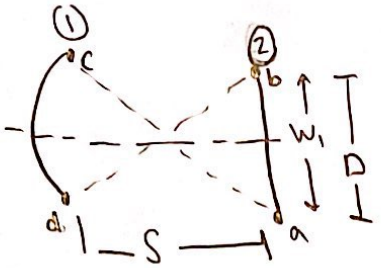
Problem 1



$$F_{21} = \frac{1}{2w_1}\left[(ac+bd)-(ad+bc)\right]$$

D $\quad \sqrt{S^2+D^2} \quad \sqrt{S^2+D^2} \quad S \quad S$

$$F_{21} = \frac{1}{2D}\left[2\sqrt{S^2+D^2} - 2S\right]$$

$$F_{21} = \frac{\sqrt{S^2+D^2}}{D} - \frac{S}{D}$$

$$A_1 F_{12} = A_2 F_{21}$$

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

$$F_{12} = \left(\frac{A_2}{A_1}\right)\left[\frac{\sqrt{S^2+D^2}}{D} - \frac{S}{D}\right]$$

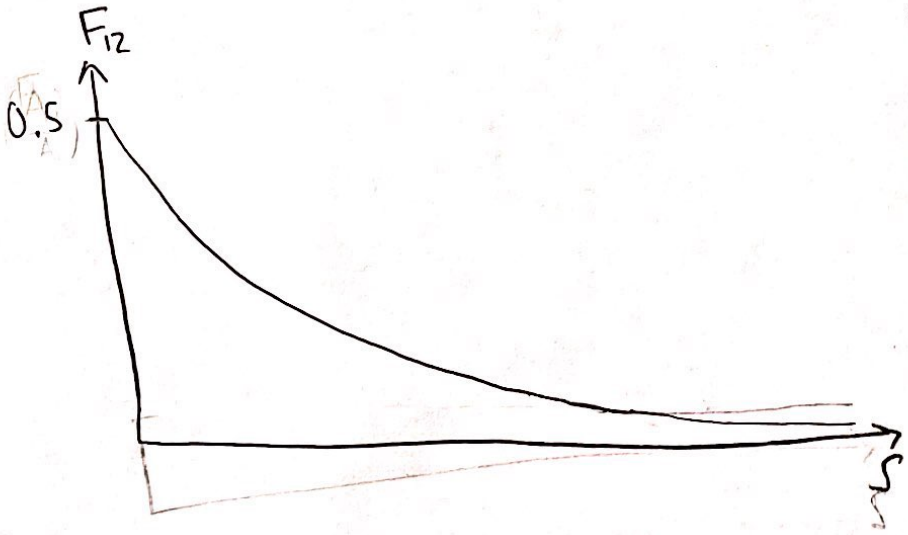
$A_2 = \frac{\pi D}{2}$ $\quad A_1 = Dw$

$A_2 > A_1$

If $S=0$, $F_{21}=1$

So $F_{12} = \frac{A_2}{A_1}$

As $S \to \infty$, $F_{21} \to 0$



$$\frac{A_2}{A_1} = \frac{\frac{\pi D^2}{4}}{\frac{\pi D^2}{2}} = 0.5$$

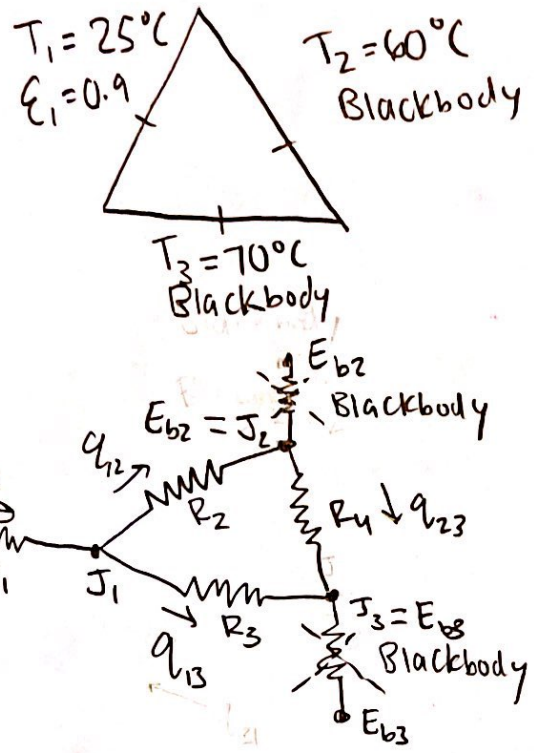
$$\frac{\sqrt{\infty^2+D^2}}{D} - \frac{\infty}{D}$$

