Roll No. Total No. of Pages : 02

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M.Tech. (Mechanical Engineering) (Sem.–3)

ADVANCED HEAT AND MASS TRANSFER

Subject Code : MTME-231

M.Code : 75007

Time : 3 Hrs. Max. Marks : 100

INSTRUCTIONS TO CANDIDATES :

1. **Attempt any FIVE questions out of EIGHT questions.**
2. **Each question carries TWENTY marks.**

1. Establish the general differential equation in cartesian coordinates for three dimensional unsteady heat conduction by considering an infinitesimal volume element. Reduce the conduction equation for the following cases:

   a) Unsteady state two-dimensional flow with heat generation at uniform rate within the material.

   b) Steady one dimensional flow without heat generation.

2. a) One end of a long rod is inserted into a furnace and the other end projects into the surrounding air at 20ºC. Under steady state conditions, the temperature of the rod measured at two points, 100 mm apart, was found to be 120ºC and 100ºC respectively. If the diameter of the rod is 25mm and the thermal conductivity of the fin material is 120 W/m – deg, make calculations for surface heat transfer coefficient.

   b) Prove that for a body whose thermal resistance is zero, the temperature required for cooling or heating can be obtained from the relation

$$\frac{T - T_a}{T_i - T_a} = \exp\left(-\frac{hA}{mc_p}\tau\right)$$

   Where T is the temperature of the body at any time τ, T_i is the initial temperature of the body, T_a is the atmospheric temperature. A is the surface area, m is the mass, c_p is the specific heat, and h is the heat transfer coefficient on the surface of the body.

3. a) Define emissivity of a surface. Explain spectral, directional, hemispherical and total emissivity.

   b) Assuming sun to be a black body having a temperature of 5800 K at the surface. Calculate, a) the total emissive power, b) the wavelength at which the maximum spectral intensity occurs, c) the maximum value of $E_{b\lambda}$, d) The total amount of radiant energy emitted by the sun per unit time if its diameter can be assumed to be 1.391×10^9m.

4. A cryogenic spherical tank with diameter 0.4m filled with a cryogenic fluid at T_1 = 100 K is placed in another spherical container of diameter 0.6m which is maintained at 300 K. Emissivities of inner and outer tanks are 0.1 and 0.2 respectively.

Find :

a) The rate of heat loss into the air vessel by radiation,

b) If a spherical radiation shield of diameter 0.5 m and emissivity 0.05 on both surfaces is placed between the spheres, what is the new rate of heat loss?

5. Explain in detail the mechanism of forced convection. Show by dimensional analysis that data for forced convection may be correlated by an equation of the form :

$$Nu = f(Re, Pr)$$

Where Nusselt number, $Nu = hl/k$; Reynolds number, $Re = Vl\rho/\mu$ and Prandtl number, $Pr = \mu c_p/k$

6. Derive the Von-Karman momentum integral equation for flow past a flat plate in the form :

$$\tau_w = \rho U_\infty^2 \frac{d}{dx}\left[\int_0^\delta \frac{u}{U_\infty}\left(1 - \frac{u}{U_\infty}\right) dy\right]$$

Based upon the equation, calculate the boundary layer thickness, wall shear stress and the skin friction coefficient for laminar flow over a flat plate. Assume a linear velocity distribution in boundary layer.

7. For laminar film condensation on a vertical plate, develop an expression for the film thickness, heat transfer coefficient and steam condensation rate in terms of relevant fluid properties, temperature difference and the plate dimensions. Are the fluid properties involved evaluated for the vapour phase? If not, how are they evaluated?

8. a) What are nanofluids? Discuss the various engineering applications of nanofluids.

b) Explain the special features of radiation from gases.

NOTE : Disclosure of identity by writing mobile number or making passing request on any page of Answer sheet will lead to UMC case against the Student.