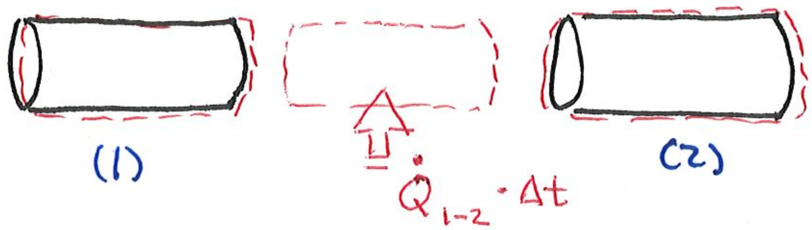
1.



Cons. of energy, finite time, closed system:

$$E_2 - E_1 = Q_{IN,1-2} + W_{IN,1-2} \to 0$$

No KE, PE

$$U_2 - U_1 = \dot{Q}_{IN} \cdot \Delta t$$

Model Cu as incompressible:

$$m(u_2 - u_1) = \dot{Q}_{IN} \cdot \Delta t$$

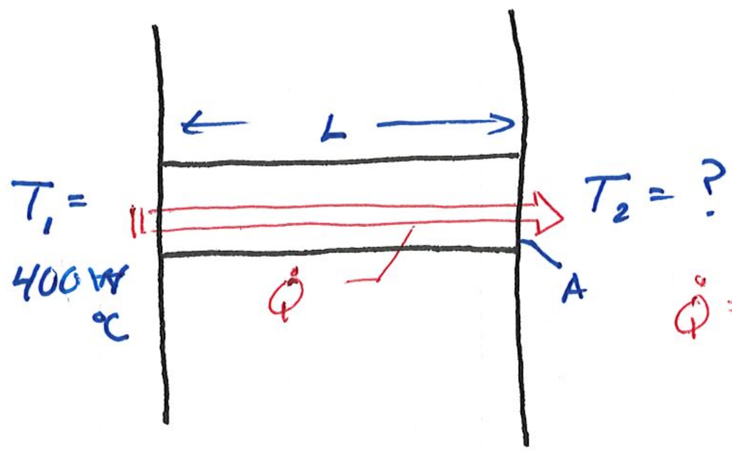
$$mc(T_2 - T_1) = \dot{Q}_{IN} \Delta t$$

$$\dot{Q}_{IN} = \frac{mc(T_2 - T_1)}{\Delta t}$$

$$= \frac{(2\,\text{kg})(385\,\frac{\text{J}}{\text{kg}\cdot{}^\circ\text{C}})(80-25)^\circ\text{C}}{2\,\text{min}\left(\frac{60\,\text{s}}{\text{min}}\right)}\left(\frac{\text{W}}{\text{J/s}}\right)$$

$$= 353\ \text{W}$$ ← ANS

2.



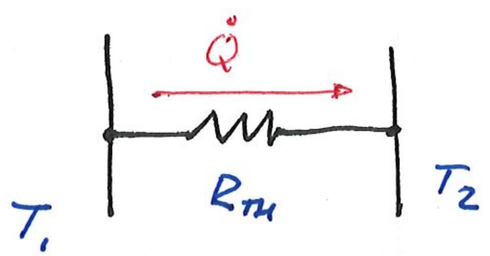
$L = 0.15\,m$

$A = 20\,cm^2$

$\dot{Q} = 353\,W$

1-D, Steady-state conduction, no generation, constant properties:

Use resistance analogy:



$$\therefore \quad \dot{Q} = \frac{T_1 - T_2}{R_{TH}} \quad [1]$$

$$R_{TH} = \frac{L}{KA}$$

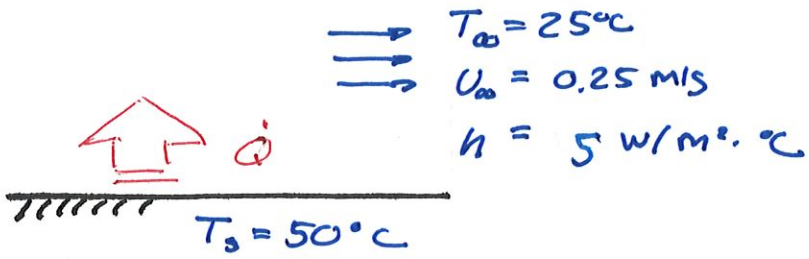
[1] becomes

$$\dot{Q} = \frac{T_1 - T_2}{\frac{L}{KA}} \qquad T_2 = T_1 - \dot{Q}\,\frac{L}{KA}$$

$$= 400\,°C - 353\,W \cdot \frac{0.15\,m}{400\,\frac{W}{m \cdot K} \cdot 20\,cm^2 \left(\frac{0.01^2\,m^2}{cm^2}\right)}$$

$$= 334\,°C$$ ← ANS

3.



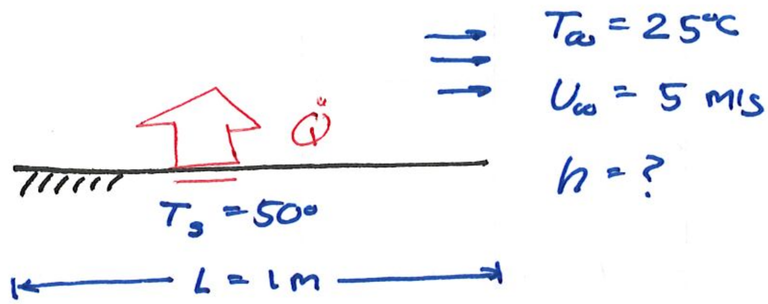
$$\dot{Q} = hA(T_s - T_\infty)$$

$$\dot{q} = \frac{\dot{Q}}{A} = h(T_s - T_\infty)$$

$$= 5 \frac{W}{m^2 \cdot \cancel{°C}} \left[50 - 25 \right] \cancel{°C}$$

$$= 125 W$$ ← ANS

4.



Air @ 25°C

$\nu = 1.56 \times 10^{-7}$ m^2/s

$Pr = 0.728$

$k = 0.02551$ W/m·K

$$Re = \frac{U_\infty L}{\nu} = \frac{5 \frac{\cancel{m}}{\cancel{s}} \cdot 1 \cancel{m}}{1.56 \times 10^{-7} \frac{\cancel{m^2}}{\cancel{s}}} = 320,200$$

∴ LANNMAR FLOW

FLAT PLATE, LAMINAR FLOW, CONST T B.C., AVERAGE NUSSELT NUMBER

$$Nu = 0.664\, Re^{0.5}\, Pr^{1/3}$$

$$= 0.664\,(320{,}200)^{0.5}\,(0.728)^{1/3}$$

$$= 338$$

$$Nu = \frac{hL}{k} \qquad h = \frac{Nu \cdot k}{L}$$

$$= \frac{338 \cdot 0.02551\ \frac{W}{m \cdot K}}{1\ m}$$

$$= 8.62\ W/m^2 \cdot K$$

$$\dot{Q} = hA(T_s - T_\infty)$$

$$\dot{q} = \frac{\dot{Q}}{A} = h(T_s - T_\infty)$$

$$= 8.62\ \frac{W}{m^2 \cdot K}\,(50 - 25)\,^\circ C$$

$$= 215\ \frac{W}{m^2}$$ ← ANS