$\frac{A_2}{A_1}(\infty - \infty)$

As $S \to \infty$

$F_{12} \to 0$

Problem 2



$A_1 = A_2 = A_3$

$F_{12} = F_{13} = F_{23} = 0.5$

$$R_1'' = \frac{1-\varepsilon_1}{\varepsilon_1 A_1} = \frac{1-0.9}{(0.9)} = 0.11$$

$$R_2'' = \frac{1}{A_1 F_{12}} = \frac{1}{.5} = 2$$

$$R_3'' = \frac{1}{A_1 F_{13}} = \frac{1}{.5} = 2$$

$$R_4'' = \frac{1}{A_2 F_{23}} = \frac{1}{.5} = 2$$

$$q_1'' = \frac{E_{b1} - E_{b3}}{R_{tot}''} = \frac{(5.67E\text{-}8)(25+273.15)^4 - (5.67E\text{-}8)(70+273.15)^4}{1.44}$$

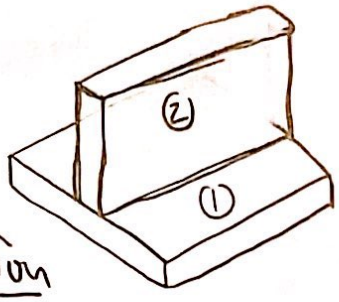
$$\frac{1}{R_{eq}''} = \frac{1}{R_2 + R_4} + \frac{1}{R_3} \Rightarrow R_{eq} = 1.33$$

$$R_{tot}'' = R_1 + R_{eq} = 1.44$$

$$\boxed{q_1'' = 226.378 \text{ W/m}^2}$$ (entering surface 1)

(It was negative so making it positive shows the net rate entering surface 1)

Problem 3



T_{surr} ③

Conduction + Convection

$P = (2)(1) + 2(0.025) = 2.05$

$A_c = (1)(0.025) = 0.025$

$m = \sqrt{\frac{(10)(2.05)}{(231)(0.025)}} = 1.88$

$M = \sqrt{(10)(2.05)(231)(0.025)}\,(600-300)$

$M = 3264.18$

$q_f = (3264.18)\tanh((1.88)(0.75))$

$q_f = 2896.941\ W$

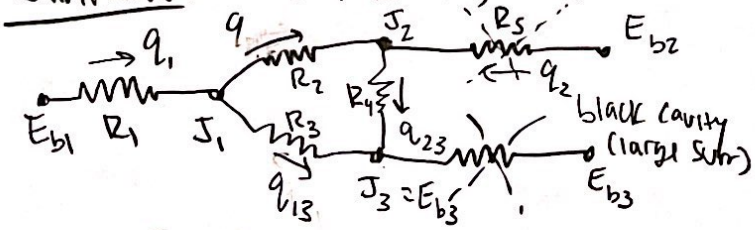
$\eta_f = \frac{q_f}{hA_f\theta_b} = \frac{(2896.941)}{(10)(2.05)(0.75)(600-300)} = 0.628$

$\eta_o = 1 - \frac{(2.05)(0.75)}{(2.05)(0.75)[(1)(1)-(0.025)(1)]}(1-0.628) = 0.77$

total Conduction & Convection for system

$\frac{\theta_b}{q_t} = \frac{1}{\eta_o h A_t} = \frac{1}{(0.77)(10)[(1)(1)-(0.025)(1)]} = 0.133 \rightarrow q_t = 2259.15\ W$

Radiation (read this x2)



$q_{tot} = \frac{E_{b1} - E_{b3}}{R_{tot}}$

$R_{tot} = R_1 + R_{eq}$

$R_{tot} = 0.228 + 2.162$

$R_{tot} = 2.39$

$q_{tot} =$

$F_{11} + F_{12} + F_{13} = 1$

0 (flat) $F_{13} = 1 - F_{12}$

0 (flat) $F_{13} = 0.72$

$F_{22} + F_{23} + F_{21} = 1$

$A_1F_{12} = A_2F_{21}$

$F_{21} = \left(\frac{A_1}{A_2}\right)F_{12} = \left(\frac{.4875}{0.75}\right)(.28)$

