Roll No. | | | | | | | | | | | | | Total No. of Pages : 02

Total No. of Questions : 08

M.Tech.(ME) (Sem.–1)

ADVANCE HEAT AND MASS TRANSFER

Subject Code : MME-503

Paper ID : [E0403]

Time : 3 Hrs. Max. Marks : 100

INSTRUCTIONS TO CANDIDATES :

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

Q1. a) Discuss the mechanism of thermal conduction in gases and solids.

b) What is the order of magnitude for the convection heat-transfer coefficient in free convection? Forced convection? Boiling?

Q2. a) A current of 200 A is passed through a stainless-steel wire [k=19 W/m·°C] 3 mm in diameter. The resistivity of the steel may be taken as 70 μΩ·cm and the length of the wire is 1 m. The wire is submerged in a liquid at 110°C and experiences a convection heat-transfer coefficient of 4kW /m^2·°C. Calculate the center temperature of the wire.

b) Consider a 0.8-m-high and 1.5-m-wide double-pane window consisting of two 4-mm-thick layers of glass (k=0.78 W/m °C) separated by a 10 -mm-wide stagnant air space (k-0.026 W/m °C). Determine the steady rate of heat transfer through this double-pane window and the temperature of its inner surface for a day during which the room is maintained at 20°C while the temperature of the outdoors is 10°C. Take the convection heat transfer coefficients on the inner and outer surfaces of the window to be h1 = 10 W/m^2·°C and h2 = 40 W/m^2· °C, which includes the effects of radiation.

Q3. a) A steel ball [c=0.46 kJ/kg °C, k=35 W/m-°C] 5.0 cm in diameter and initially at a uniform temperature of 450 °C is suddenly placed in a controlled environment in which the temperature is maintained at 100°C. The convection heat-transfer coefficient is 10 W/m^2 °C. Calculate the time required for the ball to attain a temperature of 150°C.

b) A large block of steel [k=45W/m·°C, α = 1.4×10-5 m^2/s] is initially at a uniform temperature of 35°C. The surface is exposed to a heat flux (i) by suddenly raising the surface temperature to 250°C and (ii) through a constant surface heat flux of 3.2×10^5 W/m^2. Calculate the temperature at a depth of 2.5 cm after a time of 0.5 min for both these cases.

Q4. In areas where the air temperature remains below 0°C for prolonged periods of time, the freezing of water in underground pipes is a major concern. Fortunately, the soil remains relatively warm during those periods, and it takes weeks for the subfreezing temperatures to reach the water mains in the ground. Thus, the soil effectively serves as an insulation to protect the water from subfreezing temperatures in winter. The ground at a particular location is covered with snow pack at -10°C for a continuous period of three months, and the average soil properties at that location are k = 0.4 W/m·°C and $\alpha = 0.15\ 10^{-6}$ m^2/s. Assuming an initial uniform temperature of 15°C for the ground, determine the minimum burial depth to prevent the water pipes from freezing.

Q5. a) What is forced convection? How does it differ from natural convection? Is convection caused by winds forced or natural convection?

b) A 2-m × 3-m flat plate is suspended in a room, and is subjected to air flow parallel to its surfaces along its 3-m-long side. The free stream temperature and velocity of air are 20°C and 7 m/s. The total drag force acting on the plate is measured to be 0.86 N. Determine the average convection heat transfer coefficient for the plate.

Q6. a) What is the momentum equation for the laminar boundary layer on a flat plate? What assumptions are involved in the derivation of this equation?

b) Air at 20°C and 1 atm flows over a flat plate at 35 m/s. The plate is 75 cm long and is maintained at 60°C. Assuming unit depth in the z direction; calculate the heat transfer from the plate.

Q7. a) What do you mean by radiation and how does thermal radiation differ from other types of electromagnetic radiation?

b) Two parallel plates 0.5 by 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 surfaces facing each other are to be considered in the analysis. Find the net transfer to each plate and to the room.

Q8. a) Define the Schmidt and Lewis numbers. What is the physical significance of each?

b) Dry air at atmospheric pressure blows across a thermometer that is enclosed in a dampened cover. This is the classical wet-bulb thermometer. The thermometer reads a temperature of 18.3°C. What is the temperature of the dry air? If the airstream at 32.2°C while the wet-bulb temperature remains at 18.3°C, calculate the relative humidity of the air stream.