

35. (a) The copper wire and the aluminum sheath are connected in parallel, so the potential difference is the same for them. Since the potential difference is the product of the current and the resistance,  $i_C R_C = i_A R_A$ , where  $i_C$  is the current in the copper,  $i_A$  is the current in the aluminum,  $R_C$  is the resistance of the copper, and  $R_A$  is the resistance of the aluminum. The resistance of either component is given by  $R = \rho L/A$ , where  $\rho$  is the resistivity,  $L$  is the length, and  $A$  is the cross-sectional area. The resistance of the copper wire is  $R_C = \rho_C L/\pi a^2$ , and the resistance of the aluminum sheath is  $R_A = \rho_A L/\pi(b^2 - a^2)$ . We substitute these expressions into  $i_C R_C = i_A R_A$ , and cancel the common factors  $L$  and  $\pi$  to obtain

$$\frac{i_C \rho_C}{a^2} = \frac{i_A \rho_A}{b^2 - a^2} .$$

We solve this equation simultaneously with  $i = i_C + i_A$ , where  $i$  is the total current. We find

$$i_C = \frac{r_C^2 \rho_C i}{(r_A^2 - r_C^2) \rho_C + r_C^2 \rho_A}$$

and

$$i_A = \frac{(r_A^2 - r_C^2) \rho_C i}{(r_A^2 - r_C^2) \rho_C + r_C^2 \rho_A} .$$

The denominators are the same and each has the value

$$\begin{aligned} (b^2 - a^2) \rho_C + a^2 \rho_A &= [(0.380 \times 10^{-3} \text{ m})^2 - (0.250 \times 10^{-3} \text{ m})^2] (1.69 \times 10^{-8} \Omega \cdot \text{m}) \\ &\quad + (0.250 \times 10^{-3} \text{ m})^2 (2.75 \times 10^{-8} \Omega \cdot \text{m}) \\ &= 3.10 \times 10^{-15} \Omega \cdot \text{m}^3 . \end{aligned}$$

Thus,

$$i_C = \frac{(0.250 \times 10^{-3} \text{ m})^2 (2.75 \times 10^{-8} \Omega \cdot \text{m}) (2.00 \text{ A})}{3.10 \times 10^{-15} \Omega \cdot \text{m}^3} = 1.11 \text{ A}$$

and

$$\begin{aligned} i_A &= \frac{[(0.380 \times 10^{-3} \text{ m})^2 - (0.250 \times 10^{-3} \text{ m})^2] (1.69 \times 10^{-8} \Omega \cdot \text{m}) (2.00 \text{ A})}{3.10 \times 10^{-15} \Omega \cdot \text{m}^3} \\ &= 0.893 \text{ A} . \end{aligned}$$

- (b) Consider the copper wire. If  $V$  is the potential difference, then the current is given by  $V = i_C R_C = i_C \rho_C L/\pi a^2$ , so

$$L = \frac{\pi a^2 V}{i_C \rho_C} = \frac{(\pi)(0.250 \times 10^{-3} \text{ m})^2 (12.0 \text{ V})}{(1.11 \text{ A})(1.69 \times 10^{-8} \Omega \cdot \text{m})} = 126 \text{ m} .$$