Chapter 26

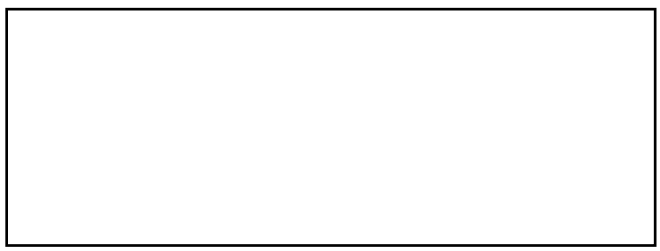
26.1. During the 4.0 min a 5.0 A current is set up in a wire, how many (a) Coulombs and (b) electrons pass through any cross section across the wire's width

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

26.2 A charged belt, 50 cm wide, travels at 30 m/s between a source of charge and a sphere. The belt carries charge into the sphere at a rate of $100\mu A$. Compute the surface charge density of the belt.

We can think of a current as being composed of that area of the belt that passes by in 1 second times the charge per unit area.

w



l=v*t=v*1s

$$i = \frac{\sigma \cdot area}{1s} = \frac{\sigma \cdot (v \cdot 1s \cdot w)}{1s}$$
$$\sigma = \frac{i}{v \cdot w} = \frac{100\times10^{-6}A}{30m/s \cdot 0.5m} = 6.67\times10^{-6}$$

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

$$J = \rho v$$

$$\rho = (\#\, of\ particles / m^3) \cdot (chg / particle) = 8.49 \times 10^{28} m^{-3} \cdot 1.6 \times 10^{-19} C$$
$$= 1.39 \times 10^{10} C / m^3$$

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

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 $1.0 \times 10^5 m/s$. 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.

$$J = \frac{2.0 \times 10^8 ions}{1 \times 10^{-6} m^3} \cdot \frac{2 \cdot 1.6 \times 10^{-19} C}{ion} \cdot 1.0 \times 10^5 m / s$$
$$= 6.4\, A / m^2 (north)$$

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

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

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

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

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

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

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

$$= 4$$

26.35 A 120 V potential difference is applied to a space heater whose resistance is 14 Ohms when hot. (a) At what rate is electrical energy transferred to thermal energy? (b) What is the cost for 5h at \$0.05/(kWh).

We begin by computing the rate of energy transfer.

$$P = \frac{V^2}{R} = \frac{(120V)^2}{14\Omega} = 1028.6W$$

We now compute the energy used in kWh and the cost.

$$U = P \cdot t = 1.028kW \cdot 5h = 5.143kWh$$

$$cst = 5.143kWh \cdot \frac{\$0.05}{kWh} = \$0.257$$

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

$$P = i^2 R$$

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

26.39 A 1250 W radiant heater is constructed to operate at 115 V. (a) What is the current in the heater when the unit is operating? (b) What is the resistance of the heating coil? (c) How much thermal energy is produced in 1.0 h?

We can compute the current from the power and voltage.

$$P = iV$$
$$i = \frac{P}{V} = \frac{1250W}{115V} = 10.86A$$

We can compute the Resistance from the Voltage and power

$$P = \frac{V^2}{R}$$
$$R = \frac{V^2}{P} = \frac{(115V)^2}{1250W} = 10.58\Omega$$

$$U = P \cdot t = 1250W \cdot 3600s = 4.5 \times 10^6 J$$

26.40 A 120V potential difference is applied to a space heater that dissipates 500W during operation. (a) What is its resistance during operation? (b) At what rate do electrons flow through any cross section of the heater element

$$P = \frac{V^2}{R}$$
$$R = \frac{V^2}{P} = \frac{(120V)^2}{500W} = 28.8\Omega$$

$$P = iV$$
$$i = \frac{P}{V} = \frac{500W}{120V} = 4.167A$$
$$i = (\#\, electrons / s) \cdot 1.6 \times 10^{-19} C$$
$$(\#\, electrons / s) = \frac{i}{1.6 \times 10^{-19} C} = \frac{4.167A}{1.6 \times 10^{-19} C}$$
$$= 2.604 \times 10^{19}$$

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

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

26.43 A 100W light bulb is plugged into a standard 120V outlet. (a) How much does it cost per 31 day month to leave the light turned on continuously. Assume that electrical energy costs \$0.06/kWh. (b) What is the resistance of the bulb? (c) What is the current in the bulb?

Compute the energy used in 31 days is (in kWh) and then compute the cost.

$$U = P \cdot t = 0.100kW \cdot 31 days \cdot \frac{24 hrs}{day} = 74.4 kWh$$
$$cst = 74.4 kW\ h \cdot \frac{\$0.06}{kW\ h} = \$4.464$$

The resistance of the bulb can be found

$$P = \frac{V^2}{R}$$
$$R = \frac{V^2}{P} = \frac{(120V)^2}{100W} = 144\Omega$$

The current in the bulb.

$$P = iV$$
$$i = \frac{P}{V} = \frac{100W}{120V} = 0.833 A$$