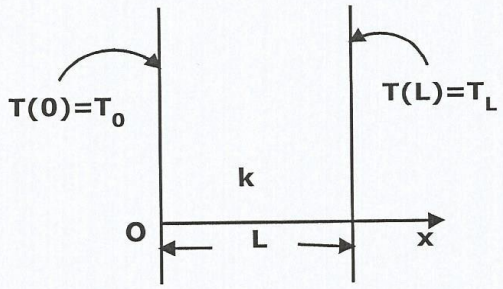
Cankaya University
Faculty of Engineering
Mechanical Engineering Department
ME 313 Heat Transfer
Fall 2017
Quiz # 2

Consider an infinite plane wall as given below. The plane wall has thickness of L=0.3 m and a thermal conductivity of $k = 1\ W/m.K$.



The temperature distribution across this plane wall at a certain instant of time is

$$T(x) = a + bx + cx^2$$

where T is in degrees Celsius and x is in meters, $a = 200°C$, $b = -200\ °C/m$ *and* $c = 30\ °C/m^2$.

(a) What is the temperature at x=0 (left face of plane wall) ?
(b) What is the temperature at x=L (the right face of the plane wall) ?
(c) On a unit surface area basis (i.e. assume 1 m^2 for surface area) , determine the rate of heat transfer into the wall at x=0 and out of the wall at x=L and the rate of change of energy stored by the wall.
(d) If the cold surface is exposed to a fluid at 100 °C , what is the convection heat transfer coefficient $\bar{h}$?

Equations:

$$q'' = -k\frac{dT}{dx} \qquad \dot{E}_{in} - \dot{E}_{out} + \dot{E}_g = \dot{E}_{st}$$

$$q_c'' = \bar{h}(T_w - T_\infty) \qquad \dot{E}_{st} = \rho c \forall \frac{dT}{dt}$$

a) $T_0 = T(0) = 200°C$

b) $T(L) = [a + bx + cx^2]_{x=0.3}$

$T_L = [200 - 200 \times 0.3 + 30(0.3)^2] = 142.7°C$

c) $q''_{in} = -k\frac{\partial T}{\partial x}\Big|_{x=0} = -(1)(b + 2cx)_{x=0} = 200\ W/m^2$

$q_{out} = -k\left(\frac{\partial T}{\partial x}\right)_{x=L} = -[(1)(b + 2cx)]_{x=0.3}$

$= -[-200 + 2(30)(0.3)] = 182\ W/m^2$

(see back of page)

$$\dot{E}_{in} - \dot{E}_{out} + \cancel{\dot{E}_g} = \dot{E}_{st}$$

$$\dot{E}_{st} = q''_{in} - q''_{o} = 200 - 182 = 18\ W/m^3$$

d) $$\bar{h} = \frac{q''_{out}}{T_L - T_\infty} = \frac{182}{142.7 - 100} = 4.3\ W/m^2K$$