Lebanese American University
School of Engineering
IME Department

MEE 403 HEAT TRANSFER
First Midterm, Duration 90 min

Name: April 16, 2013 **ID:**

1 (25 pts) A plane wall of thickness 2L=40 mm and thermal conductivity k=5 W/m.K experiences uniform volumetric heat generation at a rate $\dot{q}$, while convection heat transfer occurs at both of its surface (x=-L, +L), each of which is exposed to a fluid of temperature $T\infty=20^oC$. Under steady-state conditions, the temperature distribution in the wall is of the form $T(x)=a+bx+cx^2$, where a= 82^oC, b=-$210^oC/m$, c=-$2x10^{4o}C/m^2$, and x is in meters. The origin of the x-coordinate is at the midplane of the wall.

a) Sketch the temperature distribution and identify significant physical features

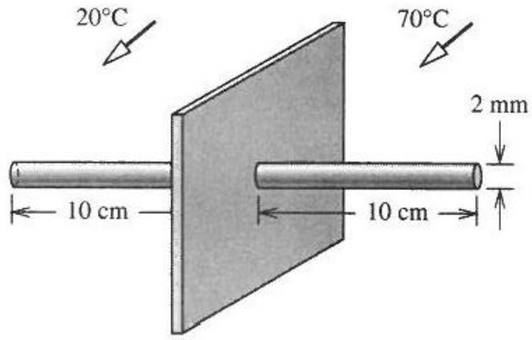
b) What is the volumetric rate of heat generation $\dot{q}$ in the wall?

c) Determine the surface heat fluxes, $q_x''(-L)$ and $q_x''(+L)$. How are these fluxes related to the heat generation rate?

d) What are the convection coefficients for the surfaces at x=-L and x=+L?

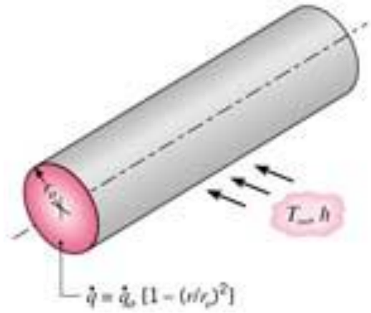
e) If the source of the heat generation is suddenly deactivated($\dot{q}=0$), what is the rate of change of energy stored in the wall at this instant?

2 (25 pts) Two air flows are separated by a 2 mm-thick plastic wall. A 20.2 cm-long, 1 cm-diameter aluminum rod transfers heat from one flow to the other as shown. The hot air flow is at 70°C, and the convective heat transfer coefficient to the rod is 48 W/m^2 K; the cold air flow is at 20°C and is at a lower velocity, giving a heat transfer coefficient of only 24 W/m^2 K. Determine the rate of heat transfer and the temperature of the midsection of the rod. Take k=190 W/m K for the aluminum.



3 (25 pts) Radioactive wastes are packed in a long, thin-walled cylindrical container, the wastes generate thermal energy nonuniformly according to the relation $\dot{q}(r) = \dot{q}_o\left[1-\left(r/r_o\right)^2\right]$, where $\dot{q}$ is the local rate of energy generation per unit volume, $\dot{q}_o$ is a constant, and r_o is the radius of the container. Steady-state conditions are maintained by submerging the container in a liquid that is at T_∞ and provides a uniform convection coefficient h. Obtain an expression for the total rate at which energy is generated in a unit length of the container.

Use this result to obtain an expression for the temperature T_s of the container wall.



4 (25 pts) A 60 cm long, 3 cm- diameter AISI 1010 steel rod k=64 W/m K is welded to a furnace wall and passes thru 20 cm if insulation before emerging into the surrounding air. The furnace wall is at 300°C, and the air temperature is 20°C. Estimate the temperature of the bar tip if the heat transfer coefficient between the rod and the air is taken to be 13 w/m^{2}K