BIRLA INSTITUTE OF TECHNOLOGY & SCIENCE, PILANI
Second Semester 2016-17
ME G631 Advanced Heat Transfer
Mid-Semester
Open Book: Only Text Book & Class Notes are allowed. Data Book is allowed

Max. Time: 90 minutes **Max. Marks: 30**

Make suitable assumptions and state them clearly

Q.1

a) At a certain instant of time the temperature distribution across a wall is given by: $T = 200 - 200x + 30x^2$. Assume no heat generation inside the wall. Does the wall is under steady state or transient condition?

b) Is heat flux vector is always perpendicular to the isotherm lines? What is the physical significance of the cross terms of the thermal conductivity tensor?

c) The temperature profile in a plane wall is found to be $T(x) = A + Bx$ where A and B are constants. List all the assumptions under which the solution is valid for a plane wall.

d) Consider a penny and a wire of the same material. The diameter of the wire is the same as the thickness of the penny. The two are heated in an oven by convection. Initially both are at the same temperature. Assume that the heat transfer coefficient is the same for both and that the Biot number is small compared to unity. Which object will be heated faster?

e) Consider steady state two-dimensional conduction in a hollow half disk as shown in Figure 1. The inner radius is r_i, outer radius r_o and thickness is δ. The disk exchange heat by convection along its two plane surfaces. The heat transfer coefficient is h and the ambient temperature is T_∞.The cylindrical surface at r_i is maintained at T_1 and that at r_o at T_2. The two end surfaces at $\theta = 0$ and $\theta = \pi$ are insulated. Write the governing differential equation and boundary conditions. Identify the homogeneous and non-homogeneous boundary conditions. Do not solve the equations but suggest solution methodology.

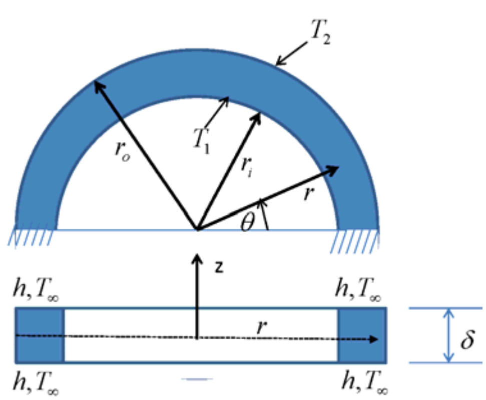

Fig.1

[2+1+1.5+1.5+4]

P.T.O

Q.2

A copper sphere of diameter of 0.3 mm exchanges heat by convection with ambient where the ambient temperature $T_\infty(t)$ varies with time according to $T_\infty(t) = T_0 e^{-\phi t}$, where $T_0 = 300\,\mathrm{K}$ and $\phi = 0.3$. The heat Transfer coefficient is 10 W/m^{2}K. Assume initially (at t = 0) the copper sphere to be in thermal equilibrium with the ambient. Using Lumped capacitance method and Duhamel's superposition principle determine temperature of the copper sphere after a period of 0.5 sec. Properties for copper are: specific heat $c = 385$ J/kg-K ., thermal conductivity k = 398.4 W/m-K and density $\rho = 8933\,\mathrm{kg/m^3}$.

[10]

Q.3

Two plates 1 and 2 of thickness L_1 and L_2 and thermal conductivity k_1 and k_2 respectively are attached together with perfect contact at the interface. Initially both the plates are at uniform temperature $T_i = 300K$.

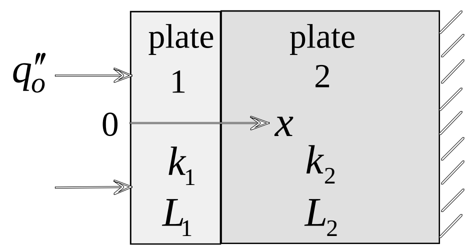

Plate 1 is suddenly heated by uniform heat flux of q''_o =1000 kW/m^2, while the exposed surface of plate 2 is insulated. Determine the temperature of the heated surface at the instant when the temperature of the plate 2 begins to change. Assume a second degree polynomial profile for the temperature. Plate 1 is of copper and plate 2 is of steel. For copper: specific heat $c = 385\,\mathrm{J/kg\,K}$., thermal conductivity k= 398.4 W/m-K and density $\rho = 8933\,\mathrm{kg/m^3}$ and for steel: $\rho = 7820\,\mathrm{kg/m^3}$, $c = 460$ J/kg K, k= 15 W/m-K. Thickness of plate 1: L_1= 2 cm and of plate 2: L_2= 4cm.

[10]