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Final

1)

$$Accum = In - Out + gen \rightarrow gen = Out$$

$$\rightarrow gen = \frac{\Delta T}{R_{tot}} = \frac{T_{in} - T_{out}}{\frac{1}{h_{in}A_{in}} + \frac{L_{ins}}{K_{ins}A} + \frac{1}{h_{out}A} + \frac{L_w}{K_w A}}$$

$$\therefore q = \frac{21 - 38}{\frac{1}{40 \cdot 400} + \frac{0.1}{0.045 \cdot 400} + \frac{1}{55 \cdot 400} + \frac{0.025}{0.13 \cdot 400}}$$

$$= -2766.8\,W$$

$$= 2.77\ kW \text{ removed}$$

Final

2 a) $\frac{1}{r}\frac{d}{dr}\left(r\frac{dT}{dr}\right)=0 \rightarrow \frac{d}{dr}\left(r\frac{dT}{dr}\right)=0$

$r\frac{dT}{dr}=C_1 \qquad \frac{dT}{dr}=\frac{-q''}{k} \rightarrow C_1=\frac{-q''r_1}{k}$

$\frac{dT}{dr}=-\frac{q''r_1}{k}\cdot\frac{1}{r} \rightarrow T(r)=-\frac{q''r_1}{k}\ln(r)+C_2$

$T(r_1)=T_1=\frac{-q''r_1}{k}\ln(r_1)+C_2 \quad \therefore C_2=T_1+\frac{q''r_1}{k}\ln(r_1)$

$$T(r)=\frac{-q''r_1}{k}\ln(r)+T_1+\frac{q''r_1}{k}\ln(r_1)$$

b.) $T(r_2)=T_2=\frac{-450\cdot 0.1}{0.56}\cdot\ln(0.15)+90+\frac{450\cdot 0.1}{0.56}\cdot\ln(0.1)$

$$T_2=57.4^\circ C$$

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3) a) $\boxed{F_{12} = 1}$

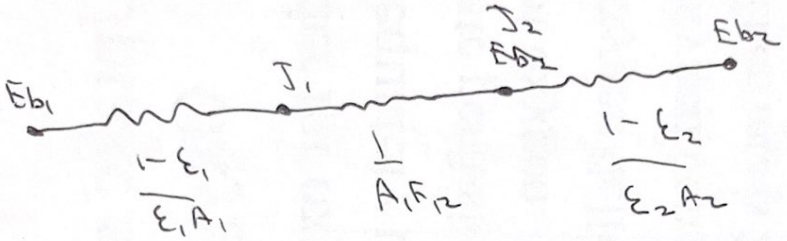
$A_1 F_{12} = A_2 F_{21} \rightarrow F_{21} = \frac{A_1}{A_2}$

$A_1 = 6 \cdot .12 \cdot .12$

$A_2 = 6 \cdot .36 \cdot .36$

$\frac{A_1}{A_2} = \frac{0.0144}{0.1296} = 0.111 = F_{21}$

b)



$q = \frac{\sigma (T_1^4 - T_2^4)}{\frac{1-\varepsilon_1}{\varepsilon_1 A_1} + \frac{1}{A_1 F_{12}} + \frac{1-\varepsilon_2}{\varepsilon_2 A_2}}$

$A_1 = 0.0864\ m^2$

$A_2 = 0.778\ m^2$

$\therefore q_{12} = \frac{5.67 \times 10^{-8} \left(800^4 - 350^4\right)}{\frac{1-0.6}{0.6 A_1} + \frac{1}{A_1} + \frac{1-0.85}{0.85 A_2}} = 1233\ W$

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4) a)

$$Re_a = \frac{\rho v L}{\mu} = \frac{1.18 \cdot 1.5 \cdot 0.5}{1.84 \times 10^{-5}} = 48097$$

Laminar

$$Nu = 0.332 Re^{1/2} Pr^{1/3} = 64.86 = \frac{h k}{k}$$

$$\therefore h = \frac{64.86 \cdot 0.0262}{0.5} = 3.399 \frac{W}{m^2 K}$$

$$q'' = h (T_s - T_{air}) = 3.399 (150 - 25) = 425 \frac{W}{m^2}$$

b)

$$Re_b = \frac{1.18 \cdot 1.5 \cdot 4}{1.84 \times 10^{-5}} = 384,782.6 > 5 \times 10^5 \quad \therefore \text{Turbulent}$$

$$\overline{Nu} = (0.037 Re^{4/5} - A) Pr^{1/3}, \quad A = 0.037 Re^{4/5} - 0.664 Re^{1/2}$$

$$A = 675.5$$

$$\therefore \overline{Nu} = 366.9 = \frac{\bar{h} L}{k}$$

$$\bar{h} = \frac{366.9 k}{L} = 2.403 \frac{W}{m^2 K}$$

$$q'' = h (T_s - T_{air}) = 300 \frac{W}{m^2}$$

c) The values are different because @ 0.5 m the flow is laminar and @ 4 m it is turbulent. ~~The turbulence mixes the fluid~~

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5.) $q = \frac{\Delta T}{R_{tot}} = \frac{\Delta T}{\frac{L}{kA} + \frac{1}{hA}} \rightarrow \frac{\Delta T}{q} = \frac{L}{kA} + \frac{1}{hA}$

$\frac{1}{hA} = \frac{\Delta T}{q} - \frac{L}{kA}$ $\quad hA = \frac{1}{\frac{\Delta T}{q''} - \frac{L}{k}}$

$q'' = \frac{q}{A}$ $\quad \therefore h = \frac{1}{\frac{40-15}{800} - \frac{0.1}{12.3}} = 43.25 \frac{W}{m^2 K}$

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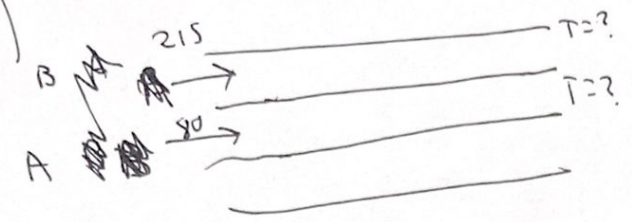
6.)



Accum = In − out + ~~gen~~

A — In = out

$mC\Delta T +$

$$q = m_a C_a (T_{ao} - T_{ai}) = m_b C_b (T_{bo} - T_{bi}) = UA_{LMTD}$$

need ↓

$$T_{ao} = T_{ai} + \frac{m_b C_b (T_{bo} - T_{bi})}{m_a C_a}$$

$$T_{bo} = \frac{215 + 80}{2} = 147.5\,^\circ C$$

$$T_{ao} = 80 + \frac{3.2976}{4.1530}(-147.5 + 215) = 178.5\,^\circ C$$

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b.) $q = m_a C_a \Delta T_a = 4.1530 \cdot (178.5 - 80)$

= ~~603. kW~~

= 602820 W