$F_{21} = 0.182 \rightarrow F_{23} = .818$

$\rho = 1 \rightarrow \alpha = 0$ ASSUME 2 D

gray-diffuse $\varepsilon = \alpha = 0$

Resistances

$A_1 = \frac{1-0.025}{2} = 0.4875$

$R_1 = \frac{1-\varepsilon_1}{\varepsilon_1 A_1} = \frac{1-0.9}{(.9)(.4875)} = \boxed{0.228}$

$R_2 = \frac{1}{A_1F_{12}} = \frac{1}{(.4875)(0.28)} = \boxed{7.326}$

$\rightarrow Z/X = \frac{.75}{1} = 0.75$

$Y/X = \frac{(1-0.025)/2}{1} = 0.4875$

Figure 13.6

$F_{12} \simeq 0.28$

$R_3 = \frac{1}{A_1F_{13}} = \frac{1}{(.4875)(.72)} = \boxed{2.85}$

$R_4 = \frac{1}{A_2F_{23}} = \frac{1}{(.75)(.818)} = \boxed{1.63}$

$R_5 = \frac{1-\varepsilon_2}{\varepsilon_2 A_2} = \infty$

$\frac{1}{R_{eq}} = \frac{1}{R_2+R_4} + \frac{1}{R_3} \Rightarrow R_{eq} = 2.162$

$$q_{tot} = \frac{(5.67E-8)(600)^4 - (5.67E-8)(0)^4}{2.39} = 3074.608$$

$q_{rad} = 2q_{tot}$ (symmetry on both sides)

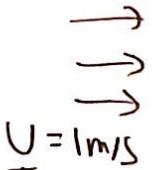
$q_{rad} = 6149.22\,W$ (leaving surface)

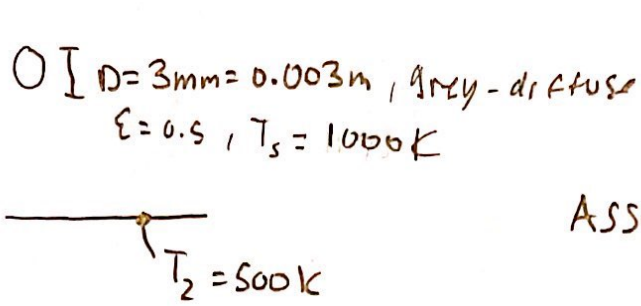
$q_{tot} = q_{rad} + q_{conv} + q_{cond}$

$q_{tot} = 6149.22W + 2259.15$

$\boxed{q_{tot} = 8408.36\,W}$ (leaving fin / plate structure

Problem 4





Assume Lumped

For $T_{air} = 1500K$ (assumption): $\rho = 0.2322$, $C_p = 1.73E-3$, $\mu = 557E-7$, $\nu = 240E-6$, $k = 100E-3$, $\alpha = 350E-6$, $Pr = 0.685$

μ @ $T = 1000 = 424.4E-7$

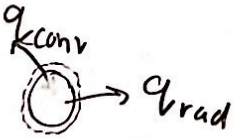
$$\overline{Nu}_D = 2 + (.4 Re_D^{1/2} + 0.06 Re_D^{2/3}) Pr^{.4} \left(\frac{\mu}{\mu_s}\right)^{1/4}$$

$$Re_D = \frac{UD}{\nu} = \frac{(1)(0.003)}{(240E-6)} = 12.5$$

$$\overline{Nu}_D = 2 + \left[(.4)(12.5)^{1/2} + (0.06)(12.5)^{2/3}\right)(.685)^{.4} \left(\frac{557E-7}{424.4E-7}\right)^{1/4}$$

$$\overline{Nu}_D = 3.598 = \frac{\bar{h}D}{k_f} \rightarrow \bar{h} = \frac{(3.598)(100E-3)}{(0.003)} = 119.947$$

$\dot{E}_{in} - \dot{E}_{out} + \dot{E}_{gen} = \dot{E}_{st}$ (0, 0, 0)



$$q_{conv} + q_{rad} = 0$$

Small object Large surroundings

$$q_{rad} = \sigma \varepsilon A (T_s^4 - T_2^4) = (5.67E-8)(0.5)(\pi (0.003)^2)(1000^4 - 500^4) = 0.75 W$$

