1) Assumptions: 1D heat conduction

Steady state

Constant thermal properties

No internal heat generation

$$\dot{Q} = \frac{T_1 - T_2}{R}$$

$$R = \frac{L}{kA}$$

$$\dot{Q} = kA\frac{T_1 - T_2}{L}$$

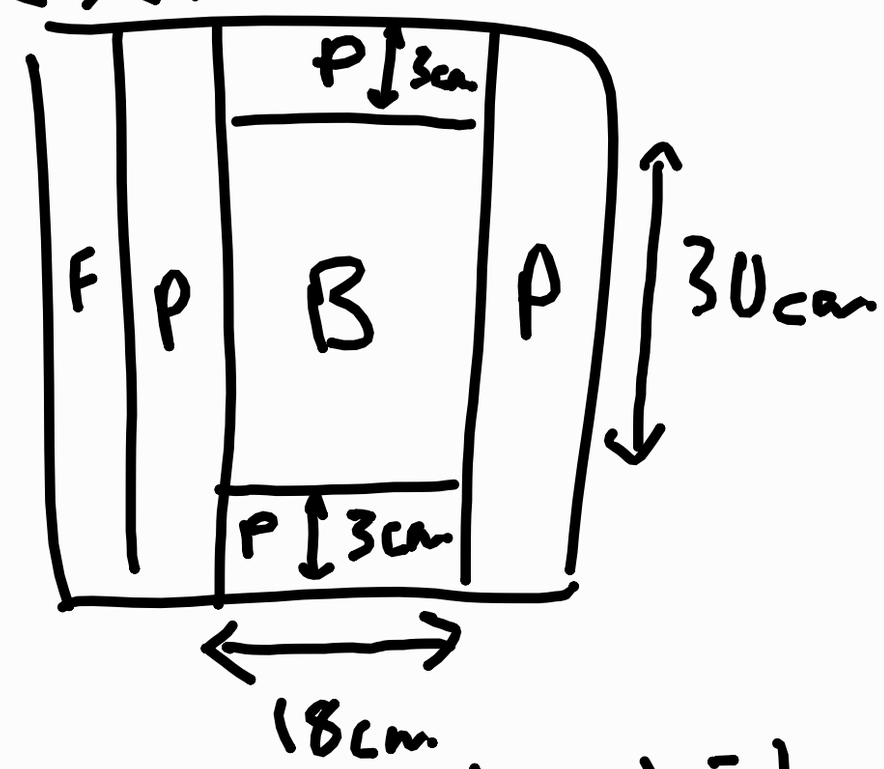
$$k = \frac{\dot{Q}L}{A(T_1 - T_2)}$$

$$k = \frac{180 \times 0.1}{0.1(0.2)(100-85)}$$

$$= 60 W m^{-1} K^{-1}$$

2) $R = R_i + R_F + R_p + \left(\frac{1}{R_B} + \frac{2}{R_p}\right)^{-1} + R_p + R_o$

$= R_F + 2R_p + \left(\frac{1}{R_B} + \frac{2}{R_p}\right)^{-1} + R_i + R_o$



$= \frac{2\times10^{-2}}{0.026(6\times33\times10^{-2})} + \frac{2\times2\times10^{-2}}{0.22(6\times33\times10^{-2})} + \left(\frac{0.72(6\times30\times10^{-2})}{18\times10^{-2}} + \frac{0.22(6\times1.5\times10^{-2})\times2}{18\times10^{-2}}\right)^{-1} + \frac{1}{10(6\times33\times10^{-2})} + \frac{1}{20(6\times33\times10^{-2})}$

$= \frac{500}{1287} + \frac{100}{1089} + \left(\frac{36}{5} + \frac{11}{50}\right)^{-1} + \frac{5}{99} + \frac{5}{198}$

