Cankaya University

Faculty of engineering

Mechanical Engineering Department

ME 313 Heat Transfer

CH 2 Example Solutions

Corrected Problem (6)

6) The temperature distribution in a plate of thickness 20 mm is given by $T(°C) = 10x + 6x^2 + 4$. Assume no heat generation in the plate; calculate heat flux on two sides of the plate. Also calculate the rate of temperature change with respect to time, if $k = 300 W/m.K$, $\rho = 5800 kg/m^3$ and $c = 420 J/kg.K$.

Solution

$T(x) = 10x + 6x^2 + 4$

L = 20 mm = 0.02 m k = 300 W/m.K

ρ = 5800 kg/m^3 c_p = 420 J/kg.K

$$\frac{\delta T}{\delta x} = 12x + 10 \ , \ \frac{\delta^2 T}{\delta x^2} = 12$$

$$q_x = -k(\frac{dT}{dx})_{x=0} = -300[12x + 10]_{x=0} = -3000 \frac{W}{m^2}$$

$$q_{x=L} = -k(\frac{dT}{dx})_{x=L} = -300[12x + 10]_{x=0.02} = -3072 \frac{W}{m^2}$$

- Rate of temperature change with time

$\dot{E}_{in} - \dot{E}_{out} + \dot{E}_g = \dot{E}_{st}$ where $\dot{E}_g = 0$

$$\frac{\delta}{\delta x}[k\frac{dT}{dx}] = \rho.c_p.\frac{\delta T}{\delta t} \quad \Rightarrow \quad \frac{k}{\rho.c_p}[\frac{\delta}{\delta x}(\frac{dT}{dx})] = \frac{\delta T}{\delta t}$$

$$\frac{300 \frac{W}{mK}}{5800 \frac{kg}{m^3}.420 \frac{J}{kg.K}} \text{x}(12) = \frac{dT}{dt} = 1.48\text{x}10^3 \frac{°C}{s}$$