31.47. Solve: **(a)** Current is defined as $I = Q/\Delta t$, so the charge delivered in time Δt is

$$Q = I\Delta t = (150\text{ A})(0.80\text{ s}) = 120\text{ C}$$

(b) The drift speed is

$$v_\text{d} = \frac{J}{ne} = \frac{I/A}{ne} = \frac{I}{\pi r^2 ne} = \frac{150\text{ A}}{\pi(0.0025\text{ m})^2(8.5\times10^{28}\text{ m}^{-3})(1.60\times10^{-19}\text{ C})} = 5.617\times10^{-4}\text{ m/s}$$

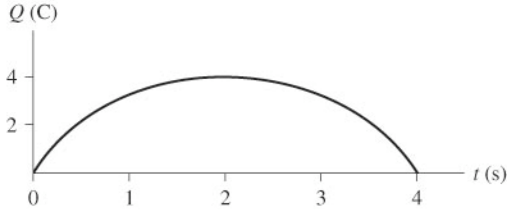
At this speed the electrons drift a distance

$$d = (5.617\times10^{-4}\text{ m/s})(0.80\text{ s}) = 4.49\times10^{-4}\text{ m} = 0.45\text{ mm}$$

31.48. Solve: The total charge in the battery is

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

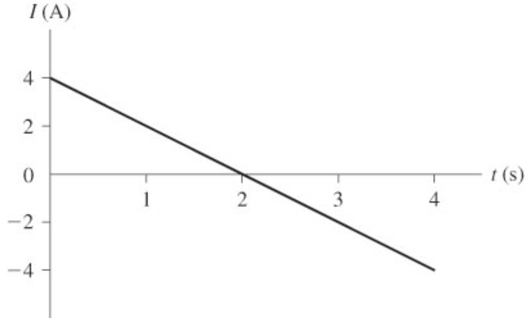
31.53. Solve: (a)



(b) Since $I = \Delta Q/\Delta t$, for infinitesimal changes

$$I = \frac{dQ}{dt} = \frac{d}{dt}\left(4t - t^2\right) = 4 - 2t$$

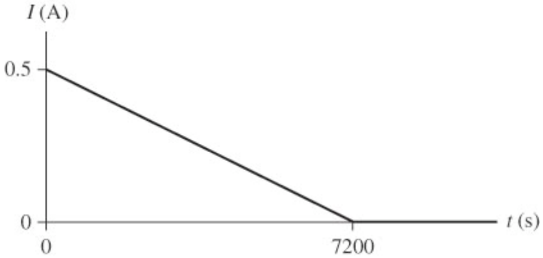
(c)



(d) The value of *I* at $t = 2.0$ s is zero. This is because the charge, having reached its maximum value, has stopped entering the wire. The negative values of *I* mean that charge is flowing out of the wire.

31.63. Model: Assume the battery is ideal.

Visualize: The current supplied by the battery and passing through the wire is $I = \Delta V_{\text{bat}}/R$. A graph of current versus time has exactly the same shape as the graph of ΔV_{bat} with an initial value of $I_0 = (\Delta V_{\text{bat}})_0/R = (1.5\text{ V})/(3.0\ \Omega) = 0.50\text{ A}$. The horizontal axis has been changed to seconds.



Solve: Current is $I = dQ/dt$. Thus the total charge supplied by the battery is

$$Q = \int_0^\infty I\,dt = \text{area under the current-versus-time graph}$$

$$= \tfrac{1}{2}(7200\text{ s})(0.50\text{ A}) = 1.80 \times 10^3\text{ C}$$

31.68. 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) The current in the lightning rod and the potential drop across it are related by Equation 31.22. Using ρ for iron from Table 31.2,

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

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

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