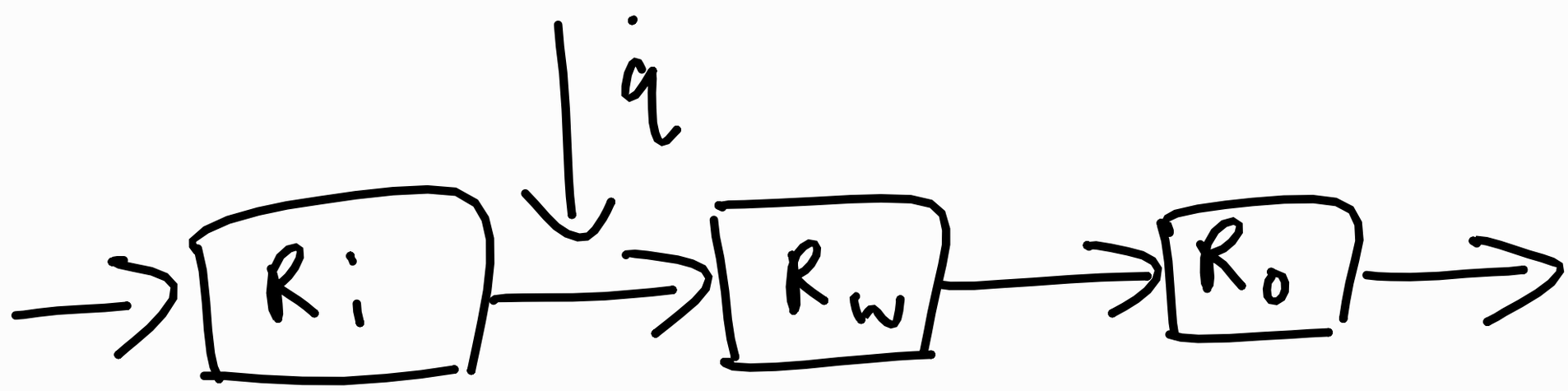
$= 0.690856218 3 W K^{-1}$

$\dot{Q} = \frac{T_1 - T_2}{R} \times \frac{4}{0.33}$

$= \frac{22-(-4)}{0.69085621833} \times \frac{4}{0.33}$

$= 456.1752602 W \simeq 456.2 W$

3)



$$R_i = \frac{1}{h} \qquad R_w = \frac{L}{k} \qquad R_o = \frac{1}{100}\ WK^{-1}$$

$$= \frac{1}{15}\ WK^{-1} \qquad = \frac{5\times10^{-3}}{1.2}$$

$$= \frac{1}{240}\ WK^{-1}$$

$$\frac{T_i - T_w}{R_i} + \dot{q} = \frac{T_w - T_o}{R_w + R_o}$$

$$\frac{22 - T_w}{\frac{1}{15}} + 1300 = \frac{T_w - (-5)}{\frac{1}{240} + \frac{1}{100}}$$

$$330 - 15T_w + 1300 = \frac{1200}{17}(T_w + 5)$$

$$\frac{1455}{17}T_w = \frac{21710}{17}$$

$$T_w = \frac{4342}{291}$$

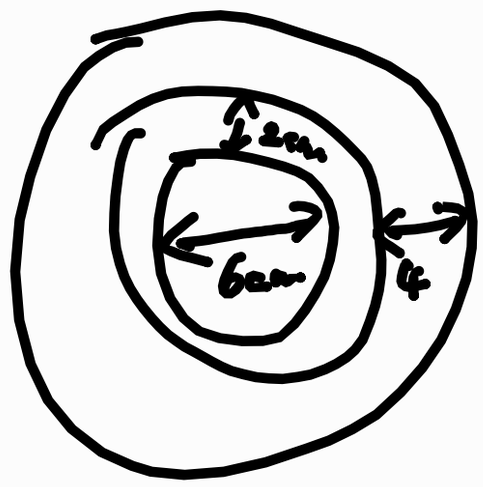
$$\approx 14.9^\circ C$$

4a) $R = R_i + R_{steel} + R_p + R_o$

$$= \frac{1}{800(6\times10^{-2}\pi\times20)} + \frac{\ln\left(\frac{4}{3}\right)}{2\pi(50)\times20} +$$

$$\frac{\ln\left(\frac{8}{4}\right)}{2\pi(0.5)\times20} + \frac{1}{200(16\times10^{-2}\pi\times20)}$$

$$= 0.011906\,49803\,WK^{-1}$$



$$Q = \frac{200-10}{0.011906\,49}$$

$$= 15957.67282$$

$$\simeq 15957W$$

b) $T_p = 10 + 15957\left(\frac{1}{200(16\times10^{-2}\pi\times20)}\right)$

$$= 17.93669534°C$$

$$\simeq 17.9°C$$

5) $R = R_{i_1} + R_{i_2} + R_c$

$$= \frac{1}{10\times(15\times10^{-3}\pi\times1)} + \frac{1}{10\times(35\times10^{-3}\pi\times1)} + \frac{\ln\left(\frac{110}{35}\right)}{2\pi(0.07)(1)}$$

$$= 5.635143679\ WK^{-1}$$

$$Q = 1\times10^{6}\times\pi\left(\frac{15\times10^{-3}}{2}\right)^{2}\times1$$

$$= 56.25\pi$$

$$Q = \frac{T_1 - T_3}{R}$$

$$56.25\pi = \frac{T_1 - 30}{5.635143679}$$

$$T_1 = 1025.812087°C$$

$$\approx 1026°C$$

6) $\dot{Q} = P$

$= VI$

$= 13 \times 8$

$= 104W$

$R = R_p + R_0$

$= \frac{\ln\left(\frac{4.2}{2.2}\right)}{2\pi(0.15)\times 10} + \frac{1}{24(4.2\pi \times 10^{-3})\pi \times 10}$

$= 0.384392890 3 W K^{-1}$

$Q = \frac{T_1 - T_2}{R}$

$104 = \frac{T_1 - 30}{0.38439289}$

$T_1 = 69.976860 59°C$

$\approx 70°C$