PHY 114. HW Chapter 26 Solutions. Spring 2023

Prb. #	ANSWERS

Note: The given numerical values for certain variables in this assignment may vary.

1

If N is the number of protons, each with charge e, that hit the target in time Δt, the average current in the beam is $I = \Delta Q / \Delta t = Ne/\Delta t$, giving

$$N = \frac{I(\Delta t)}{e} = \frac{(125\times10^{-6}\ \text{C/s})(23.0\ \text{s})}{1.60\times10^{-19}\ \text{C/proton}} = \boxed{1.80\times10^{16}\ \text{protons}}$$

2

(a) $J = \dfrac{I}{A} = \dfrac{5.00\ \text{A}}{\pi\left(4.00\times10^{-3}\ \text{m}\right)^2} = \boxed{99.5\ \text{kA/m}^2}$

(b) Current is the same.

(c) The cross-sectional area is greater; therefore the current density is smaller.

(d) $A_2 = 4A_1$ or $\pi r_2^2 = 4\pi r_1^2$ so $r_2 = 2r_1 = \boxed{0.800\ \text{cm}}$.

(e) $\boxed{I = 5.00\ \text{A}}$

(f) $J_2 = \dfrac{1}{4}J_1 = \dfrac{1}{4}\left(9.95\times10^4\ \text{A/m}^2\right) = \boxed{2.49\times10^4\ \text{A/m}^2}$

3

To find the total charge passing a point in a given amount of time, we use $I = \dfrac{dq}{dt}$, from which we can write

$$q = \int dq = \int I\,dt = \int_0^{1/240\ \text{s}} (100\ \text{A})\sin\left(\frac{120\pi t}{\text{s}}\right)dt$$

$$q = \frac{-100\ \text{C}}{120\pi}\left[\cos\left(\frac{\pi}{2}\right) - \cos 0\right] = \frac{+100\ \text{C}}{120\pi} = \boxed{0.265\ \text{C}}$$

4

From Equation 27.7, we obtain

(a) $I = \dfrac{\Delta V}{R} = \dfrac{120\ \text{V}}{240\ \Omega} = 0.500\ \text{A} = \boxed{500\ \text{mA}}$

(b) From $IR_{eq} = I_1R_1 + I_2R_2 \rightarrow R_{eq} = R_1 + R_2$, with $\Delta V = 230$ V, we obtain

$I = \dfrac{\Delta V}{R} = \dfrac{115\ \text{V}}{235\ \Omega} = 0.489\ \text{A} = 489\ \text{mA}$

5

Using $R = \dfrac{\rho L}{A}$ and data from Table 27.2, we have

RA = constant = $\rho_W L_W = \rho_{Fe} L_{Fe}$.

which yields

$$\frac{L_W}{L_{Fe}} = \frac{\rho_{Fe}}{\rho_W} = \frac{10.0\times10^{-8}\ \Omega\cdot\text{m}}{5.60\times10^{-8}\ \Omega\cdot\text{m}} = 1.79.$$

6

(a) From $R = \rho L/A$, the initial resistance of the mercury is

$$R_i = \frac{\rho L_i}{A_i} = \frac{\rho L_i}{\pi d_i^2/4} = \frac{(9.58\times10^{-7}\ \Omega\cdot\text{m})(1.000\,0\ \text{m})}{\pi\left(1.00\times10^{-3}\ \text{m}\right)^2/4} = \boxed{1.22\ \Omega}$$

	(b) Since the volume of mercury is constant, $V = A_f \cdot L_f = A_i \cdot L_i$ gives the final cross-sectional area as $A_f = A_i \cdot (L_i/L_f)$. Thus, the final resistance is given by $R_f = \frac{\rho L_f}{A_f} = \frac{\rho L_f^2}{A_i \cdot L_i}$. The fractional change in the resistance is then $\frac{\Delta R}{R} = \frac{R_f - R_i}{R_i} = \frac{R_f}{R_i} - 1 = \frac{\rho L_f^2/(A_i \cdot L_i)}{\rho L_i/A_i} - 1 = \left(\frac{L_f}{L_i}\right)^2 - 1$ $\frac{\Delta R}{R} = \left(\frac{100.040\ 0\text{cm}}{100.000\ 0\text{cm}}\right)^2 - 1 = \boxed{8.00 \times 10^{-4}\text{ increase}}$
7	(a) From Equation 27.21, $P = I\Delta V \rightarrow I = P/\Delta V = (1.00 \times 10^3\text{ W})/(120\text{ V}) = \boxed{8.33\text{ A}}$ (b) From Equation 27.23, $P = \Delta V^2/R \rightarrow R = \Delta V^2/P = (120\text{ V})^2/(1.00 \times 10^3\text{ W}) = \boxed{14.4\ \Omega}$
8	From Equation 27.21, $P = I\Delta V = 500 \times 10^{-6}\text{ A}(15 \times 10^3\text{ V}) = \boxed{7.50\text{ W}}$
9	(a) The total energy stored in the battery is $\Delta U_E = q(\Delta V) = It(\Delta V)$ $= (55.0\text{ A}\cdot\text{h})(12.0\text{ V})\left(\frac{1\text{ C}}{1\text{ A}\cdot\text{s}}\right)\left(\frac{1\text{ J}}{1\text{ V}\cdot\text{C}}\right)\left(\frac{1\text{ W}\cdot\text{s}}{1\text{ J}}\right)$ $= 660\text{ W}\cdot\text{h} = \boxed{0.660\text{ kWh}}$ (b) The value of the electricity is $\text{Cost} = (0.660\text{ kWh})\left(\frac{\$0.110}{1\text{ kWh}}\right) = \boxed{\$0.072\ 6}$