperature of 100°C and h = 10 W/m^2K. It is desired that both balls should reach a temperature of 150°C at same time. Which balls should be inserted into oil first ? After how much time second ball should be inserted into oil. Justify your answer. **8**

Take: For Pure Iron - k = 73 W/mK, ρ = 7897 kg/m^3, C = 0.452 kJ/kgK

For Pure copper - k = 386 W/mK, ρ = 8954 kg/m^3, C = 0.383 kJ/kgK.

OR

6. a) Three 10 mm diameter rods A, B and C protrude from a steam bath at 100°C to a length of 25 cm into atmosphere at 20°C. The temperature at the other ends are found to be 26.76°C for “A”, 32.0°C for “B” and 36.93°C for “C”. Neglecting the effect of radiation and assuming the surface film coefficient of heat transfer as 23 W/m^2K, evaluate their thermal conductivities. Assume insulated tip condition for fin analysis. **6**

b) State assumptions made in lumped capacitance method. Using this method derive the following relation **6**

$(T - T_\infty)/(T_i - T_\infty) = e^{-(Bi\ Fo)}$ with usual notations.

c) Write a note on Fin Effectiveness. **4**

SECTION – II

7. a) Write the statement and mathematical expression for Planck's law. Draw a graph of variation of black body emissive power with wavelength for several temperatures. State the important points in this graph. **6**

b) The filament of a 75 W light bulb may be considered a black body radiating into a black enclosure at 70°C. The filament diameter is 0.1 mm and length is 5 cm. Considering radiation, determine the filament temperature. **4**

c) Write a note on Radiation shield. **6**

OR

8. a) Define Emissivity and Monochromatic Emissivity. Draw a sketch to show variation of monochromatic emissivity of a real surface, gray surface and black surface with wavelength. **4**

b) For a hemispherical furnace of radius 1 m, the flat circular floor is at 600 K and has an emissivity of 0.5. The hemispherical roof is at 800 K and has emissivity of 0.8. Find the net radiative heat transfer from roof to floor. **4**

c) Emissivity of two large parallel plates maintained at 800°C and 300°C are 0.3 and 0.5 respectively. Find the net radiant heat exchange per m^2 of these plates. Find percentage reduction in heat transfer when polished aluminum radiation shield of $\varepsilon = 0.05$ on both sides is placed between them. Also find temperature of shield. **8**

9. a) Define and explain the significance of dimensionless numbers used in Natural Convection. **6**

b) A sheet metal air duct carries conditioned air at an average temperature of 10°C. The duct size is 320 mm × 200 mm and the length of the duct exposed to the surrounding air at 30°C is 15 m long. Find the heat gain by the air in the duct. Assume 200 mm side is vertical and top surface of the duct is insulated. **10**

Take the properties of air at 20°C as $v = 15.1 \times 10^{-6}$ m²/s,

k = 0.0256 W/mK, Pr = 0.71.

Use $Nu = 0.6\ (GrPr)^{0.25}$ for vertical surface and $Nu = 0.27\ (GrPr)^{0.25}$ for horizontal surface.

OR

10. a) Air at 27°C blows along one side of a horizontal brick slab along its 15 m long length. The slab is at 55°C initially. The velocity of air is 4.5 m/s. Specific heat of slab = 0.84 kJ/kg K, density of slab = 1600 kg/m³, volume of slab = 1.5 m³. Properties of air: $\rho = 1.128$ kg/m³, $\mu = 19.1 \times 10^{-6}$ kg/ms, k = 0.0276 W/mK, Pr = 0.699. **10**

$Nu = 0.664\ Re^{0.5}\ Pr^{0.33}$ for $Re < 5 \times 10^5$

$Nu = 0.037\ Re^{0.8}\ Pr^{0.33}$ for $Re > 5 \times 10^5$

For unit width of the slab, calculate,

i) The rate of convective heat loss from the slab

ii) Rate of radiative heat loss from slab.

iii) Initial rate of cooling of the slab per hour.

Take emissivity of slab as 0.9.

b) Calculate the heat transfer from a 60 W incandescent bulb at 115°C to ambient air at 25°C. Assume the bulb as sphere of 50 mm diameter.

Use $Nu = 0.60 (GrPr)^{1/4}$. Take properties of air at 70°C as k = 0.02964 W/mK, $v = 20.02 \times 10^{-6}$ m^2/s, Pr = 0.694. **6**

11. a) Differentiate between filmwise and dropwise condensation. **4**

b) Define effectiveness of heat exchanger. Derive the standard expression for effectiveness (ε) of a parallel flow heat exchanger in terms of capacity ratio (C) and Number of Transfer Units (NTU). **10**

c) In a double pipe counter flow heat exchanger, 10000 kg/hr of an oil having a specific heat of 2095 J/kgK is cooled from 80°C to 50°C by 8000 kg/hr of water entering at 25°C. Determine the heat exchanger area for an overall heat transfer coefficient of 300 W/m^2K. Take Cp for water as 4180 J/kgK. **4**

OR

12. a) Draw temperature distribution in a counter flow heat exchanger for infinitely large area when

i) $C_h > C_c$ and   ii) $C_h < C_c$ **2**

b) Explain Regimes of Pool boiling. What is the significance of critical heat flux ?   **8**

c) A steam condenser, condensing at 100°C has to have a capacity of 100 kW. Water at 20°C is used and the outlet water temperature is limited to 45°C. If the overall heat transfer coefficient is 3100 W/m^{2}K, determine the area required. If the inlet water temperature is increased to 30°C determine the increase in flow rate of water to maintain the same outlet temperature. Take Cp water = 4180 J/kgK.   **8**
