Chapter 28 Homework Solutions

Solutions for the following Self Tutoring and Skill Builder problems are available through Mastering Physics: Current in a Wire, and Down To The Wire. To access these solutions, click on the "View Solution" link on each problem view window.

28.30. **Solve:** Equation 28.18 will be used to relate electric field strength with the diameter. We have

$$J = \frac{I}{A} = \frac{I}{\frac{1}{4}\pi D^2} = \frac{4I}{\pi D^2} = \sigma E \Rightarrow I = \frac{\sigma \pi E D^2}{4}$$

Because the current is the same in the two wires,

$$E_{\text{nichrome}} = \left(\frac{\sigma_{\text{aluminum}}}{\sigma_{\text{nichrome}}}\right)\left(\frac{D_{\text{aluminum}}}{D_{\text{nichrome}}}\right)^2 E_{\text{aluminum}}$$

Using the values of σ from Table 28.2,

$$E_{\text{nichrome}} = \left(\frac{3.5\times10^7\ \Omega^{-1}\text{m}^{-1}}{6.7\times10^5\ \Omega^{-1}\text{m}^{-1}}\right)\left(\frac{1.0\text{ mm}}{2.0\text{ mm}}\right)^2 (0.0080\text{ N/C}) = 0.104\text{ N/C}$$

28.33. **Solve:** **(a)** The moving electrons are a current, even though they're not confined inside a wire. The electron current is

$$\frac{N_e}{\Delta t} = \frac{I}{e} = \frac{50\times10^{-6}\text{ A}}{1.60\times10^{-19}\text{ C}} = 3.12\times10^{14}\text{ s}^{-1}$$

This means during the time interval $\Delta t = 1$ s, 3.12×10^{14} electrons strike the screen.
(b) The current density is

$$J = \frac{I}{A} = \frac{I}{\pi r^2} = \frac{50\times10^{-6}\text{ A}}{\pi(0.00020\text{ m})^2} = 398\text{ A/m}^2$$

(c) The acceleration can be found from kinematics:

$$v_1^2 = (4.0\times10^7\text{ m/s})^2 = v_0^2 + 2a\Delta x = 2a\Delta x \Rightarrow a = \frac{(4.0\times10^7\text{ m/s})^2}{2(5.0\times10^{-3}\text{ m})} = 1.60\times10^{17}\text{ m/s}^2$$

But the acceleration is $a = F/m = eE/m$. Consequently, the electric field must be

$$E = \frac{ma}{e} = \frac{(9.11\times10^{-31}\text{ kg})(1.60\times10^{17}\text{ m/s}^2)}{1.6\times10^{-19}C} = 9.11\times10^5\text{ N/C}$$

(d) When they strike the screen, each electron has a kinetic energy

$$K = \tfrac{1}{2}mv_1^2 = \tfrac{1}{2}(9.11\times10^{-31}\text{ kg})(4.0\times10^7\text{ m/s}) = 7.288\times10^{-16}\text{ J}$$

Power is the *rate* at which the screen absorbs this energy. The power of the beam is

$$P = \frac{\Delta E}{\Delta t} = K\frac{N_e}{\Delta t} = (7.288\times10^{-16}\text{ J})(3.12\times10^{14}\text{ s}^{-1}) = 0.227\text{ J/s} = 0.227\text{ W}$$

Assess: Power delivered to the screen by the electron beam is reasonable because the screen over time becomes a little warm.

28.37. **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

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

At this speed the electrons drift a distance

$$d = (5.617\times10^{-4}\text{ m/s})(0.80\text{ s}) = 4.49\times10^{-4}\text{ m} = 0.449\text{ mm}$$

28.40. Solve: Equation 28.13 defines the current density as $J = I/A$. This means

$$A = \frac{\pi D^2}{4} = \frac{I}{J} \Rightarrow D = \sqrt{\frac{4I}{\pi J}} = \sqrt{\frac{4(1.0\text{ A})}{\pi(500\text{ A/cm}^2)}} = 0.050\text{ cm} = 0.50\text{ mm}$$

Assess: Fuse wires are usually thin.