SOLUTION'S CHAPTER 17

8. An electrical shock occurs when your body serves as a conductor between two points having a difference in potential. The concept behind the admonition is to avoid simultaneously touching points that are at different potentials.

12. Superconducting devices are expensive to operate primarily because they must be kept at very low temperatures. As the onset temperature for superconductivity is increased toward room temperature, it becomes easier to accomplish this reduction in temperature. In fact, if room temperature superconductors could be achieved, this requirement would disappear altogether.

17.7 The drift speed of electrons in the line is $v_d = \frac{I}{nqA} = \frac{I}{n|e|\left(\pi d^2/4\right)}$, or

$$v_d = \frac{4(1000\ \text{A})}{\left(8.5\times10^{28}/\text{m}^3\right)\left(1.60\times10^{-19}\ \text{C}\right)\pi(0.020\ \text{m})^2} = 2.3\times10^{-4}\ \text{m/s}$$

The time to travel the length of the 200-km line is then

$$\Delta t = \frac{L}{v_d} = \frac{200\times10^3\ \text{m}}{2.34\times10^{-4}\ \text{m/s}}\left(\frac{1\ \text{yr}}{3.156\times10^7\ \text{s}}\right) = \boxed{27\ \text{yr}}$$

17.12 The volume of the copper is

$$V = \frac{m}{density} = \frac{1.00\times10^{-3}\ \text{kg}}{8.92\times10^3\ \text{kg/m}^3} = 1.12\times10^{-7}\ \text{m}^3$$

Since, $V = A\cdot L$, this gives $A\cdot L = 1.12\times10^{-7}\ \text{m}^3$. (1)

(a) From $R = \frac{\rho L}{A}$, we find that

$$A = \left(\frac{\rho}{R}\right)L = \left(\frac{1.70\times10^{-8}\ \Omega\cdot\text{m}}{0.500\ \Omega}\right)L = \left(3.40\times10^{-8}\ \text{m}\right)L.$$

Inserting this expression for A into Equation 1 gives

$\left(3.40\times10^{-8}\ \text{m}\right)L^2 = 1.12\times10^{-7}\ \text{m}^3$, which yields $L = \boxed{1.82\ \text{m}}$

(b) From equation (1), $A = \frac{\pi d^2}{4} = \frac{1.12 \times 10^{-7}\ \text{m}^3}{L}$, or

$$d = \sqrt{\frac{4\left(1.12 \times 10^{-7}\ \text{m}^3\right)}{\pi L}} = \sqrt{\frac{4\left(1.12 \times 10^{-7}\ \text{m}^3\right)}{\pi (1.82\ \text{m})}}$$

$$= 2.80 \times 10^{-4}\ \text{m} = \boxed{0.280\ \text{mm}}$$

17.18 With different orientations of the block, three different values of the ratio L/A are possible. These are:

$$\left(\frac{L}{A}\right)_1 = \frac{10\ \text{cm}}{(20\ \text{cm})(40\ \text{cm})} = \frac{1}{80\ \text{cm}} = \frac{1}{0.80\ \text{m}},$$

$$\left(\frac{L}{A}\right)_2 = \frac{20\ \text{cm}}{(10\ \text{cm})(40\ \text{cm})} = \frac{1}{20\ \text{cm}} = \frac{1}{0.20\ \text{m}},$$

and $$\left(\frac{L}{A}\right)_3 = \frac{40\ \text{cm}}{(10\ \text{cm})(20\ \text{cm})} = \frac{1}{5.0\ \text{cm}} = \frac{1}{0.050\ \text{m}}$$

(a) $$I_{max} = \frac{\Delta V}{R_{min}} = \frac{\Delta V}{\rho (L/A)_{min}} = \frac{(6.0\ \text{V})(0.80\ \text{m})}{1.7 \times 10^{-8}\ \Omega \cdot \text{m}} = \boxed{2.8 \times 10^{8}\ \text{A}}$$

(b) $$I_{min} = \frac{\Delta V}{R_{max}} = \frac{\Delta V}{\rho (L/A)_{max}} = \frac{(6.0\ \text{V})(0.050\ \text{m})}{1.7 \times 10^{-8}\ \Omega \cdot \text{m}} = \boxed{1.8 \times 10^{7}\ \text{A}}$$

17.27 (a) The resistance at 20.0°C is

$$R_0 = \rho \frac{L}{A} = \frac{\left(1.7 \times 10^{-8}\ \Omega \cdot \text{m}\right)(34.5\ \text{m})}{\pi \left(0.25 \times 10^{-3}\ \text{m}\right)^2} = 3.0\ \Omega,$$

and the current will be $I = \frac{\Delta V}{R_0} = \frac{9.0\ \text{V}}{3.0\ \Omega} = \boxed{3.0\ \text{A}}$

(b) At 30.0°C,

$$R = R_0\left[1 + \alpha (T - T_0)\right]$$

$$= (3.0\ \Omega)\left[1 + \left(3.9 \times 10^{-3}\ (°\text{C})^{-1}\right)(30.0°\text{C} - 20.0°\text{C})\right] = 3.1\ \Omega$$

Thus, the current is $I = \frac{\Delta V}{R} = \frac{9.0\ \text{V}}{3.1\ \Omega} = \boxed{2.9\ \text{A}}$

17.35 The energy required to bring the water to the boiling point is

$$E = mc(\Delta T) = (0.500\ \text{kg})(4186\ \text{J/kg}\cdot{}^\circ\text{C})(100^\circ\text{C} - 23.0^\circ\text{C}) = 1.61\times10^5\ \text{J}$$

The power input by the heating element is

$$\wp_{input} = (\Delta V)I = (120\ \text{V})(2.00\ \text{A}) = 240\ \text{W} = 240\ \text{J/s}$$

Therefore, the time required is

$$t = \frac{E}{\wp_{input}} = \frac{1.61\times10^5\ \text{J}}{240\ \text{J/s}} = 672\ \text{s}\left(\frac{1\ \text{min}}{60\ \text{s}}\right) = \boxed{11.2\ \text{min}}$$

17.39 The resistance per unit length of the cable is

$$\frac{R}{L} = \frac{\wp/I^2}{L} = \frac{\wp/L}{I^2} = \frac{2.00\ \text{W/m}}{(300\ \text{A})^2} = 2.22\times10^{-5}\ \Omega/\text{m}$$

From $R = \rho L/A$, the resistance per unit length is also given by $R/L = \rho/A$. Hence, the cross-sectional area is $\pi r^2 = A = \dfrac{\rho}{R/L}$, and the required radius is

$$r = \sqrt{\frac{\rho}{\pi(R/L)}} = \sqrt{\frac{1.7\times10^{-8}\ \Omega\cdot\text{m}}{\pi(2.22\times10^{-5}\ \Omega/\text{m})}} = 0.016\ \text{m} = \boxed{1.6\ \text{cm}}$$