Problem 1

Solve: The total charge in the battery is

$$Q = I\Delta t \ = (90 \text{ A})(3600 \text{ s}) = 3.2 \times 10^5 \text{ C}$$

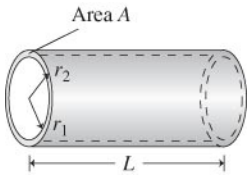
Problem 2

Solve: Since current is conserved, $I_{\text{top}} = I_{\text{mid}} = I_{\text{bot}} = 10$ A.

Problem 3

Assume the battery is ideal.

Visualize:



Solve: The tube's resistance is

$$R = \frac{\rho L}{A} = \frac{\rho L}{\pi\left(r_2^2 - r_1^2\right)} = \frac{\left(1.5\times10^{-6}\ \Omega\text{m}\right)\left(0.20\text{ m}\right)}{\pi\left[\left(0.0015\text{ m}\right)^2 - \left(0.0014\text{ m}\right)^2\right]} = 0.329\ \Omega$$

When connected to the battery, $\Delta V_{\text{tube}} = \Delta V_{\text{bat}} = 3.0$ V. Thus, the current is

$$I = \frac{\Delta V_{\text{tube}}}{R} = \frac{3.0\text{ V}}{0.329\ \Omega} = 9.1\text{ A}$$

Problem 4

Solve: **(a)** The charge delivered is

$$\left(50\times10^3\text{ A}\right)\left(50\times10^{-6}\text{ s}\right) = 2.5\text{ C}.$$

(b)

$$I = \frac{A}{\rho L}\Delta V \Rightarrow A = \frac{\rho L I}{\Delta V} = \frac{\left(9.7\times10^{-8}\ \Omega\text{m}\right)\left(5.0\text{ m}\right)\left(50\times10^3\text{ A}\right)}{100\text{ V}} = 2.43\times10^{-4}\text{ m}^2$$

This is the area required for a maximum voltage drop of 100 V. The corresponding diameter of the lightning rod is

$$r = \sqrt{\frac{A}{\pi}} = \sqrt{\frac{2.43\times10^{-4}\text{ m}^2}{\pi}} = 8.8\times10^{-3}\text{ m} = 8.8\text{ mm}$$