

4.42 Repeat Problem 4.41 for a bar of germanium with $\mu_e = 0.4 \text{ (m}^2/\text{V}\cdot\text{s)}$, $\mu_h = 0.2 \text{ (m}^2/\text{V}\cdot\text{s)}$, and $N_e = N_h = 2.4 \times 10^{19} \text{ electrons or holes/m}^3$.

Solution:

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

$$\sigma = (N_e \mu_e + N_h \mu_h) e = (2.4 \times 10^{19})(0.4 + 0.2)(1.6 \times 10^{-19}) = 2.3 \quad (\text{S/m}).$$

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

$$I = JA = \sigma EA = (2.3) \left(\frac{5\text{V}}{0.08} \right) (\pi(4 \times 10^{-3})^2) = 7.225 \quad (\text{mA}).$$

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

$$\mathbf{u}_e = -\mu_e \mathbf{E} = -(0.4) \left(\frac{5}{0.08} \right) \frac{\mathbf{E}}{|\mathbf{E}|} = -25 \frac{\mathbf{E}}{|\mathbf{E}|} \quad (\text{m/s}),$$
$$\mathbf{u}_h = \mu_h \mathbf{E} = (0.2) \left(\frac{5}{0.08} \right) = 12.5 \frac{\mathbf{E}}{|\mathbf{E}|} \quad (\text{m/s}).$$

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

$$R = \frac{V}{I} = \frac{5 \text{ V}}{7.225 \text{ mA}} = 0.69 \quad (\text{k}\Omega).$$

(e) Power dissipated in the bar is $P = IV = (5\text{V})(7.225 \text{ mA}) = 36.125 \text{ (mW)}$.
