Chapter 26

26.1. During the 4.0 min a 5.0 A current is set up in a wire, how many (a) Coulombs and (b) electrons pass through any cross section across the wire's width

$$\Delta q = i\Delta t = 5.0A \cdot 240s = 1200C$$
$$\Delta q = n e$$
$$n = \frac{\Delta q}{e} = \frac{1200C}{1.6\times10^{-19}C} = 7.5\times10^{21}\, electrons$$

26.4 A small but measurable current of $1.2\times10^{-10}A$ exists in a copper wire whose diameter is $2.5mm$. The number of charge carriers per unit volume is $8.49\times10^{28}m^{-3}$. Assuming the current is uniform, calculate the (a) current density and (b) the electron drift speed.

(a) W can compute the current density from the definition.

$$J = \frac{i}{A} = \frac{1.2\times10^{-10}A}{\pi(.00125m)^2} = 2.44\times10^{-5}A/m^2$$

(b) Now that we know J, we can compute the velocity

$$J = \rho v$$

$$\rho = (\#of\ particles/m^3)\cdot(chg/particle) = 8.49\times10^{28}m^{-3}\cdot1.6\times10^{-19}C$$
$$= 1.39\times10^{10}C/m^3$$

$$v = \frac{J}{\rho} = \frac{2.44\times10^{-5}A/m^2}{1.39\times10^{10}C/m^3} = 1.8\times10^{-15}m/s$$

26.7 A beam contains 2×10^8 double charged positive ions per cubic centimeter, all of which are moving north with a speed of $1.0\times10^5 m/s$. What are the (a) magnitude and (b) direction of the current density $\vec{J}$? (c) What additional quantity do you need to calculate the total current i in this ion beam.

$$J = \frac{2.0\times10^8 ions}{1\times10^{-6}m^3}\cdot\frac{2\cdot1.6\times10^{-19}C}{ion}\cdot1.0\times10^5 m/s$$
$$= 6.4\,A/m^2(north)$$

You need the beam spot size to find the total current.

26.17 A conducting wire has 1.0 mm diameter and a 2.0 m length and a $50 m\Omega$ resistance. What is the resistivity of the material?

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

$$\rho = R\frac{A}{L} = 50\times 10^{-3}\Omega \cdot \frac{\pi \cdot (0.0005m)^2}{2.00m} = 1.9635\times 10^{-8}\Omega \cdot m$$

26.23 Two conductors are made of the same material and have the same length. m Conductor A is a solid wire of diameter 1.0mm. Conductor B is a hollow tube of outside diameter 2.0mm and inside diameter 1.0mm. What is the resistance ratio R_A / R_B, measured between their ends?

We can write the resistance for each conductor

$$R_A = \rho \frac{L}{A_A}$$

$$R_B = \rho \frac{L}{A_B}$$

$$\frac{R_A}{R_B} = \frac{\rho \frac{L}{A_A}}{\rho \frac{L}{A_B}}$$

$$= \frac{A_B}{A_A}$$

$$= \frac{\pi r_{outer}{}^2 - \pi r_{inner}{}^2}{\pi r^2}$$

$$= \frac{r_{outer}{}^2 - r_{inner}{}^2}{r^2} = \frac{(\frac{3}{2}mm)^2 - (\frac{1}{2}mm)^2}{(\frac{1}{2}mm)^2}$$

$$= 4$$

26.42 Thermal energy is produced in a resistor at a rate of 100W when the current is 3.00A. What is the resistance.

$$P = i^2 R$$

$$R = \frac{P}{i^2} = \frac{100W}{(3A)^2} = 11.11\Omega$$