Total Pages—7

(Set-K)

B.Tech. - 6th
Heat Transfer

Full Marks : 70

Time : 3 hours

Answer **six** questions including Q. No. 1 which is compulsory

The figures in the right-hand margin indicate marks

1. Answer the following questions : 2 × 10

(*a*) Calculate the equivalent thermal conductivity of the Cartesian domain shown in Fig.1(a).

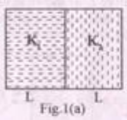

Fig.1(a)

(*b*) Consider steady one dimension heat conduction through the slab as shown in

Fig.1(b). $T_1 = 70°C$ and $T_2 = 30°C$. Calculate the temperature at point *P* assuming thermal conductivities of both the materials equal.

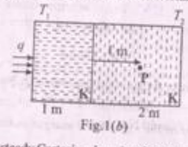

Fig.1(*b*)

(*c*) A steady Cartesian domain of thickness *L* with uniform volumetric heat generation q''' is insulated at $X = 0$ and exposed to environment with surface heat transfer coefficient h_∞ and temperature T_∞ as shown in Fig 1(c). Write the differential energy equation and boundary condition.

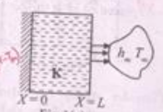

Fig.1(*c*)

(*d*) A pin fin of radius 2 mm ($K = 200$ W/mK) is exposed to surrounding at $h_\infty = 50$ W/m^{2}K & $T_\infty = 27°C$. The root temperature of the fin is 200°C. Calculate the heat transfer rate through the fin.

(*e*) If the viscosity of air is $24{\cdot}5 \times 10^{-6}$ N-s/m^2, specific heat capacity is 1 KJ/kg K and thermal conductivity is 0·12 W/mk, calculate the Prandtl Number.

(*f*) Write the Dittus Boelter equation and explain all terms. Write its application.

(*g*) Define Nusselt Number. Write its physical Significance.

(*h*) Calculate the shape factor of a hemispherical body placed on a flat surface with respect to itself.

(*i*) Calculate the spectral emissive power of Sun.

(*j*) In a counter flow HX, the heat capacity rate of both hot and cold fluids are equal. If NTU is 0·5, calculate the effectiveness of HX.

2. A hollow cylinder $r_1 \le r \le r_2$ has its boundary surfaces at r_1 and r_2 maintained at uniform temperatures T_1 and T_2 ($T_1 > T_2$) respectively. The thermal conductivity of cylinder material varies linearly with temperature from k_1 at T_1 to k_2 at T_2. Show that the heat flow rate is given by

$$q = \frac{\frac{(k_1 + k_2)}{2}(T_1 - T_2)}{\ln \frac{r_1}{r_2}}$$ 10

3. The boundary temperatures of a thin plate (1 m × 1m) are shown in Fig. P.3. Determine the temperature at the center of the plate. 10

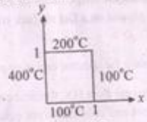

Fig. P.3

4. A 15 cm O.D. steam pipe carrying wet steam at 3600 kpa ($T_{sat} = 244°C$) is covered with two layers of lagging each 4 cm thick. The coefficients of thermal conductivity for the two layers 0·07 and 0·1 W/mK, respectively. The ambient temperature 27° and the heat transfer coefficient on outer surface is 3 W/m^{2}K. Find

The heat lost per hour for a 100 m length of the pipe.

The surface temperature of the lagging.

Neglect thermal conductivity effect of the pipe material. 10

5. Air at 20° C flows over a thin plate with a velocity of 3 m/s. The plate is 2 m long and 1 m wide. Estimate the boundary layer thickness at the trailing edge of the plate and the total drag force experienced by the plate. Also calculate the mass flow of air which enters the boundary layer between $x = 30$ cm and $x = 80$ cm. The physical properties of air at 20°C are

$\rho = 1{\cdot}17$ kg/m^3, $\upsilon = 15 \times 10^{-6}$ m^2/s 10

6. (*a*) Discuss briefly the various regimes in boiling heat transfer. 4

(*b*) Distinguish between filmwise and dropwise condensation. Which of the two gives a higher heat transfer coefficient ? Why ? 6

7. A 1-sheell-2 tube pass steam condenser consists of 3000 brass tubes of 20 mm diameter. Cooling water enters the tubes at 20°C with a mean flow rate of 3000 kg/s. The heat transfer coefficient for condensation on the outer surfaces of the tubes is 15500 W/m^{2}K. If the heat load of the condenser is $2{\cdot}3 \times 10^8$ W when the steam condenses at 50°C determine

(*a*) the outlet temperature of the cooling water

(*b*) the overall heat transfer coefficient.

(c) the tube length per pass using the NTU method.

(*d*) The rate of condensation of steam if $h_{fg} = 2380$ kJ/kg. 10

8. Two parallel plates (0·5 m × 1·0 m) are spaced 0·5 m apart. One plate is maintained at 1000°C and the 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 surface facing each other are to be considered in the analysis. Find the net heat transfer to each plate and to the room. 10
