

# PHYSICS 1020

## Homework #6

### Solutions

(April 8, 2010)

1. (Giancoli 18-5) What voltage will produce 0.25 A of current through a 3800- $\Omega$  resistor?

**Solution to 18-5.** By Ohm's Law, we have

$$\begin{aligned} V &= IR \\ &= (0.25 \text{ A})(3800 \Omega) \\ &= \boxed{950 \text{ V}} \end{aligned}$$

2. (Giancoli 18-11) A 12-V battery causes a current of 0.60 A through a resistor. (a) What is its resistance, and (b) how many joules of energy does the battery lose in a minute?

**Solution to 18-11.** (a) By Ohm's Law,  $V = IR$ , so

$$\begin{aligned} R &= \frac{V}{I} \\ &= \frac{12 \text{ V}}{0.60 \text{ A}} \\ &= \boxed{20 \Omega} \end{aligned}$$

(b) We can find the power dissipated by the resistor (which is the power supplied from the battery) from  $P = IV$ :

$$\begin{aligned} P &= IV \\ &= (0.60 \text{ A})(12 \text{ V}) \\ &= 7.2 \text{ W} \end{aligned}$$

so the battery loses energy at the rate of 7.2 W, or 7.2 J/s. Therefore in one minute, the battery loses

$$7.2 \text{ W} \times 60 \text{ s} = \boxed{432 \text{ J}}$$

3. (Giancoli 18-13) What is the resistance of a 3.5-m length of copper wire 1.5 mm in diameter?

**Solution to 18-13.** The resistance is found from

$$R = \rho \frac{L}{A}$$

Since the wire has a circular cross-section, the cross-sectional area  $A$  is given by  $A = \pi r^2 = \pi d^2/4$ . The resistance is then found from

$$R = \frac{4\rho L}{\pi d^2}$$

We look up the resistivity  $\rho$  of copper in the table of resistivities in the text (Table 18-1) and find  $\rho = 1.68 \times 10^{-8} \Omega \text{ m}$ . Substituting this, the wire length  $L$ , and the wire diameter  $d$ , we get

$$\begin{aligned} R &= \frac{4\rho L}{\pi d^2} \\ &= \frac{4(1.68 \times 10^{-8} \Omega \text{ m})(3.5 \text{ m})}{\pi(1.5 \times 10^{-3} \text{ m})^2} \\ &= \boxed{0.0333 \Omega} \end{aligned}$$

4. (Giancoli 18-19) A 100-W lightbulb has a resistance of about  $12 \Omega$  when cold ( $20^\circ\text{C}$ ) and  $140 \Omega$  when on (hot). Estimate the temperature of the filament when hot assuming an average temperature coefficient of resistivity of  $\alpha = 0.0060 \text{ } (^{\circ}\text{C}^{-1})$ .

**Solution to 18-19.** The resistance  $R$  of the filament at temperature  $T$  is given by

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

where the filament has resistance  $R_0$  at temperature  $T_0$ . Solving for the temperature  $T$ , we find

$$\begin{aligned} T &= T_0 + \frac{1}{\alpha} \left( \frac{R}{R_0} - 1 \right) \\ &= 20^\circ\text{C} + \frac{1}{0.0060 \text{ } ^{\circ}\text{C}^{-1}} \left( \frac{140 \Omega}{12 \Omega} - 1 \right) \\ &= \boxed{1800^\circ\text{C}} \end{aligned}$$

5. (Giancoli 18-22) Two aluminum wires have the same resistance. If one has twice the length of the other, what is the ratio of the diameter of the longer wire to the diameter of the shorter wire?

**Solution to 18-22.** Both wires have the same resistance; call this resistance  $R$ . This resistance is given in terms of resistivity by

$$R = \rho \frac{L}{A} = \rho \frac{L}{\pi r^2} = \rho \frac{4L}{\pi d^2}$$

Now both wires have the same resistivity  $\rho$ , but different lengths  $L$  and diameters  $d$ . Call the lengths  $L_1$  and  $L_2$ , and call the diameters  $d_1$  and  $d_2$  (where the subscript 1 is for the shorter wire, and the subscript 2 is for the longer wire). Then

$$R = \rho \frac{4L_1}{\pi d_1^2} = \rho \frac{4L_2}{\pi d_2^2}$$

or, cancelling the common factors of 4,  $\pi$ , and  $\rho$ ,

$$\frac{L_1}{d_1^2} = \frac{L_2}{d_2^2}$$

Rearranging, we get

$$\frac{L_2}{L_1} = \frac{d_2^2}{d_1^2} = \left(\frac{d_2}{d_1}\right)^2$$

Taking the square root of both sides,

$$\frac{d_2}{d_1} = \sqrt{\frac{L_2}{L_1}}$$

Since  $L_2/L_1 = 2$ , we have

$$\boxed{\frac{d_2}{d_1} = \sqrt{2}}$$