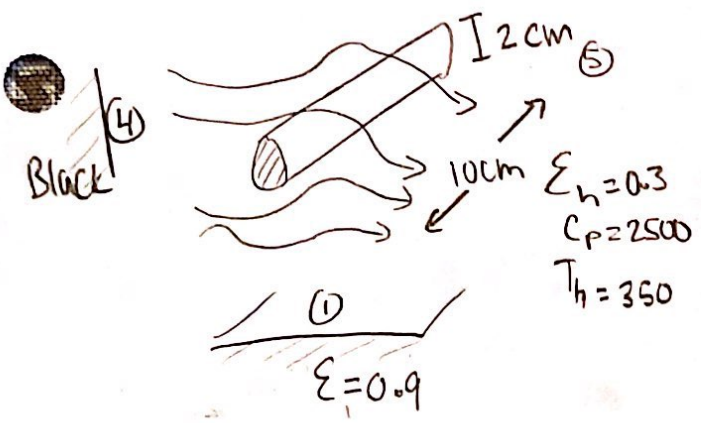
$$q_{conv} = hA(T_s - T_\infty)$$

$$q_{conv} = -q_{rad}$$

$$hA(T_s - T_\infty) = -0.75$$

$$T_\infty = \frac{0.75 + (119.947)(\pi)(0.003)^2(1000)}{(119.947)(\pi)(.003)^2} = \boxed{1221.58 K}$$

Problem 5



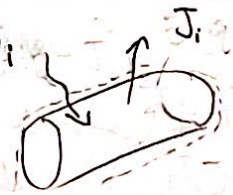
$$\overline{Nu}_D = \frac{\bar{h}D}{k} = C Re_D^{\,m} Pr^{1/3}$$

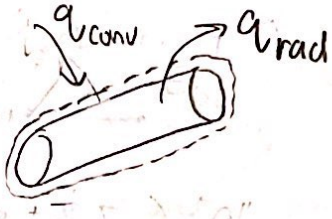
$C = 0.193$, $m = 0.618$

$$\overline{Nu}_D = (0.193)(4225.65)^{.618}(0.695)^{1/3} = 29.76 \rightarrow \boxed{\bar{h} = 47.47}$$

$$q_{conv} = \bar{h}\pi DL(T_\infty - T_s) = (47.47)(\pi)(2E-2)(10E-2)(375-350)$$

$$\boxed{q_{conv} = 7.457\,W}$$





$$\dot{E}_{in} - \dot{E}_{out} + \cancel{\dot{E}_{gen}} = \dot{E}_{st}$$

$$q_{conv} - q_{rad} = mC_p\frac{dT}{dt}$$

$$7.457 - q_{rad} = (30E-3)(2500)(0.25)$$

$$q_{rad} = -11.29\,W$$

$$q''_{rad} = -1796.86\,W/m^2$$

$$q''_{rad} = q''_h =$$

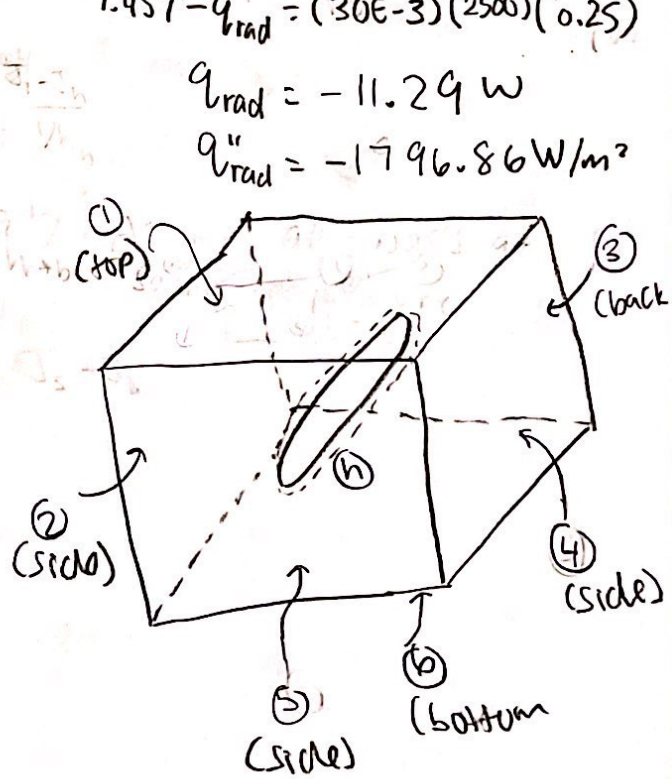
$$\frac{J_1}{\varepsilon R} - \frac{J_2}{R_2} - \frac{J_3}{R_3} - \frac{J_4}{R_4} - \frac{J_5}{R_5} - \frac{J_b}{R_b}$$

