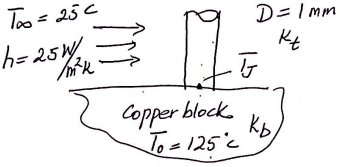
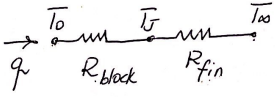
3- A long constantan wire of 1-mm diameter is butt welded to the surface of a large copper block, forming a thermocouple junction. The wire behaves as a fin, permitting heat to flow from the surface, thereby depressing the sensing junction temperature Tj below that of the block To. (a) If the wire is in air at 25°C with a convection coefficient of 25 W/m^2· K, estimate the measurement error (Tj − To) for the thermocouple when the block is at 125°C.





From table A-1 → Copper (at 400K), $k_b = 393\ W/mK$

Constantan (350K), $k_t = 25\ W/mK$

$$q = \frac{T_o - \bar{T}_J}{R_{block}} = \frac{T_o - T_\infty}{R_{block} + R_{fin}}$$

$$T_o - \bar{T}_J = \frac{R_{block}}{R_{block} + R_{fin}} (T_o - T_\infty)$$

Case 10 Table 4.1 $S = 2D$ → $R_{block} = \frac{1}{k_b S} = \frac{1}{k_b \times 2D} = \frac{1}{393 \times 2 \times 1 \times 10^{-3}}$

$= 1.27\ K/W$

$$R_{fin} = \frac{\theta_b}{q_f} = \frac{\theta_b}{M}$$

fin is infinite long $= \frac{\theta_b}{\sqrt{hPKA_c}\,\theta_b} = \frac{1}{\sqrt{hPKA_c}} = \frac{1}{\sqrt{h \times \pi D \times k \times \frac{\pi D^2}{4}}}$

$$= \frac{1}{\sqrt{25 \times \pi^2 \times (1\times10^{-3})^3 \times 25}} = 805\ K/W$$

$$T_o - \bar{T}_J = \frac{1.27}{1.27 + 805} (125 - 25) = 0.16^\circ c$$