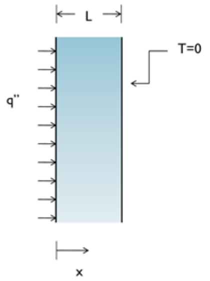
ICE for PDE

Problem 1.



$$\rho c_p \frac{\partial T}{\partial t} = k\frac{\partial^2 T}{\partial x^2}$$

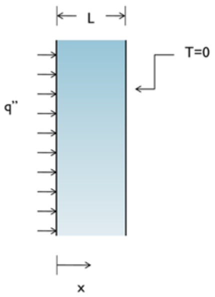
$$T(x,0) = 0$$

$$-k\left.\frac{\partial T}{\partial x}\right|_{x=0} = q''$$

$$T(L,t) = 0$$

L=0.1m, k=200 W/(m.K), $\rho = 10000\, kg/m^3$, $c_p = 500\, J/(kg.K)$, $q'' = 1 \times 10^6\, W/m^2$.

Problem 2



$$\rho c_p \frac{\partial T}{\partial t} = k\frac{\partial^2 T}{\partial x^2}$$

$$T(x,0) = 0$$

$$-k\left.\frac{\partial T}{\partial x}\right|_{x=0} = q''$$

$$-k\left.\frac{dT}{dx}\right|_{x=L} = h(T - T_{bulk})$$

$T_{bulk} = 20°\mathrm{C}$, $h = 1 \times 10^4\, W/m^2K$.

Problem 3

The advection-diffusion equation is used to compute the distribution of concentration along the length of a rectangular chemical reactor.

$$\frac{\partial c}{\partial t} = D\frac{\partial^2 c}{\partial x^2} - U\frac{\partial c}{\partial x} - kc$$

where c=concentration (mg/m^3), t=time(min), D= a diffusion coefficient (m^2/min), x=distance along the tank's longitudinal axis (m) where x=0 at the tank's inlet, U=velocity in the x direction (m/min), and k=a reaction rate (min^{-1}) whereby the chemical decays to another form. Develop an explicit scheme to solve this equation numerically. Test it for k=0.15, D=100, and U=1 for a tank of length 10 m. Use a $\Delta x = 1$m, and a step size $\Delta t = 0.005$. Assume that the inflow concentration is 100 and that the initial concentration in the tank is zero. Perform the simulation from t=0 to 100 and plot the final resulting concentration versus x.