4.42 Repeat Problem 4.41 for a bar of germanium with $\mu_e = 0.4$ (m^2/V·s), $\mu_h = 0.2$ (m^2/V·s), and $N_e = N_h = 4.8 \times 10^{19}$ electrons or holes/m^3.

Solution:

(a) Conductivity is given in Eq. (4.65),

$$\sigma = (N_e\mu_e + N_u\mu_u)e = (4.8 \times 10^{19})(0.4 + 0.2)(1.6 \times 10^{-19}) = 4.6 \qquad \text{(S/m)}.$$

(b) Similarly to Example 4.8, parts b and c,

$$I = JA = \sigma EA = (4.6)\left(\frac{5\text{V}}{0.08}\right)(\pi(4 \times 10^{-3})^2) = 14.5 \qquad \text{(mA)}.$$

(c) From Eqs. (4.62a) and (4.62b),

$$\mathbf{u}_e = -\mu_e \mathbf{E} = -(0.4)\left(\frac{5}{0.08}\right)\frac{\mathbf{E}}{|\mathbf{E}|} = -25\frac{\mathbf{E}}{|\mathbf{E}|} \qquad \text{(m/s)},$$

$$\mathbf{u}_h = \mu_h \mathbf{E} = (0.2)\left(\frac{5}{0.08}\right) = 12.5\frac{\mathbf{E}}{|\mathbf{E}|} \qquad \text{(m/s)}.$$

(d) To find the resistance, we use what we calculated above,

$$R = \frac{V}{I} = \frac{5\text{ V}}{14.5\text{ mA}} = 0.35 \qquad (\text{k}\Omega).$$

(e) Power dissipated in the bar is $P = IV = (5\text{V})(14.25\text{ mA}) = 72.25$ (mW).