$F_{12} \Rightarrow \bar{X} = \frac{15}{15} = 1$, $\bar{Y} = \frac{15}{15} = 1$ $\quad F_{12} = 0.2$ | Symmetry

$F_{13} \Rightarrow H = \frac{15}{15}$, $W = \frac{15}{15}$ $\quad F_{13} = 0.2$

$F_{14} \Rightarrow H = 15/15$, $W = 15/15$ $\quad F_{14} = 0.2$

$F_{15} \Rightarrow H = 15/15$, $W = 15/15$ $\quad F_{15} = 0.2$



$$F_{61} + F_{62} + F_{63} + F_{64} + F_{65} + \cancel{F_{66}}^{\,0} + F_{6h} = 1$$

$$F_{61} = 1 - 4(0.2) - 0.07 = 0.13 = F_{16}$$

$$F_{1h} = F_{6h} = F_{2h} = F_{4h} = 0.07 \qquad F_{5h} = F_{3h} = 0.36$$

$$q_1 = 0 = \frac{J_1 - J_h}{1/A_1 F_{1h}} + \frac{J_1 - J_2}{1/A_1 F_{12}} + \frac{J_1 - J_3}{1/A_1 F_{13}} + \frac{J_1 - J_4}{1/A_1 F_{14}} + \frac{J_1 - J_5}{1/A_1 F_{15}} + \frac{J_1 - J_6}{1/A_1 F_{16}} = 0$$

$$q_2 = \frac{J_2 - J_h}{1/A_2 F_{2h}} + \frac{J_2 - J_1}{1/A_1 F_{12}} + \frac{J_2 - J_3}{1/A_2 F_{23}} + \frac{J_2 - J_4}{1/A_2 F_{24}} + \frac{J_2 - J_5}{1/A_2 F_{25}} + \frac{J_2 - J_6}{1/A_2 F_{26}} = 0$$

$$q_3 = \frac{J_3 - J_h}{1/A_3 F_{3h}} + \frac{J_3 - J_1}{1/A_1 F_{13}} + \frac{J_3 - J_2}{1/A_2 F_{23}} + \frac{J_3 - J_4}{1/A_3 F_{34}} + \frac{J_3 - J_5}{1/A_3 F_{35}} + \frac{J_3 - J_6}{1/A_3 F_{36}} = 0$$

$$q_4 = \frac{J_4 - J_h}{1/A_4 F_{4h}} + \frac{J_4 - J_1}{1/A_1 F_{14}} + \frac{J_4 - J_2}{1/A_2 F_{24}} + \frac{J_4 - J_3}{1/A_3 F_{34}} + \frac{J_4 - J_5}{1/A_4 F_{45}} + \frac{J_4 - J_6}{1/A_4 F_{46}} = 0$$

$$q_5 = \frac{J_5 - J_h}{1/A_5 F_{5h}} + \frac{J_5 - J_1}{1/A_1 F_{15}} + \frac{J_5 - J_2}{1/A_2 F_{25}} + \frac{J_5 - J_3}{1/A_3 F_{35}} + \frac{J_5 - J_4}{1/A_4 F_{45}} + \frac{J_5 - J_6}{1/A_5 F_{56}}$$

$$q_6 = \frac{E_{b6} - J_6}{\frac{1-\varepsilon_6}{\varepsilon_6 A_6}} = \frac{J_6 - J_h}{1/A_6 F_{6h}} + \frac{J_6 - J_1}{1/A_1 F_{16}} + \frac{J_6 - J_2}{1/A_2 F_{26}} + \frac{J_6 - J_3}{1/A_3 F_{36}} + \frac{J_6 - J_4}{1/A_4 F_{46}} + \frac{J_6 - J_5}{1/A_5 F_{56}}$$

$$q_h = \frac{J_h - J_1}{1/A_1 J_{1h}} + \frac{J_h - J_2}{1/A_2 J_{2h}} + \frac{J_h - J_3}{1/A_3 J_{3h}} + \frac{J_h - J_4}{1/A_{4h}} + \frac{J_h - J_5}{1/A_{5h}} + \frac{J_h - J_6}{1/A_{6h}}$$

7 equations
7 unknowns } Solve for J's

→ $T_b = 727\,K$