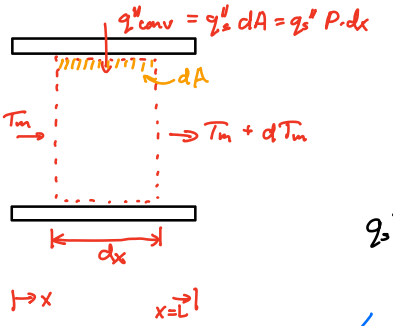
7C - 1ST CLASS

1. Constant Surface Heat Flux



$$q_{conv} = \dot{m} c_p (T_{m,o} - T_{m,i}) \leftarrow \text{Total heat transfer}$$

$$dq_{conv} = \dot{m} c_p [(T_m + dT_m) - T_m]$$

$$q_s'' P\, dx = \dot{m} c_p\, dT_m$$

$$\frac{dT_m}{dx} = \frac{q_s'' P}{\dot{m} c_p}$$

Integrate

$$T_m(x) = T_{m,i} + \frac{q_s'' P}{\dot{m} c_p} x$$

for constant surface heat flux
q_s'' = constant

2. Constant Surface Temperature

$$\frac{dT_m}{dx} = \frac{q_s'' P}{\dot{m} c_p} = \frac{P}{\dot{m} c_p} \times h \times \Delta T$$

$$\Rightarrow \Delta T = T_s - T_m$$

$$\frac{dT}{dx} \sim \frac{d(\Delta T)}{dx}$$

$$\int_{\Delta T_i}^{\Delta T_o} \frac{d\Delta T}{\Delta T} = \frac{-P}{\dot{m} c_p} \int_{x=0}^{x=L} h\, dx$$

$$\ln \frac{\Delta T_o}{\Delta T_i} = -\frac{PL}{\dot{m} c_p} \bar{h}$$

$$\frac{\Delta T_o}{\Delta T_i} = \frac{T_s - T_{m,o}}{T_s - T_{m,i}} = \exp\left(-\frac{PL}{\dot{m} c_p} \bar{h}\right)$$

$$\Rightarrow T_m(x) = T_s - (T_s - T_{m,i}) \exp\left(-\frac{PL}{\dot{m} c_p} \bar{h}\right)$$