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Paper Code : PC-ME501 Heat Transfer

Time Allotted : 3 Hours *Full Marks :70*

The Figures in the margin indicate full marks.

Candidate are required to give their answers in their own words as far as practicable

Group-A (Very Short Answer Type Question)

1. Answer any ten of the following : [1 x 10 = 10]

(I) Prandtl number is the ratio of:
Kinematic viscosity and thermal diffusivity,
Thermal diffusivity and kinematic viscosity,
Dynamic viscosity and thermal viscosity.,
None

(II) Nu for pure conduction

(III) Which of the following is/are example/s of direct contact type heat exchanger?
Desuperheater,
cooling tower

(IV) The curve for unsteady state cooling or heating of bodies is a

(V) Nusselt number is defined by

(VI) . For an opaque body sum of absorptivity and reflectivity is

(VII) Emissivity of perfectly black body is

(VIII) The normal automobile radiator is a heat exchanger of the type:
cross flow,
direct contact,
parallel flow,
counter flow

(IX) The amount of heat flow through a body by conduction
Directly proportional to the surface of the body
Directly proportional to the temperature difference on two faces
Dependent upon the material of the body
All

(X) The value of Prandtl number for air is about

(XI) In free convection, Nu is the function of

(XII) Co-efficient of reflection, coefficient of absorption and coefficient transmission are related as

Group-B (Short Answer Type Question)

Answer any three of the following [5 x 3 = 15]

2. Prove temperature distribution equation for a rectangular fin having infinite length. [5]
3. Derive bulk mean temperature and Nusselt number for constant heat flux at wall for laminar flow through pipe [5]
4. What is the physical significance of Grashof and Nusselt number? [5]
5. What is intensity of radiation? Prove $E = \pi I$. [5]
6. Prove heat flow through cylinder of uniform conductivity without heat generation [5]

Group-C (Long Answer Type Question)

Answer any three of the following [15 x 3 = 45]

7. (a) The interior of a refrigerator having inside dimensions of 0.05 mX0.05m base area and 1m height, is to be maintained at 6^0C. The walls of the refrigerator are constructed of two mild steel sheets 3 mm thick (K=46.5 W/m^{0}C) with 50 mm of glass wool insulation (K=0.046 W/m^{0}C) between them. If the average heats transfer coefficients at the outer and inner surfaces are 11.6 W/m^{20}C and 14.5 W/m^{20}C respectively. Calculate the rate of which heat must be removed from the interior to maintain the specific temperature in the kitchen at 25^0C. and the temperature on the outer surface of the metal sheet. [7]

(b) A steel tube of 10 cm ID, 15 cm OD, K_1=20 W/mK is covered with an insulation of thickness t=3 cm, K2=0.15 W/mK. A hot gas at Ti=400^0 C, hi =300 W/m2 K flows inside the tube. The outer surface of the insulation is exposed to cooler air at T0= 30^0 C with h0 = 50 W/m2 K. Find (i) heat loss from the tube to the air for the tube length L=10 m. [8]

ii) Temperature drops resulting from the thermal resistances of the hot gas flow, the steel tube, the insulation layer and outside air.

8. (a) Air at atmospheric pressure and 40^0C flows with a velocity of U= 5 m/s over 2 m long flat plate whose surface temperature is kept at a uniform temperature of 120^0C, Determine the average heat transfer coefficient over the 2 m length of the plate. Also find out the rate of heat transfer between the plate and the air per 1 m with of the plate, (air at 1 atm and 80^0C,kin Viscosity=$2.107X10^{-5}m^2/s$, K= 0.03025 W/mK: Pr = 0.6965) [8]

(b) Lubricating oil at a temperature of 60^0C enters 1 cm diameter tube with a velocity of 3 m/s. The tube surface is maintained at 40^0C, assuming that the oil has the following average properties, calculate the tube length required to cool the oil to 45^0C, density=865kg/m^3, K=0.14W/mK,C_p=1.78kJ/kg^{0}C, Assume the flow to be laminar and fully developed. Nu_{av}=3.657, [7]

9. (a) Copper plate fins of rectangular cross-section, 1 mm thick, 10 mm long and thermal conductivity as 380 W/mK are attached to a plane wall maintained at a temperature of 230^0C. The fins dissipate heat by convection into an ambient at 30^0 C with a heat transfer coefficient of 40 W/m2 K. Fins are spaced at 8 mm. Assume negligible heat loss from the tip. Calculate i) Fin Efficiency, ii) Area weighted fin efficiency, iii)the total heat transfer rate per m2 of plane wall surface iv) the heat transfer rate from the plane wall if there were no fins attached, [8]

(b) 10. A steel ball 100 mm in diameter and initially at 900^0C is placed in air at 30^0C. Talking for steel, K=40W/mK, ρ=7800 Kg/m3 and c=460 J/Kg K and if h = 20 W/m2K, find the temperature of the ball after 30 Sec, and the rate of cooling after 30 Sec. [7]

10. (a) Discuss the boiling curve of water showing all the regimes. [8]

(b) Liquid mercury flows at a rate of 1.6kg/s through a copper tube of 20 mm diameter. The mercury enters the tube at 15^0C and after getting heated it leaves the tube at 35^0C. Calculate the tube length for constant heat flux at the wall which is maintained at an average temperature of 50^0C. For liquid metal flowing through a tube, the following empirical correlation is presumed to agree well with experimental results: $Nu_{ave}=7+0.025(Pe)^{0.8}$, where Pe=ReXPr. [7]

11. (a) Discuss the boundary layer formation over a plat plate. [8]

(b) Discuss the parallel flow and counter flow heat exchanger with flow diagram. [7]

*** END OF PAPER ***