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Code No: G2103/R13

M. Tech. I Semester Supplementary Examinations, JAN/FEB-2018

ADVANCED HEAT & MASS TRANSFER/
ADVANCED HEAT TRANSFER
(Common to TS&ES and TE)

Time: 3 hours **Max. Marks: 60**

Answer any FIVE Questions
All Questions Carry Equal Marks

1. a A thick walled circular tube has inside radius r_1 and outside radius r_2. A hot gas at temperature T_1 flows inside the tube, and a cold gas at temperature T_2 flows outside. The thermal conductivity k of the tube is considered constant. The heat transfer coefficients for flow inside and outside the tube are specified as h_1 and h_2, respectively. Write the mathematical formulation of this heat conduction problem in order to determine the one-dimensional, steady-state temperature distribution T(r) through the tube wall. [5]

   b A brick column with cross section 10 cm by 10 cm [Thermal conductivity, k=0.69 W/m ^{0}C and thermal diffusivity, α=0.5 x 10^{-6} m^2/s] is initially at a uniform temperature T_i=225^{0}C. Suddenly the surfaces are subjected to convective cooling with a heat transfer coefficient h=60 W/m^2 ^{0}C into an ambient at T_∞=25^{0}C. Calculate the center temperature T_0 at t=1 hour after the start of the cooling. [7]

2. a Consider a sphere and a cylinder of equal volume made of copper. Both the sphere and the cylinder are initially at the same temperature and are exposed to convection in the same environment. Which do you think will cool faster, the cylinder or the sphere? Why? [4]

   b Water is to be heated from 15^{0}C to 65^{0}C as it flows through a 3 cm internal diameter, 5 m long tube. The tube is equipped with an electric resistance heater that provides uniform heating throughout the surface of the tube. The outer surface of the heater is well insulated, so that in steady operation all the heat generated in the heater is transferred to the water in the tube. If the system is to provide hot water at a rate of 10 L/min, determine the power rating of the resistance heater. Also, estimate the inner surface temperature of the pipe at the exit. [8]

3. a How can a node on an insulated boundary be treated as an interior node in the finite difference formulation of a plane wall? Explain. [3]

   b An iron rod L=5 cm long of diameter D=2 cm with thermal conductivity k=50 W/m ^{0}C protrudes from a wall and is exposed to an ambient at T_∞=20^{0}C and h=100 W/m^2 ^{0}C. The base of the rod is at T_0=320 ^{0}C, and its tip is insulated. Assuming one-dimensional steady-state heat flow, calculate the temperature distribution along the rod and the rate of heat loss into the ambient by using finite differences. [9]

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4. a Consider steady flow of a fluid between two parallel plates with u and v being the velocity components in the axial x and the normal y directions, respectively. Simplify the energy equation in the rectangular coordinates for flow between two parallel plates under the following assumptions. [6]
   i. The flow is fully developed.
   ii. The temperature gradients in the axial x direction are negligible.

   Discuss the physical significance of each term in the resulting energy equation.

   b Atmospheric air at T_∞=275 K flows across a 1-mm diameter electric wire that is maintained at a uniform temperature T_w=325 K. If the wire dissipates 70 W/m, calculate the free stream velocity u_∞ of the air. [6]

5. a A vertical plate 0.3 m high and 1 m wide, maintained at a uniform temperature 124^{0}C, is exposed to quiescent atmospheric air at 30^{0}C. [6]
   i) Calculate the average heat transfer coefficient for free convection.
   ii) Find the total heat transfer rate from both surfaces of the plate by free convection into the air.

   b Ethylene glycol at 40^{0}C flows along a heated vertical plate L=0.5 m long and is maintained at a uniform temperature of 80^{0}C. Determine the minimum flow velocity below which the effect of free convection on heat transfer becomes more than 5 percent.(for ethylene glycol take Pr=50) [6]

6. a Consider film condensation on a vertical plate. Will the heat flux be higher at the top or at the bottom of the plate? Why? [4]

   b Water is to be boiled at atmospheric pressure on a 3 cm diameter mechanically polished steel heater. Determine the maximum heat flux that can be attained in the nucleate boiling regime and the surface temperature of the heater surface in that case. [8]

7. a Determine the radiative energy emitted between 2 and 10 μm wavelengths by a 1 m by 1 m gray surface at 600 K which has an emissivity ε=0.8. [4]

   b A furnace is of cylindrical shape with Radius and height equal to 2m. The base, top and side surfaces of the furnace are all black and are maintained at uniform temperatures of 500, 700 and 1200 K respectively. Determine the net rate of radiation heat transfer to or from the top surface during steady operation. [8]

8. a Show that mass transfer by forced convection can be expressed as Sh=f(Re,Sc). [6]
   [where Sh – Sherwood number ; Re – Reynolds numbe and Sc – Schmidt number]

   b Dry air at 27^{0}C and 1 atm flows over a wet plate 50 cm long at a velocity of 50 m/s. Calculate the mass transfer coefficient of water vapour in air at the end of the plate. [6]

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