Registration No. : | | | | | | | | | | |

Total number of printed pages – 4

B. Tech.
PCME 4305

Sixth Semester Examination – 2011

HEAT TRANSFER

Full Marks – 70

Time : 3 Hours

*Answer Question No. **1** which is compulsory and any **five** from the rest.*
The figures in the right-hand margin indicate marks.

1. Answer the following questions : 2×10

   (a) Define contact resistance and name four important factors that affect the contact resistance.

   (b) Write down two dimensional heat conduction equation for a homogeneous isotropic material in rectangular coordinate system.

   (c) Draw the thermal circuit for heat transfer between core of an nuclear reactor and the operator working near its vicinity.

   (d) The heat transfer coefficient for a gas flowing over a thin flat plate 3 m long and 0.3 m wide varies with distance from the leading edge according to $h_1(x) = 10\ x^{-0.25}$ W/ m^2K. Find out the average heat transfer coefficient.

   (e) Why higher rate of heat transfer is experienced in drop wise than in film condensation ?

   (f) What advantage does the effectiveness-NTU method have over LMTD method ?

P.T.O.

(g) Distinguish between a black body and a gray body.

(h) Define Prandtl number and state its significance.

(i) Why are the correlations for an entry region different than those of a fully developed zone?

(j) Sketch the temperature and velocity profiles in free convection on a vertical wall.

2. (a) A furnace wall consists of 200 mm layer of refractory bricks, 6 mm layer of steam plate and 100 mm layer of insulation bricks. The maximum temperature of the wall is 1150° C on the furnace side and the minimum temperature is 40° C on the outermost side of the wall. An accurate energy balance over the furnace shows that the heat loss from the wall is 400 W/m^2. It is known that there is a thin layer of air between the layer of refractory bricks and steel plate. Thermal conductivity for three layers is 1.52, 45 and 0.138 W/m° C, respectively. Find

(i) How many mm of insulation brick is the air equivalent?

(ii) The temperature of outer layer surface of the steel plate. 10

3. An electronic semiconductor device generates heat equal to 520 kW. In order to keep the surface temperature at the upper safe limit of 60° C the generated heat as to be dissipated to the surrounding which is at 30° C. To accomplish this task aluminum fins of 0.8mm square and 15 mm long are attached to the surface. The thermal conductivity of aluminum fins is 170W/m-K. If the heat transfer coefficient is 12W/m^2-K. Calculate the number of the fins required and the efficiency of the fins. Assume no heat loss from tip of fins. 10

4. An egg can be approximated as a sphere 5mm in diameter, with thermophysical properties $k=0.6 W/m^2.K$, $\alpha = 0.14 \times 10^{-6} m^2/s$. The egg is taken from a refrigerator at 2° C and is dropped into boiling water where the convective heat transfer coefficient is estimated as $1200 W/m^2.K$. Calculate the time required to reach the centre temperature of the egg to 75° C. 10

5. (a) Explain Buckingham Π theorem. What are repeating variables and how they are selected? 4

(b) Air is flowing over a flat plate of 5m long and 2.5 m wide with a velocity of 4m/sec at 15° C. If $\rho = 1.208 kg/m^3$ and $= 1.47 \times 10^{-5} m^2/sec$. Calculate

(i) length of the plate, over which the boundary layer is laminar and thickness of the boundary layer (Laminar).

(ii) Shear stress at the location where the boundary layer ceases to laminar.

(iii) Total drag force on both sides of the plate where boundary layer is laminar. 6

6. (a) Explain critical heat flux and discuss various regimes of boiling heat transfer. 4

(b) A horizontal 40W florescent tube which is 3.8 cm in diameter and 120 cm long stands at 1atm and 20° C. If the surface temperature is 40° C and radiation is neglected, what percentage of power is dissipated by convection ? The properties of air at 30° C are $\beta = 1/303 K^{-1}$, $\nu = 16.19 \times 10^{-6} m^2/sec$, $K_f = 0.02652 W/mK$ and $Pr = 0.706$. 6

7. Two square plates 1m × 1m are parallel to each other and directly opposite at a distance of 1m. The hot plate is at 800K ($\epsilon = 0.6$) and cold plate is at 600K ($\epsilon = 0.8$). The radiation takes place between the plates as well as with ambient at 300K through the opening between the plates. Determine the heat transfer by radiation between the two plates and the ambient. 10

8. (a) In a parallel flow double pipe heat exchanger water flows through the inner pipe and is heated from 28° C to 78° C. Oil flowing through the annulus is cooled from 230° C to 97° C. It is desired to cool the oil to a lower exit temperature by increasing the length of the heat exchanger. Determine the minimum temperature to which the oil may be cooled. 4

(b) A chemical having specific heat of 3.5kJ/kg K flowing at the rate of 18×10^3kg/hr enters a parallel flow heat exchanger at 110° C. The flow rate of cooling water is 48×10^3kg/hr with an inlet temperature of 27° C. The heat transfer area is $12m^2$ and the overall heat transfer coefficient is $1030W/m^2K$. Find out 6

(i) effectiveness of heat exchanger

(ii) outlet temperature of water

(iii) outlet temperature of chemical